Pegem Journal of Education and Instruction, Vol. 12, No. 2, 2022 (pp. 226-234)

RESEARCH ARTICLE WWW.PEGEGOG.NET

The effect of virtual laboratory applications prepared for Geometrical Optics Lesson on students' achievement levels and attitudes towards Physics*

Şükran ERDOĞAN, Doç[1*]. Dr. Ersin BOZKURT[2]

[1] Department of Physics, Selcuk University, Institute of Science, Konya/Turkiye

[2] Department of Physics, Necmettin Erbakan University, Ahmet Keleşoğlu Faculty of Education, Education, Konya/Turkiye

Abstract

The purpose of this study is to investigate the effect of teaching through a virtual laboratory prepared using simulations teaching materials and that are based on constructivist thought about geometrical optics upon the students' academic success and their attitudes towards physics. Quasi-experimental pretest and posttest control groups was used as the research method. While the independent variable of the study is teaching method that is based on virtual laboratory application, the dependents variables are students' success at physics lesson and their attitude towards physics. The study was carried out with 59 students from the same grade but a different section and taking Physics II lesson that is taught in Department of Computer and Instructional Technologies in the spring term of 2013 and 2014 academic year. One of the sections was objectively determined as the experimental group and the other one is determined as the control group. The subject was taught to 29 students in the experimental group in a virtual laboratory environment which was created using simulations, and 30 students in the control group was taught the same subject in a traditional laboratory environment. As a result in this study, it was seen that teaching in the virtual laboratory environment where simulations were used in the subject of Geometrical Optics was more affective in physics success than teaching in traditional laboratory environment but there was no meaningful difference in attitudes towards physics.

Keywords: Attitude towards physics, Physics education, geometrical optics, Physics success, Virtual laboratory.

Introduction

Students generally see physics as an abstract and difficult course to learn. This situation has created an important field of study for physics educators about how physics should be taught and learned (Aydın & Öztekin, 2018; Ceylan & Saygıner, 2017; Dağdalan & Taş, 2017). It is frequently emphasized in studies that the education with traditional approaches, in which plain lecture is used as the method and the course book is used as the course material has a low effect on students' academic achievement and meaningful learning (Akkağıt & Tekin, 2012; Pena & Quilez, 2001).

Although the physics course is a broad-spectrum course based on conceptual foundations, this course is generally tried to be taught in a way that is transactional oriented. This situation complicates the physics course and causes students to deal with numerical operations rather than concepts. For this reason, students try to form these concepts and events in physics in their own minds. This causes great misconceptions in students. However, the physics lesson is so closely related to the events that it is not difficult to explain the laws of physics and physical concepts to the students by visualizing them. In this context, the importance of teaching with experimental methods in physics teaching has been revealed (Çepni, Kaya, & Küçük, 2005; Ergin et al., 2001; Sönmez et al., 2005). In addition, it is known that laboratory practices are not valued basically due to the same reasons such as the lack of consistency between the experimental activities carried out in the laboratories in schools and the questions asked in the university exam, the lack of tools and equipment in the science laboratories, and that the content of the curriculum is full of the subject area (Alkan, Çilenti, & Özçelik, 1991; Çepni, Akdeniz, & Ayas, 1995; Ekici, 2015). Alternative teaching methods are needed to overcome such problems and to increase the success of students in physics education.

Today, information and communication technologies (ICT) help in producing, perceiving and sharing knowledge in

* This study was produced from the doctoral thesis conducted by the first author under the supervision of the second author. The summary of this study has been published in the INES2017 Congress' abstract book.

Corresponding Author e-mail: sukranerdogan@selcuk.edu.tr

https://orcid.org/0000-0002-0894-7376

How to cite this article: Doç EŞ. BOZKURT E (2022). The effect of virtual laboratory applications prepared for Geometrical Optics Lesson on students' achievement levels and attitudes towards Physics. Pegem Journal of Education and Instruction, Vol. 12, No. 2, 2022, 226-234

Source of support: Nil

Conflict of interest: None.

DOI: 10.47750/pegegog.12.02.22

Received: 09.11.2021

Accepted: 21.01.2021 **Publication:** 01.04.2022

every discipline faster. Beyond the field of education, a number of new technologies, especially computers and the internet have become important and effective tools in increasing productivity and motivating individuals in many business areas. In physics teaching, it is very difficult to visualize and animate abstract concepts, in short, to reconstruct them in the mind and rearrange them as information. To be able to understand some physics concepts, principles, events and phenomena with the help of experimental work; It is not always easy to transfer the knowledge and experience gained in this process to other fields. In such cases, it has been demonstrated by various studies that teaching and learning will be facilitated and the permanence of knowledge will be ensured with the simulation technique on the computer (Tankut, 2008; Tatlı & Ayas, 2011; Uğur, 2001). In addition, the use of ICT in learning inside and outside the school can make learning more enjoyable due to the easier and faster perception of information, and it helps learners to develop problem-solving skills by encouraging them. ICT has features of facilitating, enriching, visualizing and concretizing learning environments. (Büyükkara, 2011; Demirel, 2001).

It is known that students have misconceptions and learning difficulties in many subjects of physics. The researches done show that students at all educational levels, from primary school to university, have many misconceptions and learning difficulties in the subjects of "Optics", which is one of the important subjects of physics (Aydın & Öztekin, 2018; Galili & Hazan, 2000; Heywood, 2005; Taşlıdere, 2013; Yıldız, 2012). Galili and Lavrik (1998) stated that the reason why students have difficulty in learning optics is the lack of teaching methods and materials. Akdeniz, Yıldız, and Yiğit (2001) also emphasized that science subjects should be studied in depth in the laboratory environment.

In our country, it is emphasized in studies that laboratory materials that attract the attention of undergraduate students and encourage students to think and research are insufficient (Bozkurt, 2008; Yıldız, 2012). Olympiou and Zacharia (2010) stated that laboratory practices designed for teaching optics are also insufficient. In cases where traditional laboratory applications are insufficient, virtual laboratory environments in which simulations are used can be applied in the teaching of optics as well as in teaching many physics subjects. As a matter of fact, it is stated in the literature that virtual laboratories in which simulations are used are more effective than traditional laboratories in teaching many subjects of physics (Akkağıt & Tekin, 2012; Bozkurt & Sarıkoç, 2008; Çinici et al., 2013).

Conceptual Framework

Virtual Laboratories

A virtual laboratory is defined as a computer-based application environment that provides interactive and real-time simulation opportunities in experiments that need to be done in order to gain practical experience in education (Akın & Karaköse, 2003). Virtual laboratories are multimedia and simulation-based exploratory computer-centered teaching systems. Virtual laboratories are simulations of learning fields (physics, chemistry, biology, astronomy, earth science, etc.) related to science.

In recent years, with the use of technology in the field of education, virtual laboratories have begun to be considered as an alternative to traditional laboratories in schools. What both traditional and virtual laboratory environments actually want to bring to the student is not different. However, both environments have their own advantages or limitations. Traditional laboratories; allow students to feel like real scientists in terms of contributing to the development of students' psycho-motor skills, requiring attention in designing experiments, waiting for a certain time during data collection. On the other hand, in some cases, traditional environments may be limited. E.g; experiments requiring dangerous substances, the cost of materials used in laboratories, the fact that some experiments are carried out with materials that cannot be brought to the laboratory environment and the time spent in the laboratory is limited, etc. (Kapıcı and Akçay, 2019). Virtual laboratories can offer solutions to such problems. Some advantages of virtual lab environments can be listed as follows:

- It is possible to design and implement more experiments in less time.
- It is suitable in terms of safety and cost.
- It allows to embody abstract concepts such as electricity, chemical molecular structures or thermodynamics that cannot be seen in real life.
- It provides the opportunity to give the desired message in a clear, concise and short way by eliminating the details about the subject.
- Online applications that will help students can be placed inside.
- It reduces the workload of the teacher.
- It facilitates the student's learning by doing.

Teaching Science/Physics through Simulation

With the integration of technology into education, interactive applications developed in the computer environment in abstract courses such as science and mathematics have started to be included more frequently in learning environments. In this respect, one of the most effective applications is the "simulation" method.

Simulation is one of the learning methods in which students can change the parameters and take an active role in the learning process (Tekdal, 2002). In other words, simulation is applications in which experiments that cannot be performed in real life due to some reasons (dangerous experiments, cost and accessibility of experimental materials, experiments in which the results are too fast or too slow, etc.) are transformed into interactive learning environments with concrete or visual materials (Ceylan & Saygıner, 2017).

Thanks to the real-life suitability feature of the simulation, students have the opportunity to experience in a realistic environment. However, in simulations, it is possible to intervene in the environment, as the user's ability to give different initial values. In this way, it provides the opportunity to learn by exploring. The most distinctive feature that distinguishes it from animation or other multimedia applications is that students have the opportunity to change the presented parameters in simulations.

The points to be considered while preparing the simulations can be listed as follows (Dağdalan & Taş, 2017):

- To encourage students to scientific inquiry,
- To interact,
- To make the invisible visible,
- To use multi-media components,
- To present real-life examples,
- To present flexible designs that can be used in many educational fields.

Technical features of the simulations include:

- Provides interaction with drag-and-drop method,
- Provides the opportunity to change the variables freely,
- Allows measuring with measuring tools such as ruler, stopwatch, thermometer.

Studies (Bozkurt & Sarıkoç, 2008; Dinçer & Güçlü, 2013, Keçeci et al., 2016; Sarabando, Cravino & Soares, 2014; Yılmaz & Eren, 2014; Yolaş-Kolçak, Mongol & Ünsal, 2014) reveals that the use of simulation in science education is a more effective method compared to traditional teaching methods. In these studies, it is stated that the use of simulation, especially in science/physics education, has an effect on academic achievement, permanence and attitude; students increase their interest and it enables them to learn on their own. Nuhoğlu and Yalçın (2004) stated that teaching materials for teaching physics subjects should be developed in order to improve students' attitudes towards physics laboratory.

The aim of this research is to examine the effect of teaching through a virtual laboratory application prepared using simulations based on constructivist thinking on Geometrical Optics, on the academic achievement and attitudes of students towards physics compared to teaching through traditional laboratory method. In accordance with this purpose, the problem statement of the research is expressed as follows: "What is the effect of teaching through a virtual laboratory application on Geometrical Optics on the academic achievement and attitudes of students towards physics compared to teaching through traditional laboratory method?" The sub-problems of the research are as follows:

1. Is there a significant difference between the pre-test scores of the experimental group (EG) students who are taught through the virtual laboratory application and the control group (CG) students who are taught through the traditional laboratory method regarding the geometrical optics achievement?
2. Is there a significant difference between the pre-test and post-test scores of the EG students who are taught through the virtual laboratory application regarding the geometrical optics achievement?
3. Is there a significant difference between the pre-test and post-test scores of the CG students who are taught through the traditional laboratory method regarding the geometrical optics achievement?
4. Is there a significant difference between the post-test scores of the EG students who are taught through the virtual laboratory application and the CG students who are taught through the traditional laboratory method regarding the geometrical optics achievement?
5. Is there a significant difference between the pre-test scores of students in the EG taught through the virtual laboratory application and the CG students taught through the traditional laboratory method regarding the attitude towards physics?
6. Is there a significant difference between the pre-test and post-test scores of the EG students who are taught through the virtual laboratory application regarding the attitude towards physics?
7. Is there a significant difference between the pre-test and post-test scores of the CG students who are taught through the traditional laboratory method regarding the attitude towards physics?
8. Is there a significant difference between the post-test scores of the EG students who are taught through the virtual laboratory application and the CG students who are taught through the traditional laboratory method regarding the attitudes towards physics?

Method

Research Pattern

In this study, it was aimed to investigate the effect of a virtual laboratory application prepared on geometrical optics in the Physics II course of the Computer and Instructional Technologies Education (CITE) department, on the achievements of students and their attitudes towards physics. The quasi-experimental pretest and posttest control group design was used as the research model (Karasar, 2005). The quasi-experimental pretest and posttest control group model allows to test the effect of independent variables on dependent variables after the experimental procedure, and allows the results to be interpreted in terms of cause and effect (Büyüköztürk, 2007, Karasar, 2005). While the independent variable of the study is the teaching method based on virtual laboratory application, the dependent variables are the success of the students in the physics course and the attitudes of the students towards physics.

The study groups were determined impartially from the two existing branches taking the physics course, one as the experimental group (EG) and the other as the control group (CG).

Before starting the experimental application, a pre-test was applied to the experimental and control groups. In the EG, lessons based on the constructivist approach were taught through virtual laboratory applications, while in the CG, lessons were taught through the traditional approach (lecture, question-answer, etc.) in accordance with the curriculum. At the end of the experimental application, a post-test was applied to both groups.

Study Group

The study group of the research consists of 59 students studying in the 2nd year of CITE Department. The research was carried out in the Physics II course taught in the 2013-2014 spring term, and a pre-test on geometrical optics was applied in two different branches of the same class who took this course. As a result of the independent sample t-test applied to the scores obtained from the pre-tests, it was observed that there was no significant difference between the branches ($p>.05$). Accordingly, one of the branches was randomly determined as the experimental ($N=29$) and the other as the control ($N=30$) group.

Data Collection Tools

In the study, the "Geometrical Optics Achievement Test" was used to measure the academic achievement of the students, and the "Attitude towards Physics Scale" was used to determine their attitudes towards physics.

The Geometrical Optics Achievement Test was prepared by researchers to cover the content of geometrical optics. Geometrical Optics topics in Physics II course are; The Laws of Reflection, Specular Reflection- Diffuse Reflection, Image Formation in Flat Mirrors, Image Formation in Spherical Mirrors, Refraction Laws, Thin Lenses, Image Formation by Refraction in Thin Lenses, and Optical Instruments. While preparing the achievement test, first of all, 44 items measuring these topics were prepared. The draft test was corrected in accordance with the opinions of 2 experts who taught Physics II, and the validity of the test was tried to be ensured. This draft test, consisting of 44 items, was applied to a total of 53 students who had taken the Physics II course before, and item analysis was made according to the data obtained. The achievement test took its final form by removing 14 items with discrimination indexes below $r_{jx}=.20$. The reliability coefficient of the Geometrical Optical Achievement Test, which consists of 30 items in its final form, was calculated as KR-20 = .75. The reliability coefficient calculated for such tests is .70 and higher, which is generally considered sufficient for the reliability of the test scores (Büyüköztürk, 2007).

Attitude towards Physics Scale developed by Kurnaz and Yiğit (2010) was used to determine students' attitudes. Consisting of 24 items, the scale is in 4-point Likert type and has 3 sub-dimensions. These sub-dimensions are "Valuing Physics", "Making Physics Behavior" and "Perspective Against Physics". In addition, the Cronbach-alpha internal consistency coefficient of the scale was calculated as 0.95.

Application

Geometrical Optics subjects were taught in a virtual laboratory environment created from simulations in the EG, and in the CG through traditional teaching methods for five weeks. In the EG, two different simulations were used throughout the research. One of them is "Optics Applet" and the other is "Thin Lens" simulation (Christian & Lee, 2011; Hwang, 2004). The simulations used are compiled Java-based simulations. Both simulations were translated into Turkish and rearranged in a way that students can understand.

The "Thin Lens" simulation has been used to quickly and practically explain special rays and image formations in mirrors (flat mirror, concave mirror and convex mirror) and thin lenses. It says "Thin lenses and spherical mirrors" on the opening window of the "Thin lens" simulation. The "Optics Applet" simulation was mostly used for the applications under the guidance of the teacher in the discovery phase of the students.

In the CG, the subjects were presented by the lecturer by the lecture method and the participation of the students in the lesson was ensured through the techniques such as

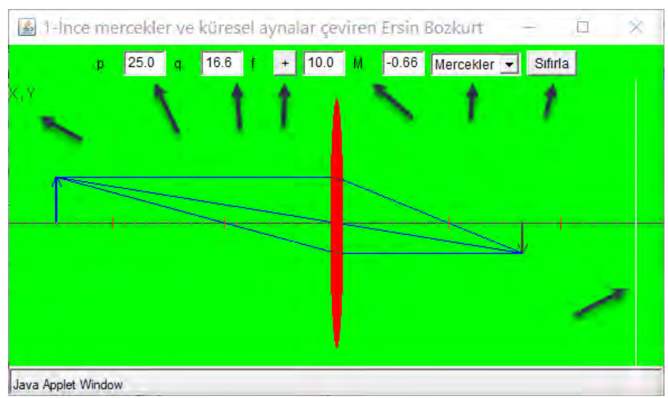

Fig. 1: "Thin Lens" Simulation (Hwang, 2004)

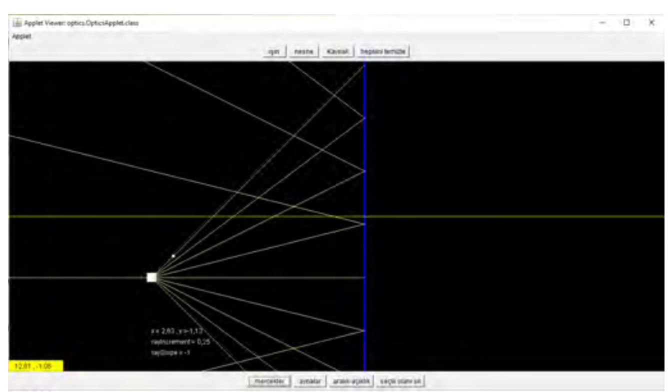

Fig. 2: "Optics Applet" simulation (Christian & Lee, 2011)

question-answer, discussion, etc. Subjects in the EG and CG were covered in the same time.

Data Analysis

The data obtained through data collection tools were analyzed with the help of Excel spreadsheet program and SPSS 15.0 package program. First of all, the data obtained from the Geometrical Optical Achievement test were scored as correct (1 point) and incorrect (0 points) and the total success score in the pre-test given before the application and the total achievement score in the post-test given after the application were calculated. Independent sample t-test was used to test the statistical significance of the difference between the groups' achievement scores from the geometrical optics test; Paired-sample t-test was used to test the statistical significance of the difference between the pre-test and post-test achievement scores of the groups obtained from the geometrical optics test. The answers given by the students from positive to negative (4-3-2-1 points) to each item in the Attitude Towards Physics scale were scored, and the total attitude score of each student in the pre-test given before the application and the total attitude score in the post-test given after the application were calculated. Independent sample t-test was used to test the statistical significance of the difference between the attitude scores of the groups obtained from the attitude towards physics scale; Paired-sample t-test was used to test the statistical significance of the difference between the pre-test and post-test attitude scores of the groups obtained from the attitude scale towards physics.

Findings

The first sub-problem of the research was "Is there a significant difference between the pre-test scores of the EG students who are taught through the virtual laboratory application and the CG students who are taught through the traditional laboratory method regarding the geometrical optics achievement?". As a result of the independent sample t-test done to find an answer to this problem, while the average of the pre-test geometrical optics achievement scores of the EG was 6.48, the average of the pre-test geometrical optics achievement scores of the CG was 6.43. This result shows that there was no significant difference between the prior knowledge of the two groups before the application (Table 1).

The second sub-problem of the research is "Is there a significant difference between the pre-test and post-test scores of the EG students taught through the virtual laboratory application regarding the geometrical optics achievement?". As a result of the dependent sample t-test done to find an answer to this problem, when the pre-test and post-test success score averages of the EG are examined, it is seen that the pre-test average is 6.48, and the post-test average is 13.79. This difference between the pre-test and post-test averages is statistically significant at the $p<.05$ level (Table 2). This finding shows that teaching through the virtual laboratory practice adopted in the EG has a positive effect on success.

The third sub-problem of the research is "Is there a significant difference between the pre-test and post-test scores of the CG students who are taught through the traditional laboratory method regarding the geometrical optics achievement?". As a result of the dependent sample t-test done to find an answer to this problem, when the pre-test and post-test success score averages of the CG are examined, it is seen that the pre-test average is 6.43, and the post-test average is 9.00. This difference between the pre-test and post-test averages is statistically significant at the $p<.05$ level (Table 3). This finding shows that teaching through the traditional laboratory practice adopted in the CG has a positive effect on success.

The fourth sub-problem of the research is "Is there a significant difference between the post-test scores of the EG students who are taught through the virtual laboratory application and the CG students who are taught through the traditional laboratory method regarding geometrical optics achievement?". As a result of the independent sample t-test done to find an answer to this problem, while the average of the EG's post-test geometrical optics achievement scores was 13.79, the average of the CG's post-test geometrical optical achievement scores was 6.43. This difference between the posttest averages of the two groups is statistically significant at the $p<.05$ level (Table 4). This result shows that teaching through virtual laboratory application is more effective in

Table 1: Comparison of Pre-Test Data on Geometrical Optics Achievement of EG and CG by Independent Sample t-test

Pre-test	*N*	*X ort*	*SS*	*Sd*	*t*	*p*	*Meaningfulness Level*
EG	29	6,48	2,760	57	,067	,947	p>.05 The Difference Matters
CG	30	6,43	2,909				

Table 2: Comparison of Pre-Test and Post-Test Data on Geometrical Optics Achievement of the EG by Dependent Sample t-test

Experimental Group (EG)	*N*	*X ort*	*SS*	*Sd*	*t*	*p*	*Meaningfulness Level*
Pre- test	29	6,48	2,760	28	-9,428	,000	p<.05 The Difference Matters
Post- test	29	13,79	4,716				

geometrical optics success than teaching through traditional laboratory method.

As a result of the analyzes, it has been shown that teaching through virtual laboratory application and traditional teaching both increase the success of Geometrical Optics at a statistically significant level (p<.05). However, it is seen that these increases in success are statistically higher in teaching through virtual laboratory application. The pre-test and post-test mean scores of the EG and CG regarding the Geometrical Optics achievement are given in Figure 3.

The fifth sub-problem of the research is "Is there a significant difference between the pre-test scores of students in the EG taught through the virtual laboratory application and the CG students taught through the traditional laboratory method regarding the attitude towards physics?". As a result of the independent sample t-test done to seek an answer to this problem, while the average of the pre-test attitude towards physics scores of the EG was 55.97, the average of the pre-test attitude towards physics scores of the CG was as 55.80. This result shows that there was no significant difference between the attitudes of the two groups towards physics before the practice (Table 5).

The sixth sub-problem of the research is "Is there a significant difference between the pre-test and post-test scores of the EG students who are taught through the virtual laboratory application regarding the attitude towards physics?". As a result of the dependent sample t-test done to find an answer to this problem, when the mean scores of attitude towards physics belonging to the pre-test and post-test are examine, it is seen that the pre-test average is 55.97 and the post-test average is 63.34. This difference between the pre-test and post-test averages is statistically significant at the p<.05 level (Table 6). This finding shows that teaching through the virtual laboratory practice adopted in the EG positively affects the attitude towards physics.

The seventh sub-problem of the research is "Is there a significant difference between the pre-test and post-test scores of the CG students who were taught through the traditional laboratory method regarding the attitude towards physics?". As a result of the dependent sample t-test done to find an answer to this problem, when the pre-test and post-test success score averages of the CG are examined, it is seen that the pre-test average is 55.80 and the post-test average is 62.47. This difference between the pre-test and post-test averages is

Table 3: Comparison of Pre-Test and Post-Test Data on Geometrical Optics Achievement of the CG by Dependent Sample t-test

Control Group (CG)	*N*	*X ort*	*SS*	*Sd*	*t*	*p*	*Meaningfulness Level*
Pre- test	30	6,43	2,909	29	-4,074	,000	p<.05 The Difference Matters
Post- test	30	9,00	3,464				

Table 4: Comparison of Post-Test Data on Geometrical Optics Achievement of EG and CG by Independent Sample t-test

Post test	*N*	*X ort*	*SS*	*Sd*	*t*	*p*	*Meaningfulness Level*
EG	29	13,79	4,716	57	4,460	,000	p<.05 The Difference Matters
CG	30	9,00	3,464				

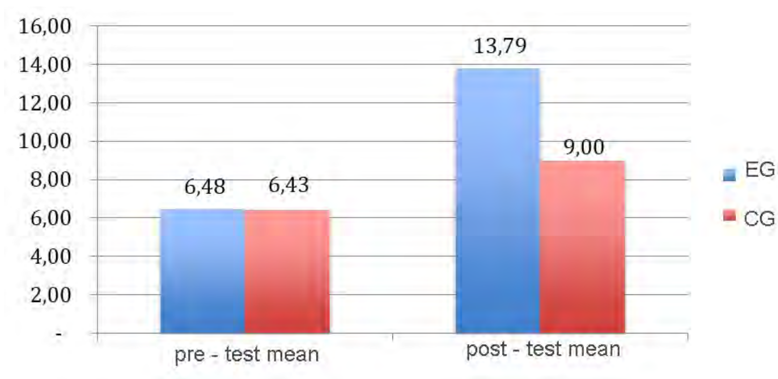

Fig. 3: Pre-test and post-test averages of EG and CG for Geometrical Optical Achievement

Table 5: Comparison of Pre-Test Data of EG and CG's Attitudes Towards Physics by Independent Sample t-test

Experimental Group (EG)	*N*	*X top*	*SS*	*Sd*	*t*	*p*	*Meaningfulnes Level*
Pre- test	29	55,97	12,146	28	-4,486	,000	p>.05 The Difference Matters
Post- test	29	63,34	11,343				

Table 6: Comparison of the EG's Pre-Test and Post-Test Data on Attitudes towards Physics by Dependent Sample t-test

Pre-test	*N*	*X top*	*SS*	*Sd*	*t*	*p*	*Meaningfulness Level*
EG	29	55,97	12,146	57	,047	,962	p>.05 The Difference Doesn't Matter
CG	30	55,80	14,587				

Table 7: Comparison of the CG's Pre-Test and Post-Test Data on Attitudes towards Physics by Dependent Sample t-test

Control Group (CG)	*N*	*X_{top}*	*SS*	*Sd*	*t*	*p*	*Meaningfulness Level*
Pre- test	30	55,80	14,587	29	-2,677	,012	p>.05 The Difference Matters
Post- test	30	62,47	13,059				

Table 8: Comparison of Post-Test Data on Attitudes to Physics of EG and CG by Independent Sample t-test

Post Test	N	X top	SS	Sd	t	p	Meaningfulness Level
EG	29	63,34	11,343	57	,275	,784	p>.05 The Difference Doesn't Matter
CG	30	62,47	13,059				

statistically significant at the p<.05 level (Table 7). This finding shows that the traditional laboratory practice adopted in the CG and teaching affect the attitude towards physics positively.

The eighth sub-problem of the study is "Is there a significant difference between the post-test scores of the EG students who are taught through the virtual laboratory application and the CG students who are taught through the traditional laboratory method regarding the attitudes towards physics?". As a result of the independent sample t-test done to seek an answer to this problem, while the average of the attitude towards physics post-test scores of the EG was 63.34, the average of the attitude to physics post-test scores of the CG was obtained as 62.47. This difference between the post-test averages of the two groups is not statistically significant at the p<.05 level. (Table 8). This result shows that teaching through virtual laboratory application has no effect on attitude towards physics compared to teaching through traditional laboratory method.

As a result of the analyzes, it is shown that teaching through virtual laboratory application and teaching through traditional laboratory method increase attitude towards physics at a statistically significant level (p<.05). However, the difference between these increases in attitude towards physics between the two groups is not statistically significant. In other words, it is seen that teaching through virtual laboratory application does not have a significant effect on attitude towards physics compared to teaching through traditional laboratory method. The pre-test and post-test mean scores of the EG and CG regarding attitudes towards physics are given in Figure 4.

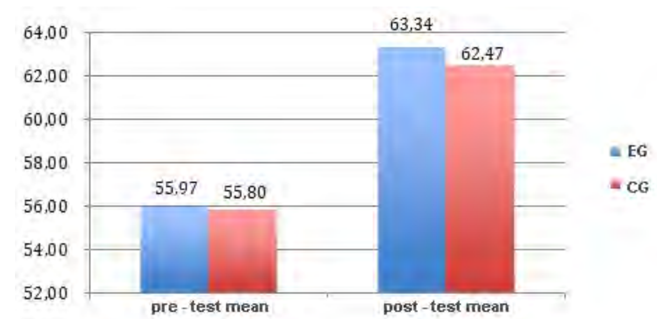

Figure 4: Pre-test and post-test averages of EG and CG for attitude towards physics

Discussion and Conclusion

Before the application, it was determined that there was no significant difference between the pre-test mean scores of the EG and CG, therefore, the groups were homogeneous in terms of their knowledge levels before the application. When the findings related to the effect of virtual laboratory applications on academic achievement in geometrical optics subjects were examined, it was seen that there was a higher increase in the academic achievement of the students in the EG in which simulation-supported virtual laboratory applications were applied, compared to the students in the CG in which the traditional method was used. The findings show that the simulation-based teaching environment is successful both visually and in terms of usability. Studies in the literature on the effectiveness of virtual laboratory applications in science/physics education also support this finding (Akçay et al., 2005; Akkağıt & Tekin, 2012; Bozkurt & Sarıkoç, 2008; Çinici et al., 2013; Emrahoğlu & Bülbül, 2010; Karamustafaoğlu, Aydın & Özmen, 2005; Kim, 2006; Ong & Manan, 2004; Wieman & Perkins, 2006).

During the experiments on geometrical optics in the virtual environment, the students made more applications in less time and learned by doing and experiencing. On the other hand, it enabled the reduction of the workload of the teacher, the elimination of the details about the subject and the giving of the desired message in a clear, concise and short way. As a matter of fact, it is stated in the literature that simulations are an effective teaching technique (Bozkurt & Sarıkoç, 2008; Emrahoğlu & Bülbül, 2010; Ong & Manan, 2004; Özdener, 2005).

Another finding obtained from the study shows that teaching through virtual laboratory application and teaching through traditional laboratory method increase students' attitudes towards physics at a statistically significant level. However, the difference between these increases in attitude towards physics between the two groups is not statistically significant. In other words, it is seen that teaching through virtual laboratory application does not have a significant effect on the attitude towards physics compared to teaching with the traditional method. This situation contradicts the finding obtained from Dinçer and Güçlü's (2013) study. In the related study, it was stated that the academic achievement, permanence and attitude levels of the students who were taught through simulation were higher than those who were taught through traditional methods.

It is a fact that there are some limitations as well as the benefits of virtual laboratory applications. It is emphasized in the literature that traditional laboratories allow students to feel like real scientists because they contribute to the development of students' psycho-motor skills, require attention in designing experiments and they make students wait for a certain time during data collection (Kapıcı & Akçay, 2019). It is also stated in the literature that virtual experiments do not fully reflect the complex structure of real events, and students do not find virtual environments that are not created with real tools or designed in a realistic way convincing enough (Couture, 2004). It is thought that all these reasons may be effective in the absence of a significant difference between the attitudes of the experimental group students and the control group students towards physics.

When all these results are evaluated, it can be said that simulation supported virtual laboratory applications are an effective teaching method that can be used while explaining geometrical optics subjects of Physics course. Therefore, virtual lab applications can be used normally, not just where traditional labs are limited. As a matter of fact, it is stated in the literature that the use of both laboratory environments together or sequentially gives better results than using a single laboratory (applied or virtual laboratory) (Kapıcı, Akçay & de Jong, 2019).

References

Akçay, S., Aydoğdu, M., Yıldırım, H., & Şensoy, Ö. (2005). Fen eğitiminde ilköğretim 6. sınıflarda çiçekli bitkiler konusunun öğretiminde bilgisayar destekli öğretimin öğrenci başarısına etkisi. *Kastamonu Eğitim Dergisi, 1*(13), 103-116.

Akdeniz, A., Yıldız, İ., & Yiğit, N. (2001). İlköğretim 6. sınıf öğrencilerinin ışık ünitesindeki kavram yanılgıları. Çukurova Üniversitesi *Eğitim Fakültesi Dergisi, 20*, 72-78.

Akın, E., & Karaköse, M. (2003). Elektrik ve bilgisayar mühendisliği eğitiminde sanal laboratuvarların kullanımı. Elektrik-Elektronik-Bilgisayar Mühendislikleri Eğitimi 1. Ulusal Sempozyumu, Ankara, Türkiye, 166-169.

Akkağıt, Ş.F. & Tekin, A. (2012). Simülasyon Tabanlı Öğrenmenin Ortaöğretim Öğrencilerinin Temel Elektronik ve Ölçme dersindeki Başarılarına Etkisi. *Ege Eğitim Dergisi, 2012(*13)2: 1-12.

Alkan, C., Çilenti, K. & Özçelik, D. (1991). *Kimya* öğretimi. Eskişehir: Anadolu Üniversitesi Yayınları.

Aydın, S. & Öztekin, S. (2018). Üç aşamalı tanı testi ile fen lisesi öğrencilerinin geometrik optik konusundaki zihinsel modellerin belirlenmesi. *Uluslararası Eğitim Bilim ve Teknoloji Dergisi, 4*(3), 155-172.

Bozkurt, E. & Sarıkoç, A. (2008). Fizik eğitiminde sanal laboratuvar, geleneksel laboratuvarın yerini tutabilir mi? *Selçuk* Üniversitesi *Ahmet Keleşoğlu Eğitim Fakültesi Dergisi, 2008*(25), 89-100.

Büyükkara, S. (2011). İlköğretim 8. sınıf fen ve teknoloji dersi ses ünitesinin bilgisayar simülasyonları ve animasyonları ile öğretiminin öğrenci başarısı ve tutumu üzerine etkisi. (Yayınlanmamış yüksek lisans tezi). Selçuk Üniversitesi Eğitim Bilimleri Enstitüsü, Konya.

Ceylan, E. & Saygıner, Ş. (2017 Ekim). Fen ve Matematik Eğitiminde Geleneksel Laboratuvar Uygulamalarına Alternatif: PhET Simülasyonları. Uluslararası Eğitim Bilimleri Sempozyumu, 27-28 Ekim, Sivas.

Couture, M. (2004). Realism in the design process and credibility of a simulation-based virtual laboratory. *Journal of Computer Assisted Learning, 20*(1), 40-49.

Çepni, S., Akdeniz, A.R. & Ayas, A. (1995). Fen bilimlerinde laboratuvarın yeri ve önemi (III): Ülkemizde laboratuvar kullanımı ve bazı öneriler. Çağdaş *Eğitim Dergisi, 206*, 28-34.

Çepni, S., Kaya, A., & Küçük, M. (2005). Fizik öğretmenlerinin laboratuvarlara yönelik hizmet içi ihtiyaçlarının belirlenmesi. Türk Eğitim Bilimleri Dergisi, 3(2), 181-196.

Christian, W., & Lee, M. (2011). Optics Bench JS [Computer software]. Retrieved March 19, 2022, from https://www.compadre.org/Repository/document/ServeFile.cfm?ID=15324

Çinici, A., Özden, M., Akgün, A., Ekici, M., & Yalçın, H. (2013). Sanal ve geleneksel laboratuvar uygulamalarının 5. sınıf öğrencilerinin ışık ve ses ünitesiyle ilgili başarıları üzerine etkisinin karşılaştırılması. *Bayburt* Üniversitesi *Eğitim Fakültesi Dergisi, 8*(2), 92-106.

Dağdalan, G. & Taş, E. (2017). Simülasyon destekli fen öğretiminin öğrencilerin başarısına ve bilgisayar destekli fen öğretimine yönelik tutumlarına etkisi. *Fen Bilimleri* Öğretimi *Dergisi, 5*(2), 160-172.

Demirel, Ö. (2001). Öğretim *teknolojileri ve materyal geliştirme*. Ankara: Pegem Yayıncılık.

Dinçer, S. & Güçlü, N. (2013). Fen bilgisi eğitiminde bilgisayar destekli simülasyon kullanımının etkililiği ve yeni yönelimler: Bir meta-sentez çalışması. *International Journal of Human Sciences, 10*, 35-48.

Ekici, M. (2015). Fen bilimleri öğretmenlerinin sanal laboratuvar hakkındaki görüşleri ve bu yöntemden faydalanma düzeyleri. Yayınlanmamış Yüksek Lisans Tezi. Adıyaman Üniversitesi Fen Bilimleri Enstitüsü, Adıyaman.

Emrahoğlu, N. & Bülbül, O. (2010). 9. sınıf fizik dersi optik ünitesinin bilgisayar destekli öğretiminde kullanılan animasyonların ve simülasyonların akademik başarıya ve akılda kalıcılığa etkisinin incelenmesi. Ç Ü. *Sosyal Bilimler Enstitüsü Dergisi, 19*(3), 409-422.

Galili, I. & Hazan, A. (2000). Learners' knowledge in optics: interpretation, structure and analysis. *International Journal of Science Education, 22*(1), 57-88.

Heywood, D.S. (2005). Primary trainee teachers' learning and teaching about light: Some pedagogic implications for initial teacher training. *International Journal of Science Education, 27*(12), 1447-1475.

Hwang F.K. (2004). Thin Lens (converging/diverging lens/ mirrors) [Computer software]. Retrieved March 19, 2022, from: https://www.phy.ntnu.edu.tw/ntnujava/index.php?topic =48.0

Kapıcı, H.Ö. & Akçay, H. (2019). Fen eğitiminde sanal laboratuvarlar. B. Akçay (Ed.), Fen öğrenme ve öğretim yaklaşımları içinde (331-345. ss.). Ankara: Nobel Akademi.

Kapıcı, H.Ö., Akçay, H., & de Jong, T. (2019). Using hands-on and virtual laboratories alone or together-which Works better for knowledge acquistion and skills? *Journal of Science Education and Technology, 28*, 231-250.

Karamustafaoğlu, O., Aydın, M., & Özmen, Ö. (2005). Bilgisayar destekli fizik etkinliklerinin öğrenci kazanımlarına etkisi: Basit harmonik hareket örneği. *The Turkish Online Journal of Educational Technology, 4*(4), 67-81.

Karasar, N. (2005). *Araştırmalarda rapor hazırlama* (13. Baskı). Ankara: Nobel Yayın Dağıtım.

Keçeci, G., Yıldız, S. & Kurbağ-Zengin, F. (2016, 6-8 Ekim). Dengeli beslenme konusunun ilkokul 4. Sınıf öğrencilerine simülasyon uygulamalarıyla öğretimi. 4th International Instructional Technolgies Teacher Education Symposium (ITTES), Fırat Üniversitesi, Elazığ.

Kim, P. (2006). Effecets of 3D virtual reality of plate tectonics on fifth grade students' achievement attitude toward science. *Interactive Learning Envieronments, 14*(1), 25-34.

Ong, S. & Manan, M. (2004). Virtual reality simulations and animations in a web-based interactive manifacturing engineering modüle. *Computers & Education, 43*(4), 361-382.

Pena, E.M. & Quilez, M.J.G. (2001). The importance of images in astronomy education. *International Journal of Science Education, 23,* 1125-1135.

Sarabando, C., Cravino, J.P., & Soares, A.A. (2014). Contribution of a computer simulation to students' learning of the physics concepts of weight and mass. Procedia Technolgy, 13, 112-121.

Sönmez, E., Dilber, R., Karaman, İ., & Şimşek, D. (2005). Fizik laboratuarında kullanılan deney malzemeleri üzerine bir çalışma. *Kâzım Karabekir Eğitim Fakültesi Dergisi, 11*, 590-604.

Tankut, Ü.S. (2008). İlköğretim 7. Sınıf Sosyal Bilgiler Dersinde Bilgisayar Destekli Öğretimin Akademik Başarıya ve Kalıcılığa Etkisi. (Yayımlanmamış yüksek lisans tezi). Çukurova Üniversitesi Sosyal Bilimler Enstitüsü, Adana.

Tatlı, Z. ve Ayas, A. (2011, Ekim). Sanal kimya laboratuarı geliştirilme süreci. International Computer & Instructional Technologies Symposium, Elazığ-Turkey.

Taşlıdere, E. (2013). Kavram karikatürleri ile zenginleştirilmiş çalışma yapraklarının öğrencilerin geometrik optuk konusundaki kavramsal anlamalarına etkisi. *Eğitim ve Bilim, 38*(167), 144-161.

Uğur, A. (2001). Eğitimde bilgisayar grafikleri ve grafik yazılımları. *Ege Eğitim Dergisi, 2011*(1), 1: 146-156.

Wieman, C.E. & Perkins, K.K. (2006). A powerful tool for teaching science. *Nature Physics, 2*, 290-292.

Yılmaz, M. V& Eren, A. (2014). Sınıf öğretmen adaylarına basit elektrik devreleri konusunun simülasyon ve laboratuvar uygulamaları teknikleriyle öğretimi. Trakya Üniversitesi Eğitim Fakültesi Dergisi, 4(2), 84-99.

Yolaş-Kolçak, D., Moğol, S. & Ünsal, Y. (2014). Fizik öğretiminde kavram yanılgılarının giderilmesine ilişkin laboratuvar yöntemi ile bilgisayar simülasyonlarının etkilerinin karşılaştırılması. Eğitim ve Bilim, 39(175), 154-171.