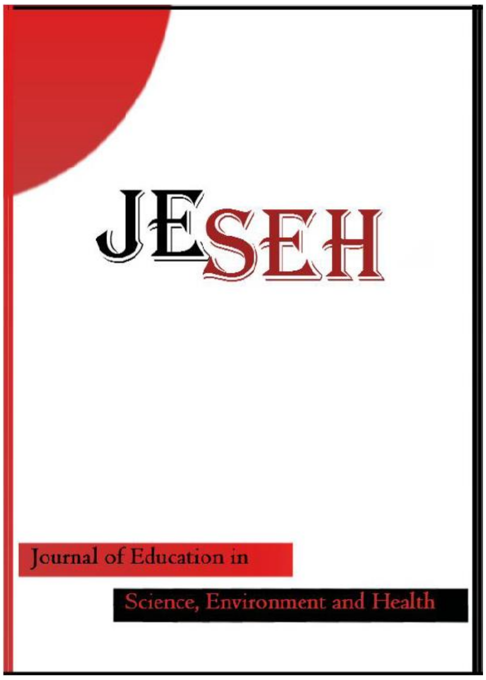

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The Effect of Virtual Laboratory Applications on 8th Grade Students' Achievement in Science Lesson

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Abstract

The aim of this study is to reveal the effect of using virtual lab application in science teaching on students' academic achievement and students' views on virtual lab application. The study group of the research consists of 62 students studying in the 8th grade of a secondary school in Antalya in the 2019-2020 academic years. Mixed method design was used in the research. In the quantitative dimension of the study, the control group and the experimental group taught with virtual laboratory applications were compared in terms of achievement. The qualitative dimension of the study was composed of the data obtained from the interview forms conducted with the experimental group students after the application and the data obtained from the observation forms made during the application. Research results revealed that virtual laboratory applications increased the academic success of the experimental group students. On the other hand, it has been shown that virtual laboratory applications contribute to students' meaningful learning by enabling the concretization of abstract subjects, and that these applications positively support students' interest, excitement and motivation towards the science course because they are found attractive.

Introduction

The age of information and technology, in which we live in, affects societies on the basis of all sectors from production areas to consumption areas and contributes to the development of societies along with the globalizing world. Thanks to the scientific developments, developments in education and educational technologies have become a part of modern education approach (Karasar, 2012). The use of developing technological applications in obtaining scientific knowledge also affects learning-teaching methods and strategies (Say & Pan, 2017). For this reason, technology-based teaching methods are used instead of the traditional teaching methods used today during the learning-teaching process. This situation is an indicator of the progress experienced in the field of education (Ekici et al., 2007).

The innovations and developments in education aim to simplify the concepts that seem complicated in education and to achieve permanent learning by doing, in accordance with the constructivist approach (Tekdal, 2010). With the development of technology, it has become necessary to use multimedia supported teaching activities that can activate the cognitive, affective and psychomotor structures of students in learning environments (Harwood & McMahon, 1997). Therefore, ensuring that the classroom environments are updated in accordance with technology so that students who actively use technology in daily life do not break away from education and training will ensure that the education and training process that will take place is up-to-date and more effective (Kaya & Aydın, 2011). When the literature is reviewed, it is possible to say that technology-supported educational researches using technology in education are gathered under certain headings. We see that one of them is computer-aided education, in which learning outcomes are given to learners using computers, and the other is simulations specific to gains developed with applications such as Java and Macromedia Flash (Duman & Avcı, 2016). Apart from these two applications, another technological tool used is virtual laboratories where students can perform their experiments by following the instructions given to them, just like in a real laboratory. In virtual laboratories, different from computer aided applications and simulations, it is possible to design virtual experiments suitable for many achievements in science education (Duman & Avcı, 2016).

Many definitions have been made for virtual experiments in the literature. Virtual experiments are defined as computer software for learning / teaching that enable learners to make scientific inquiries with a virtual experiment setup prepared with virtual laboratory materials (Özdemir, 2019). De Jong et al. (2013) describe the virtual experiment as a computer software in which observations or measurements are carried out with simulated laboratory materials, on the other hand, Yi et al. (2005) define the virtual experiment as a visual learning environment where the learners use virtual objects representing the experimental materials through the use of mouse and keyboard on the computer. Thanks to the developments in information technologies, it is possible to conduct experiments in virtual laboratories that can achieve results with realistic accuracy in a virtual environment with prepared simulation software. Virtual laboratories where simulation software is used are a new technology that is used with a focus on education where theoretical knowledge can be transformed into practice (Tatlı & Ayas, 2011).

The simulation software used in virtual laboratories is a teaching method in which the student can change the parameters of the experiment and perform the experiments exactly. It is seen in the literature that virtual experiments have contributed to science education, especially physics and chemistry education. There is a certain period of time for the experiments performed in the traditional laboratory, during which the student has to complete the experiment. However, since there is no such time shortage in virtual experiments, students can be more comfortable in designing experiments, analyzing the results and interpreting them (Bell, 1999; Finkelstein et al., 2005). Özdemir (2019) has developed a virtual experiment to be used in the discovery of the electron and teaching the Thomson Atom Model based on experimental findings and questioning. In the study, which was not intended to examine the students 'thoughts about this virtual experiment, it was concluded that this virtual experiment contributed to the students' understanding of the Thomson atomic model, and on the other hand, it was understood that the students thought that the virtual experiment made modern physics subjects, which they found complex and abstract, understandable by simplifying and concretizing. Again, as a result of the studies by Duman and Avcı (2016) that they used laboratory applications suitable for the gains in the “States of Matter and Heat” unit of the 8th grade science lesson, it was seen that virtual laboratory applications were more effective in student achievement and in ensuring the permanence of the knowledge learned compared to the traditional teaching approach.

When the studies on the use of virtual laboratory applications in education are examined, while it is observed that these applications have contributed positively to the academic success of students (Tekdal, 2002; Kici & Sof, 2005; Qing Yu et al. 2005; Domingues et al., 2010; Chen, 2010; Duman & Avcı.2016; Özdemir, 2019), increased students’ motivation for the lesson (Arjamand & Khattak, 2013; Stefanovic, 2013) and made individual experiments possible for students unlike some real experiments which cannot be done individually and pose danger (Bozkurt & Sarıkoç, 2008), it is also seen that they provide the opportunity to carry out dangerous and costly experiments under laboratory conditions without danger and at much less cost (Bozkurt & Sarıkoç, 2008; dos Santos et al., 2010; Tankut, 2008: Tekdal, 2002).

The purpose and importance of the research

Today, rapid developments in hardware and software in computer systems have made the use of graphics important in education. The software used in education is so developed that the information that is difficult to obtain in the real world with simulations are obtained easily in a high quality, cheap and fast manner (Uğur, 2001). Virtual laboratories with simulation software on the basis are a new technology that is used for education, where theoretical knowledge is transformed into practice (Tatlı & Ayas, 2011). With this new technology, it is possible for every student to learn by doing and living by making experiments which cannot be done due to the hardware deficiencies such as lack of laboratories or materials in school or their difficulty or danger of being implemented in real life, easily and economically and also in a shorter time.

In this study, a virtual laboratory application was carried out within the scope of the science lesson in order to increase the quality of the students' learning process and their interest in learning science. It is thought that the teaching-learning process of a subject within the scope of science lesson with virtual experiment increases the importance of this study in terms of science education. In this study, it was aimed that students discover the variables that affect solid, liquid and gas pressure by experimenting with virtual laboratory application and analyze the relationship between these variables. In line with this goal, it was aimed to determine how virtual experiments supported by the 8th grade science lesson pressure unit virtual laboratory technology affect students' academic achievements and their interests and motivations towards science learning. For this purpose, answers to the following questions were sought:

1. Is there a significant difference between the pre-test scores of the experimental group in which the virtual laboratory method was applied and the control group where the science curriculum prescribed method is applied?

2. Is there a significant difference between the post-test scores of the experimental group in which the virtual laboratory method was applied and the control group to which the science curriculum prescribed method is applied?
3. What are the opinions of the students in the experimental group about the application of the virtual labs method?

Method

Research Model

In this research, mixed method research design was used. Mixed method research offers researchers an alternative approach in reaching the goals of "depth and detail", which are the weaknesses of quantitative research methods, and "generalization and prediction" for which qualitative research methods are weak (Yıldırım & Şimşek, 2013). The mixed research method design allows researchers to use both qualitative and quantitative approaches / methods in a single study (Cresswell & PlanoClark, 2014). In this study, the convergent parallel design, one of the mixed method research designs, is used. In this research design, qualitative and quantitative data, which are equally important, are collected together and analyzed separately. In the last context, similarities and differences between quantitative and qualitative findings are compared and interpreted. In this way, efforts are made to achieve much better results (Creswell & Plano Clark, 2014).

In order to compare the academic achievements of the students in the experimental group in which the virtual laboratory application was used in the science course teaching and the preferred control group students of the science curriculum prescribed methods, an experimental with pretest-posttest control group was chosen.

Table 1: Research pattern

Groups	Before Application	Method of Application	After Application
Experiment	Pre-Test (Test1)	Virtual Laboratory	*Post-Test (Test1) *Interview Form
Control	Pre-Test (Test1)	The science curriculum prescribed methods	*Post-Test (Test1)

In order to support the quantitative data of the study, the opinions of the students in the experimental group about the virtual laboratory application were taken and the qualitative documents created during the application process were used.

Study Group

The study group of the research consists of 8th grade students studying at a secondary school in Antalya in the 2019-2020 academic years. A total of 62 students, 31 in the experimental group and 31 in the control group, participated in the study. Groups were appointed through unbiased election.

Table 2. Number of students participating in the study

Groups	Female	Male	Total
Control Group	14	17	31
Experiment Group	11	20	31
Total	25	37	62

The process of performing experimental procedures

This research was conducted with 8th grade students in a secondary school in Antalya. After determining the subject (pressure) to be used in the experimental process of the study, the virtual laboratory application to be used regarding the subject was determined and the virtual experiments to be used during the application were determined from the Education Information Network (EBA) and the Phet web page. Before the application, the students in the experimental group were informed about the virtual laboratory application. The application process was carried out by the same teacher in the experimental and control groups. In addition, 3 pre-service science teachers took part in the application process as observers. While the same subjects were taught by making virtual experiments in the experimental group, the control group was taught on a textbook basis. During the three-week unit in the experimental group, virtual experiment applications were given at appropriate places. The photographs taken during the virtual laboratory application to the experimental group are shown in Figure 1.

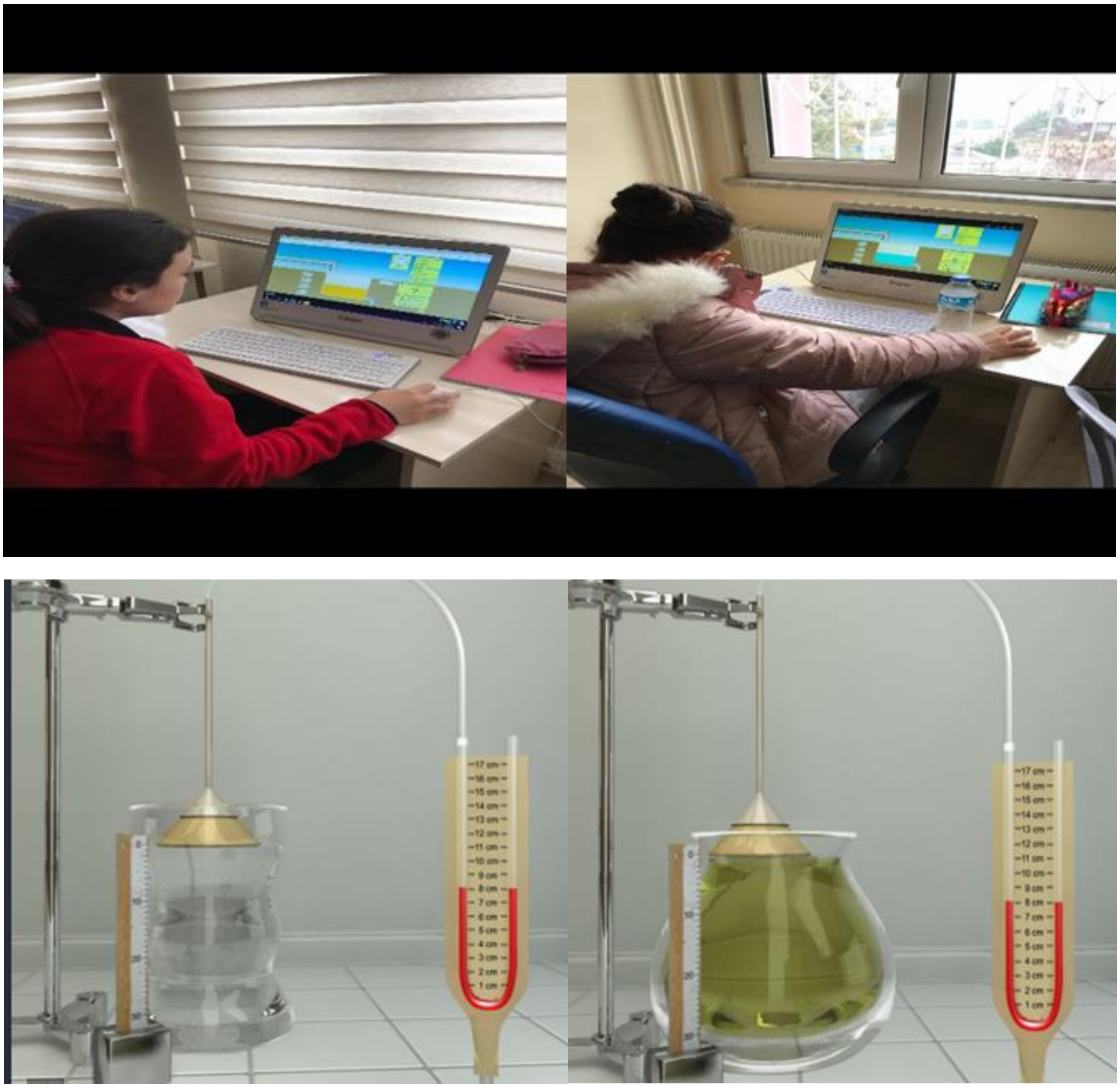

Figure 1. Examples of the applications made by the experimental group students

Reliability and Validity of Data Collection Tools

In the study, the achievement test prepared for the pressure unit in the science lesson, semi-structured student interview form containing student views about the application, and observer diaries were used as data collection tools.

Achievement Test

In the research, multiple choice test including 20 questions was prepared to cover all the gains of the 8th class pressure unit in order to apply it to the experimental and control groups as a data collection tool. In terms of the adequacy of the test questions in measuring the unit gains, whether there were scientific errors, and the comprehensibility of the questions as language, a total of five experts, two science educators, three science teachers, were consulted. The questions were revised in line with the opinions of the experts. The final version of the achievement test was solved by three 9th grade students and feedback was received from the students about whether they understood the questions, and according to the feedback received, very small revisions were made in the test and the achievement test was finalized. The final version of the test was applied to 200 ninth grade students at another school. The KR-20 reliability coefficient of the success test was found to be 0.86.

Interview Form

In the research, interview questions consisting of open-ended questions were prepared by reviewing the relevant literature in order to learn the thoughts of the experimental group students. The interview form prepared was evaluated by two field experts and revised according to the feedback received from them. In order to determine the comprehensibility of the questions in the form, three seventh grade students were asked, and the questions were finalized according to the feedback received. The questions in the interview form were directed to the students in the experimental group.

Observation Form

During this application, an observation form drawing attention to the basic points of the application was prepared for the prospective science teachers who go to schools to make observations. In the light of the items in this form, the prospective teachers were asked to make observations by taking into account the main headings of the virtual laboratory practice, students' interest in the lesson, the course teacher's process of realizing the virtual lab application, and to write their observations under the relevant item in the form.

Data Collection Process

Before the application, an achievement test was prepared to cover the acquisitions in the curriculum on the subject of Pressure and to suit the levels of the students. The achievement test was applied as a pre-test to the students in the experimental and control groups before the research. The achievement test, which was prepared after the lessons with the science curriculum prescribed methods, was applied to the experimental group students with virtual laboratory applications and the students in the control group as a post test. In order to support the quantitative data, the opinions of the teacher of the lesson and the students in the experimental group about the virtual laboratory application were taken, and the observations of the pre-service teachers were used during the process.

Analysis of Data

Analysis of Quantitative Data

Quantitative data were obtained with the success test prepared on the subject in the study. The data of the research were analyzed by t test.

Analysis of Qualitative Data

Descriptive analysis and content analysis techniques were used to analyze the qualitative findings of the research. The main framework for the qualitative data to be collected in the descriptive analysis was determined depending on the research problem, and after making relevant inferences from the data, direct quotations were made from the interview and observation data. Inference from the data collected during the descriptive analysis phase was supported by direct quotations. In the content analysis phase, the qualitative data collected were collected under certain categories. At this stage, the main themes that were determined based on the categories for qualitative analysis were included. Analyzes were made under these main themes, and the analyzes were supported with the quotations obtained in the descriptive analysis (Yıldırım & Şimşek, 2013).

Findings

In this section, quantitative and qualitative findings will be given under separate headings.

Quantitative Findings

According to Table 3, it is seen that the mean score of the experimental group students is 37.25, while the control group students is 33.54. Independent t-test was used to compare the pretest scores of the groups. There was no significant difference between the pretest mean scores of the groups (p> 0.05).

Table 3. Comparison of experimental and control group pretest scores

Groups	N	Mean	Sd	t	p
Experiment_pre-test	31	37,25	12,09	1,131	0,263
Control_pre-test	31	33,54	13,67		

After the application, the academic achievement test was applied to the control and experimental groups as a post-test. Analysis results of the posttest results of the groups are given below.

Table 4. Comparison of experimental and control group posttest scores

Groups	N	Mean	Sd	t	p
Experiment_post-test	31	62,90	16,62	3,236	0,002
Control_post-test	31	48,70	17,88		

According to the data of Table 4, it is seen that the mean score of the experimental group students is 62.90 and the control group students is 48.70. Independent t-test was used to compare the posttest scores of the groups. There was a statistically significant difference between the posttest mean scores of the groups (p< 0.05).

Qualitative Findings

After analyzing qualitative data through content analysis, two main themes were determined. These themes are: the effect of virtual lab application on cognitive domain and the effect of virtual lab application on affective domain. These two main themes are categorized as 1-Cognitive Domain 2-Affective domain. Other determined sub-themes are presented in paragraphs within these main themes.

Cognitive Domain

The cognitive domain theme contains findings that support the quantitative findings of the research. The findings on the quantitative dimension show that the virtual laboratory application positively affects the learning of the students in the cognitive field. Qualitative findings obtained in our study also support this result. From the data collected in this section, it is revealed that the virtual laboratory application 1-) concretizes abstract subjects, 2-) provides meaningful learning.

Abstract-Concrete

In the virtual lab application, the students discovered the variables that affect the fluid pressure by experimenting. During these trials, the students also used their scientific process skills. By changing the independent variable, they observed its effect on the dependent variable. Meanwhile, they expressed the variables that should be kept constant as the controlled variable and kept it constant. The students' designing their own experiments led them to see that an abstract concept became concrete and their learning became easier. Figure 2 shows the virtual laboratory application that students have created to observe the variables affecting fluid pressure. The opinion of Student 1 on this subject is given below.

> Student 1:…with the experiment we conducted in the virtual laboratory in the lesson, I have experimented and observed the factors affecting fluid pressure by changing the type and depth of the fluid. The computer screen comes to life right now. I think I learned very well as I learned the fluid pressure issue on the computer myself. I have never touched the liquid, but I still learned the fluid pressure.

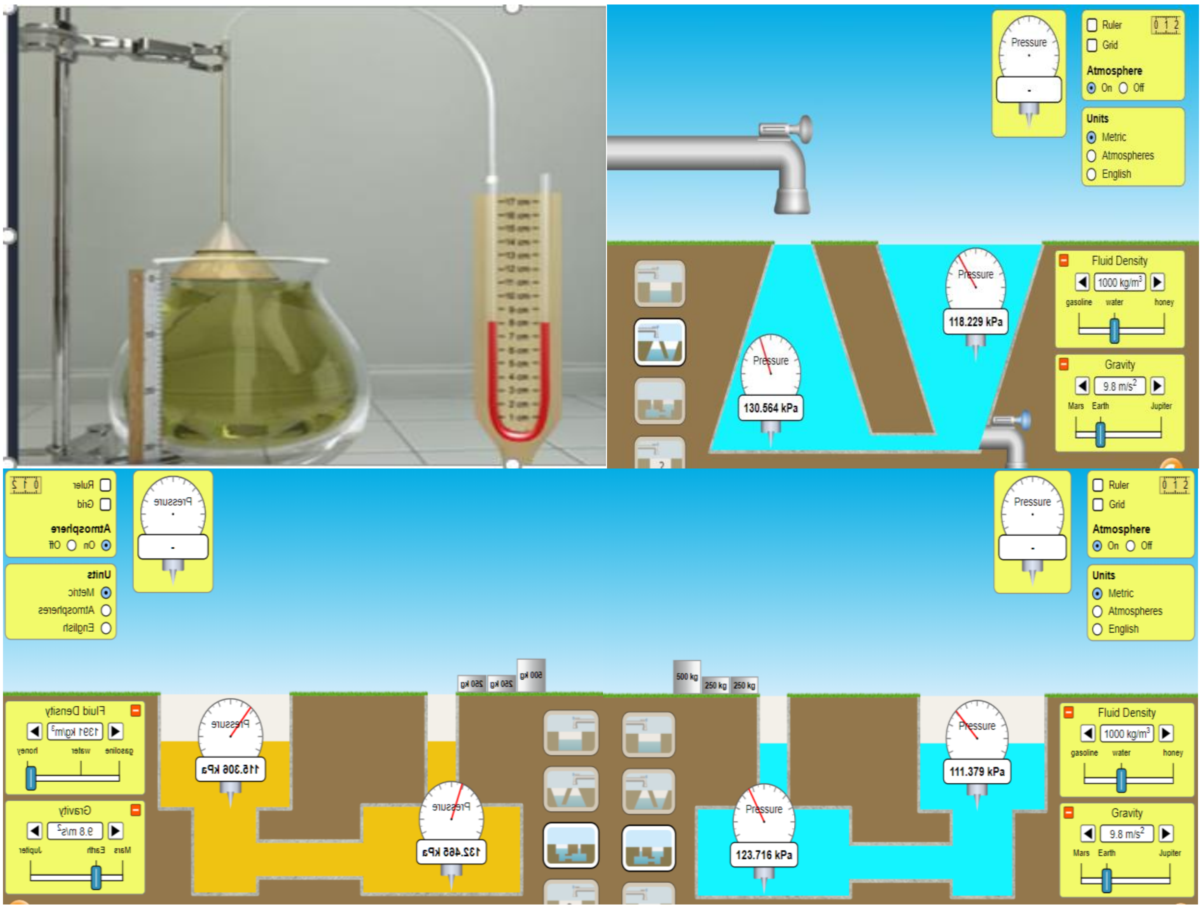

Figure 2. Screenshots of one of the experimental group students showing the variables that determine fluid pressure.

Observer A's notes on this subject also support this finding.

> Observer A:… the students were thrilled that they were going to design a virtual experiment in the virtual lab application. All had curious looks in their eyes. When I started practicing the experiment, the lesson became very enjoyable. All of them took notes by experimenting in virtual experiments on their computers. In this lesson, the teacher posed questions measuring whether liquid and solid pressure had been learned. All of the students who took the floor gave correct answers to the teacher's questions. (05.11.2019).

Meaningful learning

It is seen that the students' conducting the learning process with the virtual laboratory enables them to learn meaningfully the effect of the factors affecting the pressure, especially the solid and liquid pressure, which is an abstract topic. The experimental group students found themselves successful in solving the questions about the pressure unit in other tests, apart from the post-test application. They were able to adapt what they learned to other problem situations they encountered. The opinion of Student 2 on this issue is given below.

> Student 2:… I knew the factors that affect the pressure, but this knowledge was merely memorization. However, I understood the subject better by practicing with virtual experiments, for example by trying the effect of changing the type of fluid and seeing the result.

> Student 3:… I think I learned well by really understanding the subject. The teacher's lesson was much more enjoyable with these experiments.

Observation notes of Observer B also support these findings.

> Observer B:… After the virtual laboratory practice, the students were very successful in answering the questions asked by the teacher. We can say that the application made contributes to students' meaningful learning (08.11.2019).

Affective Domain

Virtual laboratory applications increased students' motivation and increased their interest in science lesson. The opinions of Students 4, 5 and 6 on this issue are given below.

> Student 4:… I would love to do virtual experiments in other units this year as well. With virtual experiment applications, the lessons are more fun and enjoyable.
>
> Student 5: ... this activity was very nice, I think we both had fun and followed the lessons with pleasure.
>
> Student 6:… I had never seen virtual lab experiments before. An app that was interesting and made us learn better, I was looking forward to the day of science lesson.

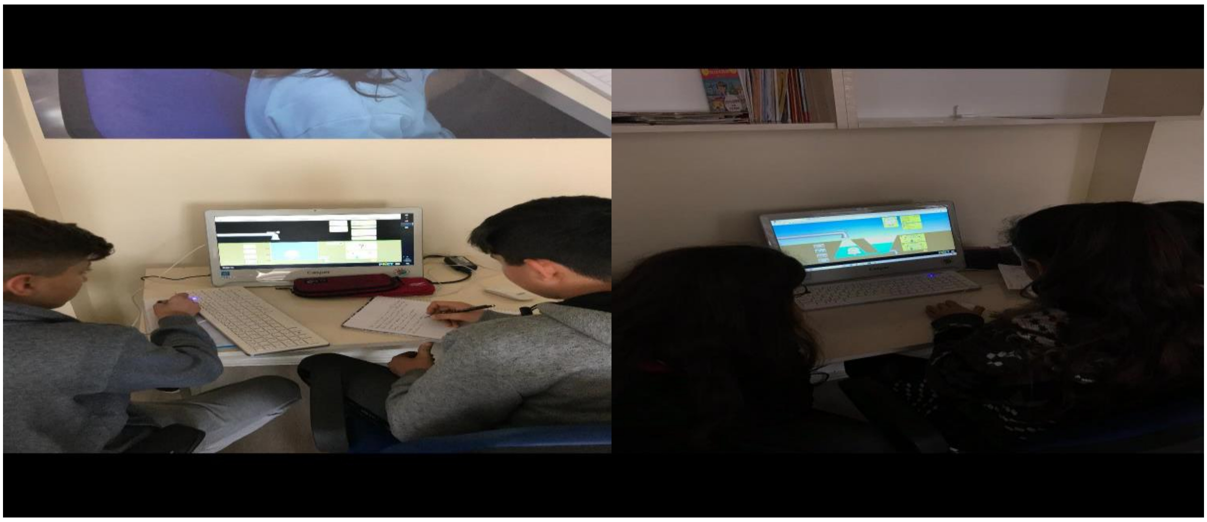

Figure3. Examples showing students' interest in virtual lab application

Observation notes of Observers A and B also support these findings.

> Observer A:… the students are very excited before the lesson starts and look forward to the start of the lesson as soon as possible. It is impossible not to see the effect of the last lesson. (12.11.2019).
>
> Observer B:… the students are so focused on the computers that one is in the virtual experiment that changes variables while the other records the results. They draw conclusions by making comments between them. (15.11.2019).

Discussion

In this study, it has been shown that virtual laboratory applications increase the academic success of students. This result of the study supports the conclusion of Duman and Avcı (2016) that the virtual laboratory applications applied to the experimental group students during the teaching of the "States of Matter and Heat" unit in the 8th grade science lesson have a positive effect on the academic success of the student and the retention of the learned information. At the same time, this result of the research coincides with the results of other studies in the literature (Bozkurt & Sarıkoç, 2008; Chang, 2000; Çömek, 2003; Kolomuç, 2009; Karagöz et al., 2016; Olgun, 2006; Özdemir, 2019). It also supports the results of the studies that show that students learn more easily and better in the teaching-learning process, which is supported by virtual experiment applications that emerged in these studies.

Another result of the study was that virtual laboratory applications enabled students to learn by embodying abstract subjects. In Özdemir's (2019) study of "Use of virtual experiments as learning activity in modern physics course: A case of cathode ray tube experiment" with science undergraduate students, it is understood that virtual experiment applications allow effective learning and by simplifying and concretizing the complex and abstract physics concepts of virtual experiments. The inference of Özdemir (2019) is similar to the result that the virtual laboratory applications emerging in this study contribute to the meaningful learning of abstract subjects.

Another result determined as a result of the research is that virtual laboratory applications increase students' interest and motivation to science lesson. Studies in the literature show that similar to the results of this research, in learning environments organized with virtual laboratory applications, students are more interested, curious and excited in the learning process, and students have positive opinions against virtual laboratory applications (Arvind & Heard 2010; Bozkurt & Sarıkoç, 2008 Ceylan & Seçken, 2019; Duman & Avcı 2016; Mırçık & Saka, 2016; Aşıksoy & Islek, 2017; Sarı et al. 2019).

Conclusion and Recommendations

When the quantitative and qualitative data of the research are evaluated together, it is seen that the virtual laboratory application contributes positively to the academic success of the students. In addition to the statistical results of the research data, the qualitative findings obtained in the study show that the educational process carried out with virtual laboratory applications contributes to students' learning by concretizing abstract subjects. In this case, it shows that it is possible for students to learn an abstract subject meaningfully with the virtual laboratory. Another conclusion that can be drawn in the light of the qualitative findings obtained in the study is that the virtual laboratory application increased the interest, curiosity and motivation of the students in science class. Other researchers can develop virtual versions of existing experiments in the fields of physics, chemistry, and biology in science education at different educational levels and investigate the effects of these experiments on students' learning. In order to popularize the use of virtual laboratory applications, courses and seminars can be organized within the scope of in-service training for teachers to prepare and use these applications.

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