INVESTIGATING THE PERCEPTIONS OF UNIVERSITY STUDENTS AND FACULTY ABOUT VIRTUAL PHYSICS AND CHEMISTRY LABORATORY ACTIVITIES

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

HİLAL GÜLER

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
COMPUTER EDUCATION AND INSTRUCTIONAL TECHNOLOGY

FEBRUARY 2022

Approval of the thesis:

INVESTIGATING THE PERCEPTIONS OF UNIVERSITY STUDENTS AND FACULTY ABOUT VIRTUAL PHYSICS AND CHEMISTRY LABORATORY ACTIVITIES

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ABSTRACT

INVESTIGATING THE PERCEPTIONS OF UNIVERSITY STUDENTS AND FACULTY ABOUT VIRTUAL PHYSICS AND CHEMISTRY LABORATORY ACTIVITIES

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February 2022, 97 pages

This study aims to investigate the perceptions of university students and faculty about virtual chemistry and physics laboratory activities. The study was carried out in the 2020-2021 academic year with students and faculty members who were registered to general chemistry and general physics courses in 18 different universities in different parts of Turkey. Participants of the study attended virtual laboratory activities on weekly basis as a mandatory part of their courses during the fall and spring semesters of 2020-2021 academic year. At the end of each semester, the perceptions of the participants were collected through questionnaires containing three choice questions and open-ended questions. The total number of students who voluntarily participated in the study were 88 and the number of faculty members was four. The data collected from the participants by using open-ended questions were analyzed by content analysis and presented under the headings of advantages and disadvantages by thematization. The data on the results of the three-choice questions were presented in a table with frequencies and percentages. The number of positive and negative opinions was almost the same. While there were participants who expressed negative opinions, there were also participants who expressed positive opinions, because they could do the experiments even during the pandemic period. Participants reported positive opinions with 128 frequencies in different categories and negative opinions with 112 frequencies in different categories. Almost half of the participants (47,1%) think that virtual laboratory was effective. 88.9 % of the participants stated that if they had to make a choice, they would prefer the physical laboratory even if 54% of them have no physical laboratory experience before. 42,9% of the students think that they have learned experiments when conducting experiments in virtual laboratories. The results of the current study can shed light to design, development and implementation of more effective and efficient virtual laboratory applications.

Keywords: Virtual laboratory, Chemistry laboratory, Physics laboratory, Student perceptions, Faculty perceptions, Science teaching

ÖZ

ÜNİVERSİTE ÖĞRENCİLERİNİN VE ÖĞRETİM ÜYELERİNİN SANAL KİMYA VE FİZİK LABORATUVARI ETKİNLİKLERİNE İLİŞKİN GÖRÜŞLERİNİN İNCELENMESİ

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Şubat 2022, 97 sayfa

Bu çalışma üniversite öğrencilerinin ve öğretmenlerinin sanal kimya ve fizik laboratuvarları etkinliklerine ilişkin görüşlerini incelemeyi amaçlamıştır. Bu çalışma, Türkiye'nin farklı bölgelerindeki 18 farklı üniversiteden genel kimya ve genel fizik derslerine kayıtlı öğrencilerin ve öğretim üyelerinin katılımıyla 2020-2021 eğitim-öğretim yılı içerisinde gerçekleştirilmiştir. Öğrenciler ve öğretim üyeleri 2020-2021 yılı güz dönemi boyunca sanal kimya ve fizik laboratuvarında haftalık olarak açılan deneylere katılım göstermişlerdir. Deneylere katılım zorunludur. Bu dönem sonunda katılımcılardan üç seçenekli sorular ve açık uçlu sorular içeren anketler vasıtasıyla görüşleri toplanmıştır. Toplam 88 öğrenci ve dört öğretim üyesinden oluşan katılımcılar, çalışmaya gönüllü olarak katılım sağlamışlardır. Katılımcılardan açık uçlu sorular vasıtasıyla elde edilen veriler içerik analizi yöntemi ile incelenmiş, avantaj ve dezavataj başlıkları altında temalandırılarak sunulmuştur. Üç seçenekli anket sonuçlarına ilişkin veriler ise frekans ve yüzdeleri ile beraber tablo halinde sunulmuştur. Anket sorularına verilen yanıtlar göstermiştir ki olumlu ve olumsuz görüş belirten katılımcı sayısı neredeyse aynıdır. Olumsuz görüş belirten katılımcılar olduğu gibi pandemi döneminde deneylerden geri kalmadıkları için olumlu görüş belirten katılımcılarda olmuştur.

Farklı kategorilerde 128 frekansla pozitif görüş ve 112 frekansla olumsuz görüş bildirilmiştir. Katılımcıların neredeyse yarısı (%47,1) sanal fizik ve kimya laboratuvarının etkili olduğunu düşünüyor. Katılımcılarda %54'nün daha önce hiç fiziksel laboratuvar deneyimi olmamasına rağmen fiziksel ve sanal laboratuvar arasında seçim yapmaları istendiğinde fiziksel laboratuvarı seçeceklerini belirtmişlerdir. Katılımcıların %42,9'u sanal laboratuvarda deneyleri öğrendiklerini belirtmişlerdir. Katılımcıların cevaplarına dayanılarak sunulan avantajlar ve dezavantajlar göz önünde bulundurularak iyileştirme yapılırsa daha etkili ve verimli sanal laboratuvarlar geliştirilebileceği sonucuna varılmıştır.

Anahtar Kelimeler: Sanal laboratuvar, Kimya laboratuvarı, Fizik laboratuvarı, Öğrenci görüşleri, Öğretim üyesi görüşleri, Fen bilimleri

To my beloved family…

ACKNOWLEDGEMENTS

Firstly and foremost, in the whole process of my thesis, I would like to thank my deep and sincere appreciation to my supervisor Prof. Dr. Ömer Delialioğlu for contribution with his valuable ideas. This thesis woud not even be likely to exist without his insight, patience, guidance, support and encouragement throughout the study.

I would like to express my sincere gratitude and thanks to my examination committee members, Prof. Dr. Selçuk Özdemir and Asst. Prof. Dr. Göknur Kaplan for their valuable suggestions and comments.

Finally, I would like to express my love and deep gratitude to my family for their patience, encouragement and unwavering faith in me.

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LIST OF ABBREVIATIONS

VL: Virtual Laboratory

PL: Physical Laboratory

WBE: Web Based Education

CHAPTER 1

INTRODUCTION

2.1 Introduction

In this chapter, the background and purpose of the study, the research questions, and the significance of the study are respectively presented.

2.2 Background of the Study

In today's world, most fields are being influenced by rapid changes of technology. Education is one of the areas where technology is frequently used. The rapid change of technology, which has wide ranges of use in almost every area of life, has made it necessary to innovate in education. Technology is also used in science education.

Science cannot be considered separately from experiments and laboratory work (Karagöz, 2013). Jasti et al. (2020) state that there are two factors that influence students' learning: the exercising of scientific skills and experience in the laboratory. We can actively use information by means of laboratories. By doing laboratory activities, students can create links between theory and practice. Practice is the key element of laboratory training (Paxinou et al., 2020). If students become more active in science education with the help of laboratory activities and experiments, the information learned becomes long-lasting (Büyükkara, 2011) because laboratory activities enable them to repeat the presented information. Furthermore, science laboratories enable students to identify new problems, observe the problems, explain the problems, use their knowledge, and make decisions. In this way, laboratory work affects reasoning skills, critical thinking skills, and processing skills, which all affect success in other fields (Karagöz, 2006). Teaching with experiments is of great importance for students' cognitive and affective learning (Büyükkara, 2011).

There are some problems encountered in the application of experiments during laboratory work. One common problem is the insufficient number of laboratories in schools. Furthermore, even if a laboratory exists, there might be insufficient equipment because of the high costs. Lack of time for longer experiments and therefore an inability to complete experiments is another problem that students encounter. Because of time limitations, there is no chance to repeat experiments (Kaba, 2012). Considering that science courses consist of content that covers abstract concepts, theories, and principles, physical laboratories might fall short in observing abstract concepts. In some laboratory sessions, the teacher demonstrates the experiments (Tatli & Ayas, 2013). In such cases, students can only watch the demonstration passively, which may be boring and distracting (Ma & Nickerson, 2006). In addition, some experiments might be dangerous and might require practice and extra precautions. This would necessitate extra budgeting and time for practice sessions. Considering these problems, it cannot be said that goals can be achieved in science education. When these problems are taken into consideration, it is clear that suitable alternatives must be sought. Technology has been used for this purpose. If technological tools are selected appropriately for the activities and an ideal learning environment is designed, students' understandings of scientific concepts can be enhanced (Ekmekci & Gulacar, 2015).

Virtual Laboratories (VLs) are simulations of physical laboratory settings and provide objects that are virtual representations of real objects used in real laboratory environments (Faour et al., 2018). They provide virtual environments that can help students in relating their theoretical knowledge to practice by experimentation (Tatli & Ayas, 2013). VLs provide students and faculty with a laboratory environment without time or space restrictions and offer the opportunity to experiment whenever and wherever they want. In real or physical laboratories, there is a schedule that is strictly organized and students have limited time to carry out experiments (Liu et al., 2015). Students can undertake only a limited number of exercises and tests in a given period of time with limited resources (Ambusaidi et al., 2018). Since there are no time or material restrictions in VLs, students can do the experiments over and over again. Moreover, there is limited available time for teachers to ensure that each student has gained the required information and experience (Makransky et al., 2016). In larger groups, it might not be possible to reach the desired goals. VLs may resolve this problem for large groups (Faour et al., 2018). It is possible to conduct experiments that can be considered risky in real laboratory environments in VLs. It is also possible to show abstract topics that cannot be demonstrated in real laboratories. VLs allow visualization of objects that are beyond perception (Olympiou & Zacharia, 2012). They provide a great opportunity for students who do not have the resources for doing experiments in real laboratory settings. In VLs, dangerous experiments can be conducted safely (Faour et al., 2018). Experiments that are even impossible to conduct in real laboratory environments can be designed in VLs (Winkelmann et al., 2020), and students can change variables that are impossible to change in the real world (Olympiou & Zacharia, 2012). In this way, VLs give students an opportunity to access information that cannot be obtained in daily life. When a student misses lab for various reasons, it is difficult to set up the same laboratory settings for a make-up session. VLs are beneficial when it is not possible to attend classes physically (Darrah et al., 2014). Also, most students do not have opportunities to interact with microscopes even if it is possible to attend classes physically. Prior research showed that if there are not enough resources, VLs could be viable options (Kapici et al., 2020). When instructional technologies are used effectively, they have the potential to improve the education system (Aydın, 2018).

VLs have both advantages and disadvantages. Their advantages can be listed as follows:

- Enhancing conceptual understanding (Brinson, 2015).
- Allowing students to construct their own learning (Ekmekci & Gulacar, 2015).
- Allowing for experiences that cannot be experienced in a physical laboratory (Olympiou & Zacharia, 2012).

- Providing virtual representation of real objects (Mirzalar Kabapinar & Adik, 2005).
- Saving space and time (De Jong et al., 2013).
- Useful for visual learners (Faour et al., 2018).
- Cost-effective (Alkhaldi et al., 2016).
- Helpful as a preparatory tool (Nolen & Koretsky, 2018).
- Allowing teaching from long distances (Dyrberg et al., 2017).
- Providing the opportunity to repeat experiments (Sari Ay & Yilmaz, 2015).
- Providing immediate feedback (Olympiou & Zacharia, 2012).
- Providing a safe environment (Son et al., 2016).
- Changing attitudes toward science (Ambusaidi et al., 2018).
- Facilitating learning (Çivril, 2017).
- Allowing students to study at their own pace (Paxinou et al., 2020).
- Increasing self-responsibility (Reeves & Crippen, 2021).
- Allowing changes in parameters while conducting experiments (Erdan, 2014).
- Providing equal opportunity (Kiraz, 2014).
- Allowing the monitoring of students' performances (Çivril, 2017).

Disadvantages of VLs can be listed as follows:

- Technical constraints (Diker, 2011).
- Lack of interest and motivation (Çivril, 2017).
- Insufficient for development of new skills (Ma & Nickerson, 2006).
- No immediate intervention (Diker, 2011).
- Lack of communication (Kiraz, 2014).
- Self-learning disability (Kiraz, 2014).
- Causing antisociality (Kiraz, 2014).
- Lack of interaction (Diker, 2011).
- Failure to provide equal opportunity (Çivril, 2017).

- Lack of partners (Faour et al., 2018).
- No contribution to changes of attitudes toward science (Ambusaidi et al., 2018).
- Not instructive (Ambusaidi et al., 2018).
- Affecting laboratory skills negatively (Faour et al., 2018).
- Overly idealized environment (Martin-Villalba et al., 2012).

Although many technological innovations have been made in the field of education, there has not been a large-scale study on VLs. These laboratories will be very helpful for students who do not have real laboratory facilities or have limited access. It is understood that it is necessary to work on this issue, especially during pandemic periods.

Nearly all around the world, human activities and interactions are restricted due to current SARS-Cov-2 pandemic. Pandemic has major impact especially on education field. Because of complete lockdown, access to the classrooms decreased (Liccardo et al., 2021). Educational activities are affected from lockdowns during the COVID-19 pandemic period (Kapilan et al., 2020). Students were limited because of safety concerns (Liccardo et al., 2021). Although theoretical courses conducted online, there were problems performing the laboratory experiments (Kapilan et al., 2020). It was challenging to change teaching format due to pandemic since it requires a different approach (Qiang et al., 2020). Educational institutions tried to come up with solutions to complete laboratory experiments in case of shutdown due to Covid-19 pandemic. For this reason, virtual laboratories were commissioned (Kapilan et al., 2020).

A study conducted after experiencing the virtual laboratories in the pandemic period, according to results, 90% of the participants were happy about virtual laboratory (VL). They pointed out that VL improved their learning process. Even, most of the students stated that virtual laboratories should take place in engineering curriculum. VL provided a working environment without exposure to the virus. (Kapilan et al., 2020)

2.3 Significance of the Study

In this study, “virtual laboratory” refers to a simulated version of a traditional physical laboratory. It refers to a learner-centered approach in which the learner is provided with objects that are virtual representations of real objects used in physical laboratories (Faour et al., 2018). The American Chemical Society (ACS) stated in 2011 that computer simulations mimicking laboratory processes are likely to be valuable supplements to students’ hands-on activities. VLs are already in use in most private schools. However, because of compulsory distance education, it is important that VLs be available to all students. Alqadri (2018) stated that if it is not possible to conduct experiments in real laboratories for various reasons, VLs are highly recommended. For this reason, in Turkey, the Council of Higher Education presented a project entitled “Board of Higher Education Virtual Laboratory Project,” which includes eighteen universities from all geographical regions of Turkey. With this project, students have access to physics and chemistry laboratory classes online. Fortunately, the advancement in information technology has made computers powerful cognitive tools that support science learning (Yang & Heh, 2007).

This study aims to determine students’ and instructors’ perceptions about and impressions of the Board of Higher Education Virtual Laboratory Project. The research was designed to investigate the effectiveness of this project for its users (students) and operators (instructors).

In addition, the results obtained from this study will guide instructors and VL designers to prepare more effective laboratory environments and develop positive learning experiences for learners (Çivril, 2017). This study does not represent only one particular school in a particular region. It is important because it includes participants from several parts of Türkiye.

2.4 Statement of the Problem

The adaptation of technology into education to make education more accessible in today’s world is very important because real laboratory facilities are not adequately offered to many students. This situation is valid in the majority of universities in Turkey, which has a young population (Kiraz, 2014). VLs have increased rapidly with the development of computer and Internet technology and they are now frequently used in educational environments (Bozkurt, 2008). By this means, students in all conditions are given the opportunity to receive thorough education and large segments of society can be reached (Kiraz, 2014). There is a need for revealing students’ and faculty’ thoughts about virtual physics and chemistry laboratories because users’ expectations of technology may change after they experience it (Zhang et al., 2020).

2.5 Purpose of the Study

The purpose of this study is to investigate the thoughts and perceptions of students and faculty about virtual physics and chemistry laboratory activities.

Accordingly, this study seeks to answer the following research questions:

1. What are the perceptions of students toward virtual physics and chemistry laboratory activities?

2. What are the perceptions of faculty toward the virtual physics and chemistry laboratory activities?

CHAPTER 2

LITERATURE REVIEW

3.1 Introduction

In this part of the study, a review of the literature is presented based on an investigation of the related literature to date. To create a theoretical framework, this review of studies in the literature is presented within subcategories of distance education, physical laboratories, and virtual laboratories for science education.

3.2 Distance Education

Distance education is a system in which educators and students in different places interact with the help of various communication technologies and carry out education and training activities in order to provide education services to large masses and to provide equal opportunities in education (Kiraz, 2014). Distance learning is an educational implementation based on principles of student activities and self-learning (Diker, 2011). The definition of the United States Institute of Distance Education (USDLA) is as follows: Distance education is the delivery of education to the relevant people, together with the use of tools such as satellite, video, audio, graphics, and computer and multimedia technology (Kiraz, 2014).

Distance education is a teaching method applied when in-class activities are not possible due to limitations in traditional learning and teaching methods. Therefore, communication and interactions between those who plan and implement educational studies and learners are provided from a certain center through specially prepared teaching units and various environments (Kırlar, 2007).

The foundations of open and distance learning are rooted in the 19th century (Çivril, 2017). In the 20th century, radio, telephone, cinema, television, programmed learning, computers, and the Internet became new tools of distance education. Radio was used for the first time in the 1930s. This was followed by the use of television as a new distance education medium in the 1960s, and today, thanks to the power, flexibility, and speed of the Internet, distance education courses can be given at any time and any place (Topuz, 2010).

In Turkey, distance education studies over the Internet were first initiated in 1996 under the leadership of the Middle East Technical University Informatics Institute, and the Informatics National Committee was established at the end of 1999. Internet-based certificate, undergraduate, or graduate education programs are now being carried out by various universities (Kiraz, 2014). Web-Based education (WBE) is another new door that has opened to distance education with the development and spread of the Internet. Distance education gained new dimensions with WBE. With WBE, interactions in distance education are increased and it has become possible for students and teachers to discuss ideas simultaneously or asynchronously (Topuz, 2010). With the development of computer and Internet technologies, Internet-based education has increased rapidly and is a frequently used educational environment. Both educational institutions and companies develop their own Internet-based education models because, while also considering that technology is renewed every two years, the education of the rapidly increasing world population is only possible with the use of Internet-based education. Examples of WBE systems are virtual universities, virtual laboratories, and distance education systems (Bozkurt, 2008).
Technology is the process of transforming the knowledge acquired by human beings through scientific studies into tangible products in order to solve the problems they encounter in different areas of life and accelerate their development. Accordingly, it can be said that technology is the sum of the functional products and services that produce solutions that enable the individual to use knowledge obtained through scientific studies and make his or her life easier and more efficient (Diker, 2011). Educational technology entails the active introduction of these scientific studies into

the educational process (Diker, 2011). For example, the use of animation in today's educational environments becomes more widespread day by day and the rate of use is constantly increasing. Computer software prepared for educational purposes reveals the popularity of animation (Rieber, 2006). Developments in information technologies have also been reflected in the design and development processes of animation, making computer animation applications easier to use. With the widespread use of multimedia technologies in computer environments, the possibilities of using tools such as videos, pictures, texts, and sound and combining them with animations provide many benefits in the educational software development process (Meral, 2018).

The field of educational technologies is a field that has emerged with the development of technology and the reflection of this development in education. Computer technology has been the most important tool in the development and definition of this field (Bozkurt, 2008). It can be defined as providing computer environments that allow for real-time simulation in experiments that need to be done in order to gain practical experience in education (Erdan, 2014). The VLs that are now being developed will not only support the experimental applications of the departments operating in formal education; they will also be a trigger and a source of support for these departments to operate distance education applications (Kiraz, 2014). The benefits of distance education include flexibility and accessibility as students can conduct experiments from any location (Alkhaldi et al., 2016). Dalgarno et al. (2009) emphasize that students should be acquainted with the idea of studying from a distance with laboratory environments without going to campus laboratories (Dyrberg et al., 2017).

3.3 Physical Laboratories

Physical laboratories are defined as traditional laboratories wherein students physically attend classes to conduct experiments. This type of laboratory is also called a hands-on laboratory (Alkhaldi et al., 2016). Laboratories are effective teaching environments that combine theoretical knowledge and practice. They are important components of education and complements to education programs where students will gain experience. Experiments carried out in laboratories not only help students gain practical skills but also reinforce theoretical knowledge (Kiraz, 2014). Laboratories are places where knowledge is used actively. Laboratory studies directly affect reasoning, critical thinking, the understanding of science, and manual dexterity. In this way, students and researchers can define new problems, explain, observe, and make decisions based on the results of experiments by using information (Kiraz, 2014). Thanks to laboratory applications, students are taught the skills that they should have in professional life after graduation. This allows students to perform laboratory practices related to the fields they are studying, to gain the skills they may need in their professional lives, and to get to know their fields of application. The absence of laboratory practices in education will cause information to remain at only the theoretical level and effective learning will not be possible (Çivril, 2017).

Laboratory practices are considered an integral part of education in disciplines such as engineering, natural sciences, and technical sciences (Çivril, 2017). Laboratory practices are a part and perhaps even the focus of science education (Kiraz, 2014). The laboratory method is a widely used method that provides permanent learning in science education (Meral, 2018). Scientific experiments include processes and methods to understand scientific phenomena and scientific principles better (Paxinou et al., 2020). Promoting student understanding, applying scientific knowledge, and questioning processes with outcomes are among the focuses of current science teaching to enable students to be good problem solvers (Yang & Heh, 2007). It is stated that more learning takes place with science laboratory activities (Meral, 2018). It is now important to not merely transfer information directly to the individual but rather teach how and in what ways the individual can reach the needed information (Erdan, 2014). The laboratory method is one of the methods that enable students to learn by doing activities and laboratory practices are very important for a better understanding of abstract concepts (Meral, 2018). Unless theoretical knowledge is

supported by experiments and laboratory work, science will not be real science (Kiraz, 2014).
One of the most important problems of science teaching is that students cannot adequately practice the subjects they learn in a laboratory (Meral, 2018). Sometimes, as subjects are covered according to the curriculum of the course, related experiments cannot be done due to a lack of materials (Kiraz, 2014). The lack of up-to-date laboratory infrastructure is also an important factor (Çivril, 2017).

The disadvantages of the physical laboratory can be listed as follows.

In physical laboratories,

- there might be tool and source deficiency that preventing adequate experimenting.
- demonstration experiments may takes place a lot. Teachers may find it difficult to keep students attention and criticize the results of experiments.
- students may stay inactive because of demonstration experiments. While teacher demonstrate the experiment, students talk with each other.
- there may not be enough time to complete some experiments.
- teachers may prefer theoric education because of laboratories additional works such as preparing materials and supplies.
- it might be difficult to conduct experiments in crowded classes.
- it might not be possible to get results from experiments.
- experimentation is expensive and luxurious.
- it might not be possible to test results and this can prevent students to think questionably (Sari Ay & Yilmaz, 2015).

3.4 Virtual Laboratories

There are two common types of online laboratories, one of them is the remote laboratory and the other is the VL (Tamás Budai & Miklós Kuczmann, 2018). These look very similar from the end users' perspective. However, they have very important differences in the backend. Hardware components exist physically somewhere in the institution for remote laboratories. To conduct an experiment, the relevant parts of the experiment are connected to the network. Students can then be examined and control these parts from a remote location. On the other hand, all of the components are entirely simulated by the software in a VL and can be accessed by users remotely (Tamás Budai & Miklós Kuczmann, 2018).

According to Alkhaldi et al. (2016), a remote laboratory is a laboratory in which learners can conduct experiments remotely within a physical laboratory by connecting to the physical laboratory via a network. In remote laboratories experiments are located away from the experimenter. For instance, to move robots in a laboratory to conduct an experiment, students may connect remotely. According to Budai and Kuczmann (2018), in a remote laboratory, hardware components exist physically somewhere in the institution.

On the other hand, according to Alkhaldi et al. (2016), a VL is a virtual space where students can access and conduct experiments. Laboratory environments are simulated by programs. This is also called a simulated laboratory. According to Martin-Villalba et al. (2011), VLs have three main components. The first is simulation, whereby a mathematical model describes the relevant properties of the system. The second component is the interactive user-to-model interface. The third is a narrative that provides information about the system.

As cited by Kiraz (2014) Taşdelen defines a VL as an application that provides an interactive real-time simulation opportunity for experiments that need to be done in order to gain practical experience in education and allows real laboratory environments to be simulated over the Internet. Diker (2011) defines VLs as computer environments that provide interactive real-time simulation opportunities in experiments that need to be done in order to gain practical experience in education. A VL is an environment that allows students to conduct experiments as if they are in a physical laboratory (Diker, 2011). Scheckler defines VLs as interactive learning environments that utilize computer technologies, simulations, and various instructional technologies to digitize physical laboratory activities (Kiraz, 2014). VLs are learning environments that provide integrated experimental environments with information technologies at the place and time desired with the learners actively involved (Kiraz, 2014).

VLs are also defined as “imitations of real experiments. All the infrastructure required for laboratories is not real, but simulated on computers” (Brinson, 2015). Along with the opportunities provided by digitalization, new teaching models are simultaneously emerging in laboratory applications in all fields of education. Today’s information and communication technologies are reaching levels that allow for the provision of the necessary environments and tools for laboratory applications. In this context, with virtual or remote access laboratories, institutions can offer laboratory applications to their learners in both traditional and open and distance learning settings (Çivril, 2017).

VLs, the numbers of which are increasing rapidly in the world, must be developed to support real laboratory environments. When the literature is examined, it is seen that VLs have emerged as alternatives to physical laboratories and were developed to minimize the disadvantages of those laboratories (Kiraz, 2014). VL applications are not only complements to physical laboratory applications; they are also very useful as supporting materials in preparation for experiments to be carried out in physical laboratory environments (Çivril, 2017). With VLs, it is aimed to make laboratory studies flexible and accessible in the context of time and space and to meet the learning needs of learners. VLs are seen as opportunities to enhance learning for both distance and traditional learners.

The importance of computers in education first started in the 1970s (Bozkurt, 2008). As cited by Bozkurt (2008)**,** Arons, influenced by Bloom, suggested to scientists conducting educational research that computer software be used to ease the burden of teachers and that each teacher consider taking care of his or her students individually, arguing that studies needing to be done should be done in this direction. He argued that such interactions would provide an advantage that would allow students to come face-to-face with their misconceptions of physics subjects and phenomena and would break their resistance in explaining them (Bozkurt, 2008). As cited by Bozkurt (2008), Thinker and Stringer, pioneers of science education, said in 1978 that the computer age had begun and would change stereotyped ideas of education, offering important opportunities especially in science education. Another pioneer of science education, Bork, as cited by Bozkurt (2008), said in a speech in 1978 that computers would be present at every level of education in the 2000s (Bozkurt, 2008).

In addition to the development of computers, the birth and spread of Internet technology has been of great importance in terms of physics education. Presenting VLs via the Internet with computer software allows students to work independently of time and place and to repeat their experiments whenever they want. It is very easy to find VL studies related to almost every subject of physics in the Internet environment (Bozkurt, 2008).

In addition to institutions providing open and distance learning services, such as the Open University of England, Open University of Malaysia, Open University of Sri Lanka, and Spain's National University of Distance Education, virtual and remote access laboratories are used effectively and become a part of education in many institutions offering traditional education. Open educational resource projects in different disciplines have been developed and various consortia have been established to expand and facilitate the use of virtual and remote access laboratories in education around the world. In addition, the Open Learning Consortium, which was established to guide educators, distance education experts, and institutions on online learning, organizes workshops for educators on the use of VLs in education at regular intervals and encourages the use of VLs (Çivril, 2017).

Anadolu University's Open Education Faculty (OEF), which is the leading institution in the field of open and distance learning in Turkey, started its educational activities in 1982 and has kept its learning environments updated in line with technological developments since its establishment. In programs that require practice, special teaching methods are used for some courses. For example, the course for teaching keyboards in the “Office Management and Executive Assistant” and “Medical Documentation and Secretarial” associate degree programs is given practically via OEF Offices. In this course, applications are made using commercial keyboard teaching software installed on office computers (Çivril, 2017).

In Turkey, although academic studies are being carried out with the aim of catching up with the trends in the world regarding laboratory practices, it is seen that applications are not at the desired level and the developed environments are not used effectively and cannot be made a proper part of education. In Turkey, there are similar situations in institutions that offer programs with open and distance learning methods (Çivril, 2017).

VLs cannot fully replace physical labs. However, some disadvantages of physical laboratories paired with the potential advances and benefits offered by computer technology make the use of VLs a viable and supportive alternative to physical laboratories (Kırlar, 2007). It is beneficial to include animations as much as possible, especially in science education, in order to help visualize the course content that is to be transferred to students in educational environments. In order to ensure efficient learning, students must code the course contents shown to them both verbally and visually and recreate them in their memories (Meral, 2018). In scientific studies, there are many reports that the use of animation in science education increases students’ interest in the lessons, facilitates learning, and ensures the permanence of the learned information (Meral, 2018).

It is thought that the opportunities of information technologies can be benefited from in order to raise students’ success by removing the obstacles in front of performing laboratory activities in science lessons while also increasing motivation towards the lessons (Meral, 2018). It has been observed as a result of studies that students can be successful in WBE environments (Diker, 2011).

In one previous study, two groups were compared after the testing of their skills and success levels, and the group taught with a VL application was found to be more successful (Bozkurt, 2008). It was also determined that students had the opportunity to conduct experiments that they could not do in a physical laboratory environment thanks to web materials, and lessons became more fun with an increase in their motivation towards the lessons (Meral, 2018). With VL applications, many scientists can work on a project together independently of geographical conditions. This can contribute to increased sharing of knowledge and experience, which is very important today (Diker, 2011). Fortunately, to support science and expand students' inquiry abilities, computers are powerful cognitive tools supported by the advancement of information technology (Yang & Heh, 2007).

3.4.1 Advantages of Virtual Laboratories

The prominent advantages of virtual laboratories are providing safe environment, cost effective and allowing repetition. The advantages of virtual laboratories aforementioned in the literature are explained one by one below.

a. Enhancing conceptual understanding

According to Ekmekci and Gulacar (2015), computer-based activities will work better if the main concern is conceptual understanding. In a physical laboratory, handling the apparatuses and finalizing the tasks will be more important for students than focusing on conceptual understanding (Dyrberg et al., 2017).

The use of VLs has a better effect on the conceptual understanding of direct current electric circuits than physical laboratory demonstrations (Faour et al., 2018). For students who have limited prior knowledge, virtual representations of abstract concepts will increase their conceptual understanding of less complex mechanisms (Brinson, 2015).

b. Allowing students to construct their own learning

According to constructivist approaches, new instructional techniques are being designed that help students take responsibility for their own learning, construct their own learning, and enhance their own critical thinking skills (Ekmekci & Gulacar, 2015).

c. Allowing for experiences that cannot be experienced in a physical laboratory

VLs allows students to have experiences that are unrealistic or impossible in the real world, like changing blood pressures or global temperatures (Olympiou & Zacharia, 2012).

d. Providing virtual representation of real objects

In physical laboratories there might be some difficulties in understanding events at the micro level and explaining chemical changes related to chemical bonds (Mirzalar Kabapinar & Adik, 2005). Additionally, the literature shows that students find it mentally difficult to grasp the topic of chemical changes. In VLs, however, it is possible to investigate experiments at macro, micro, and symbolic levels (Tatli & Ayas, 2013). VLs are simulated versions of physical laboratories. Laboratory materials and objects used in physical laboratories are simulated in VLs (Faour et al., 2018). In a VL, for example, there may be a virtual microscope that provides high-resolution images of real specimens (Waldrop, 2013). The observation of emergent molecular interactions is not possible in physical laboratories but there are visual cues and alternative representations in VLs (Nolen & Koretsky, 2018). VLs also help convert intangible concepts into concrete forms (Kapici et al., 2020). Virtual experiments might be better than physical experiments, especially for abstract concepts (Chini et al., 2012).

e. Saving space and time

VLs allows students to conduct a wide range of experiments more easily and faster. Therefore, students experience more examples (Olympiou & Zacharia, 2012).

VLs also require less setup time and it is easy to get the results of lengthy investigations immediately (De Jong et al., 2013).

VL equipment can be assembled more easily and properly than physical laboratory equipment. Therefore, virtual instruments save space and time. VLs are more time-efficient than real laboratories (Faour et al., 2018).

f. Useful for visual learners

In VLs, students can also directly link unobservable processes to symbolic equations and observable phenomena, which encourages them to make abstractions for different representations (De Jong et al., 2013).

VLs might be helpful for auditory and non-visual learners and might help solve the problems of large groups of students trying to interact with their learning environments (Faour et al., 2018).

VL simulations enable students to visualize particulate views of matter and improve their performances on quizzes (Hawkins & Phelps, 2013). Processes and objects that are normally beyond perception can be visualized in VLs (Olympiou & Zacharia, 2012).

g. Cost-effective

In a VL, it is not costly to repeat various scenarios to generate additional datasets (Dyrberg et al., 2017). For example, actual chemical resources will not be wasted in a virtual chemistry laboratory (Alkhaldi et al., 2016).

When laboratory experiments are costly to repeat in various case scenarios virtual laboratory can be used to generate additional data sets. (Dyrberg et al., 2017)

h. Helpful as a preparatory tool

VLs designed as preparation for experiments in a physical laboratory enhance the effectiveness of instruction (Nolen & Koretsky, 2018). VLs are helpful for students' pre-laboratory preparations (Dyrberg et al., 2017) and can prepare students for physical laboratories successfully (Reeves & Crippen, 2021). VL applications are not only complementary to physical laboratory applications; they are also very useful as supporting material in preparation for experiments to be carried out in physical laboratory environments (Çivril, 2017).

i. Allowing teaching from long distances

A previous study aimed to introduce chemistry students to studying from a distance in laboratory environments before going to the campus laboratory (Dyrberg et al., 2017). VLs give students flexibility and accessibility for conducting experiments from any location (Alkhaldi et al., 2016). They enable students to conduct experiments even if they are unable to attend class physically (Darrah et al., 2014).

j. Allowing repetition

VLs offer students an opportunity to repeat experiments (Sari Ay & Yilmaz, 2015). In a VL environment, students can repeat the same experiments easily (Tatli & Ayas, 2013). In a VL, there are multiple opportunities to complete specific laboratory exercises and access resources with a greater amount of available time. This time allows students to repeat and modify exercises and fosters deeper learning (Brinson, 2015). VLs also give learners the freedom to make mistakes. Even if test results are incorrect, one can easily start the experiment from the beginning in a VL (Çivril, 2017).

k. Providing immediate feedback

When students make a mistake, a VL will provide immediate feedback to them. Thus, there is still time remaining to repeat the same experiment immediately (Olympiou & Zacharia, 2012).

l. Providing safe environments

VLs provide risk-free environments for students while they explore scientific concepts (Son et al., 2016). They give students safe and secure environments while the students are practicing (Ambusaidi et al., 2018).

m. Changing attitudes toward science

VLs have positive impacts on students' attitudes because VLs provide visualization and realism, helping students to develop conceptual understandings (Kapici et al., 2020). Studies show that students gain positive attitudes toward learning from VLs (Ambusaidi et al., 2018).

n. Facilitating learning

Studies have shown that it is easier to teach difficult concepts with VLs (Çivril, 2017). VLs facilitate learning by focusing students' attention directly on the phenomena being studied (Olympiou & Zacharia, 2012)

o. Allowing students to study at their own pace

In a VL, students can flexibly reset and redo experiments at their own pace (Alkhaldi et al., 2016). As Paxinou et al. (2020) state, "Research-validated self-paced learning tools can be extremely important in helping students with diverse backgrounds to construct science knowledge."

p. Increasing self-responsibility

VLs and virtual environments help students develop self-responsibility and self-confidence in their own learning (Ambusaidi et al., 2018).

Students' self-efficacy improves upon performing experiments in physical and virtual laboratories (Reeves & Crippen, 2021).

q. Allowing the changing of parameters

When VLs provide appropriate qualities in terms of visuality, users can change parameters in their experiments, like in real laboratories. This gives them the opportunity to observe the changes in the experimental results by changing parameters (Kiraz, 2014). VLs offer possibilities of reuse and repeated experiments with new parametric values (Erdan, 2014).

With VLs, experiments can be repeated over and over again. In addition, learners can make as many changes as they want to certain inputs, parameters, and variables and instantly examine how those changes affect the results of the experiments (Çivril, 2017).

r. Providing equal opportunity

With VLs, people in different conditions and locations are given the opportunity to receive education, and large segments of society can gain access to this education (Kiraz, 2014).

s. Allowing the monitoring of students' performances

In addition, teachers can constantly monitor the performance of learners by recording their processes (Çivril, 2017).

3.4.2 Disadvantages of Virtual Laboratories

The prominent disadvantages of virtual laboratories are technical constraints and lack of interaction. The disadvantages of virtual laboratories aforementioned in the literature are explained one by one below.

a. Technical constraints

Hardware failures in computers will disrupt the course flow. Due to the lack of adequate infrastructure, such problems may not be solved immediately. Sometimes work done on one computer may not open on another (Diker, 2011).

Students who clearly understand the use of their software will achieve better results than those who do not (Çivril, 2017).

b. Lack of interest and motivation

It is thought that the excitement and interest provided by a physical laboratory cannot be conveyed in VL environments (Çivril, 2017).
Students should be willing to receive education and be highly motivated because, in distance education, there is no other behavior that will motivate the student to learn or reinforce the student's learning (Diker, 2011).

c. Not sufficient for developing new skills

Students' behaviors depend on the reality, constraints, and competencies of the presented software. Such constraints limit learners' creativity in experiments (Çivril, 2017). Due to the idealized environment offered by VLs, all learners reach the same results and they cannot learn by trial and error (Cooper, 2005). It is also thought that it is difficult to meet the criteria in psychomotor and affective fields in VLs (Çivril, 2017).

d. No immediate intervention

The problems encountered in VLs cannot be addressed immediately (Kiraz, 2014). The learning difficulties encountered in the learning process are not resolved immediately and problems may subsequently develop. Failure to develop desired behaviors may be a result of not being able to receive immediate help and not resolving problems (Diker, 2011).

e. Lack of communication

Due to the high number of students, difficulty in communicating with the instructor of the course instantly may be a drawback of VLs (Kiraz, 2014).

f. Self-learning disability

The inability of students who have difficulties in self-learning to plan for themselves regarding lessons is another drawback (Kiraz, 2014). An individual without self-control may procrastinate or even drop out of the course (Diker, 2011).

g. Causing antisociality

In VLs, students are not working in real-life social environments (Kiraz, 2014), which may contribute to the production of asocial individuals (Diker, 2011).

h. Lack of interaction

Insufficient interaction may be provided in VL environments (Kiraz, 2014). In addition, students may be unable to develop their ability to use and recognize experimental tools due to a lack of physical interaction with the laboratory environment (Diker, 2011).

i. Failure to provide equal opportunity

Students who are not in good financial situations and are deprived of access to technology may not be able to benefit from VL environments (Diker, 2011). This is a major disadvantage for users in remote areas with little or no fast Internet connection (Çivril, 2017).

j. Lack of peers

In VLs, students do not have peers. This may slow down or even prevent peer-learning (Faour et al., 2018). Students conduct VL experiments alone (Tatli & Ayas, 2013) and VLs may potentially cause isolation (Ma & Nickerson, 2006). Technological innovation is not enough for learning because students also learn from their teachers and peers by interacting with them (Ekmekci & Gulacar, 2015). Students are affected by classroom dynamics in physical laboratories and these dynamics are missing in VLs (Ekmekci & Gulacar, 2015).

k. Attitude change

VLs have just as much an effect as physical laboratories in changing students' attitudes (Faour et al., 2018). According to Ambusaidi et al. (2018), VLs had no impact on students' attitudes toward science or their academic achievement.

l. Not instructive

VLs may make students feel like they are playing a video game, not learning in a laboratory (Ambusaidi et al., 2018).

m. Affecting laboratory skills negatively

Many researchers stated that VLs may affect students' practical laboratory skills negatively. It is necessary to investigate how the use of VLs may affect practical laboratory skills (Faour et al., 2018).

n. Overly idealized environment

In VLs, measurement errors are often ignored, whereas in physical laboratories measurement errors are naturally addressed (Olympiou & Zacharia, 2012).

In VLs, students have limited views on experimentation because a VL is an idealized environment (Martin-Villalba et al., 2012).

3.4.3 Examples of Virtual Laboratory

Virtual laboratories in science education: students' motivation and experiences in two tertiary biology courses (Dyrberg et al., 2017)

In this study on virtual laboratories, Labster virtual laboratory programme was used to investigate the attitudes, motivaton and self-efficacy of students when using VL. There were interactive biological and biochemical experiments in the program which includes the ability to adjust parameters, operation of relevant apparatuses and the production of results. Labster used as a supplemet to real laboratory exercises in Pharmaceutical toxicology and microbiology courses. 73 undergraduate students participated in this study, which evaluated the motivations and attitudes of students towards the virtual exercises. Students felt more confident and comfortable significantly while conducting experiments in real laboratories after completing virtual laboratory exercises. Hovewer, students did not feel more motivated to engage in virtual laboratory exercises. Teacher stated that by considering their observations, students participation to discussions was higher than previous years where the Labster was not used. According to the results of this study, it was concluded that for pre-laboratory preparation of students, VLs have potential to improve.

Using Virtual Laboratory in Direct Instruction to Enhance Students' Achievement (Alqadri, 2018)

In this study, it is aimed to investigate the effectiveness of virtual chemistry laboratory to enhance student's academic achievement in direct instruction by considering colligative properties of solution topic. In this study, guided practice phase which is one of the 5 phases of direct instruction model was used while implementing virtual laboratory. In this pre-experiment research, one group pre-test and post-test design was used. Both of the tests were achievement test and consist of 20 multiple choice items. Paricipants were 30 12th grade science students from Indonesia. There were three criteria to investigate the effectiveness of virtual chemistry laboratory. Criterias were: the score of students is at least 75, completeness of the test at least 80% and normalized gain at least in medium category. According to the results of data analysis, all the results met the criteria of effectiveness. It can be said that by considering results, virtual laboratory used effectively in direct instruction to enhance students' achievement on colligative properties of solution topic.

Virtual Simulations as Preparation for Lab Exercises: Assessing Learning of Key Laboratory Skills in Microbiology and Improvement of Essential Non-Cognitive Skills (Makransky et al., 2016)

In this study, it was aimed to investigate whether virtual laboratory can be used instead of face-to-face tutuorial in microbiology. Participants of this study were randomly selected from the student who are registered to undergraduate biology course. A total number of participants were 189. Participants divided into two groups as demonstration and vLAB. In both of the groups same topic was covered. In this study, pre-test and post-test was conducted to determine students' knowledge, intrinsic motivation and self-efficacy in the field of microbiology. Accoding to results, there were no significant differences between these two groups on their laboratory scores, their intrinsic motivation to study microbiology and their self-efficacy. Also, groups shows similar increase in knowledge of microbiology. By considering these results, it can be said that virtual laboratories function just as face-to-face tutorials in the field of microbiology. VLs could be used instead of face-to-face tutorials.

Are Virtual Labs as Effective as Hands-on Labs for Undergraduate Physics? A Comparative Study at Two Major Universities (Darrah et al., 2014)

In this study, participants' virtual laboratory and physical laboratory experience compared. Experiments conducted in the scope of introductory level college physics course. There were everthing that are required for conducting physical laboratory experiment in each virtual laboratory. Also, there were pre and post laboratory questions and post laboratory quizzes. There were a total of 224 participants from two different universities. A group of students from the one of the universities experienced virtual laboratory and a group of students from the other university which was control group experienced physical laboratory only. Findings showed that virtual laboratory as effective as traditional hands on laboratory.

Students' Perceptions and Attitudes: Implementation of Virtual Laboratory Physics Applications (PVL) during the Covid-19 Pandemic (Berlianti et al., 2021)

In this study, it is aimed to determine effectiveness of using virtual physics laboratory in fulfilling practicum activities in terms of students' perceptions and competencies of students' attitudes. Descriptive research method was used to obtain data. This study was carried out within the scope of basic physics course. The data collected through attitude assessment sheets and perception questionnaires. The average score of student perception is 4.22. The average score of students' attitude competence is 80.88 integrity; 74.89 independence, 75.17 confidence and 84.89 responsibility. According to the results, using virtual physics laboratory builds students' integrity and responsibility.

Preliminary Study: Chemistry Laboratory Virtual Innovation as an Optimization of Science Learning during the Covid 19 Pandemic (Antrakusuma et al., 2021)

In this study, it is aimed to conduct a study which is preliminary for virtual chemistry laboratory innovation for optimization of learning during Covid-19 pandemic. This is a natural science education study program conducted by Universitas Sebelas Maret – Teacher Training and Education Faculty. In this study, descriptive qualitative method was used. Data collected through interviews, observation and analysis of related documents. Collected data equipped with a Focus Group Discussion with faculty and students. According to the results, for VL innovation in the Natural Science Education Study Program, 11 chemistry practices are required due to Covid-19 restrictions on the use of laboratories. By considering results, it was concluded that to pursue and optimize laboratory skills in online education, virtual chemistry laboratory was needed. Also, developed virtual chemistry laboratory should be accessible online because it can be used regardless of time and place.

Implementing Physics Virtual Laboratory in 3D: An Example of Atwood Machine (Dmitriyev & Daineko, 2015)

In this study, it is aimed to implement a specialized software application to enhance physics experience. This work also includes physics experiments' theoretical foundations and technological foundation that leads virtual laboratory creation for physics experiments. This study specially focused on description of Atwood's machine by using theoretical and technological foundation of physics. Software implementation process also described in detail. According to the results of this study, presented virtual physics laboratory is very promising in education for better understanding of a subject.

Investigating the Effect of Virtual Laboratory Simulation in Chemistry on Learning Achievement, Self-efficacy, and Learning Experience (Peechapol, 2021)

In this study, it is aimed to investigate the effectiveness of virtual chemistry laboratory simulation on learning achievement, learning experience and self efficacy. Undergraduate freshman students were participated in this study. Research method used in this study was quasi-experimental design with two group pre-test and post-test design. Purposive sampling was used and 95 freshman undergraduate students who are enrolled in general chemistry course were participated in this study.

Participants were divided into two groups as control group and experimental group. There are students who have low knowledge level and high knowledge level determined according to pre-test results in each group. Both groups took three hours long traditional chemistry lesson. Experimental group attended virtual laboratory simulation for 1.5 hours. According to results, virtual laboratory simulation had positive effect on learning experience, learning achievement and self-efficacy. Experimental group (VL) students had higher scores than control group (physical). Also, virtual laboratory simulation increased students' motivation to learn chemistry and understanding the chemistry concept in 3D environment. According to the results of this study, virtual laboratory simulation could be a supportive tool for learning achievement and self-efficacy.

CHAPTER 3

METHODOLOGY

4.1 Introduction

In this chapter, the research design of the study and research questions are primarily shared by specifying the related information. After that, participants of the study are introduced and data collection instruments are clarified. In order to clearly explain the research, procedures used to collect and analyze the data are presented. Finally, data analysis of the study has been clarified and a summary of the chapter is given at the end.

4.2 Research Design

In this research, survey research design, which is one of the non-experimental research designs was conducted. The reason to choose survey study is that it is one of the most widely used non-experimental research designs across disciplines to collect large amounts of survey data from a representative sample of individuals sampled from the targeted population using a variety of modes such as physical, telephone, mail, and electronic (Kalaian, 2014). The population of the study is the students enrolled in general chemistry and general physics courses at 18 universities with VL infrastructure and faculty members who are teaching general chemistry and general physics from these universities. Research questions of this study are “What are the perceptions of students toward virtual physics and chemistry laboratory activities?” and “What are the perceptions of faculty toward the virtual physics and chemistry laboratory activities?”

To answer the first research question, quantitative data was collected through a survey research design from students who experienced virtual chemistry and physics laboratory activities. The data were collected in the spring semester of 2020-2021 after the students spent the first half of the 10 experimental periods. The reason for applying survey design is that it provides a snapshot of the feelings, opinions, practices, thoughts, preferences, attitudes, or behaviors of a sample of people, as they exist at a given time and a given place. (Kalaian, 2014) The main purpose of gathering data by using survey is that the researcher tries to find out students' perceptions about virtual physics and chemistry laboratory activities.
To answer the second research question data was collected from faculty members who experienced virtual physics and chemistry laboratory activities by using "Faculty' perception on VL survey". The data were collected in the fall semester of 2020-2021 after the students and faculty spent the first half of the 10 experimental periods.

4.3 Participants

Participants were students who enrolled in general chemistry and general physics courses and their faculty from 18 different public universities in Turkey. Number of students who benefit from VL were approximately 1600. Participants were mainly first and second year students. A total of 88 students out of 1600 voluntarily participated into study and answered the survey questions voluntarily. The total number of participants were 92. 88 of them were students and 4 of them were faculty members. The faculty members also answered the survey voluntarily. 72 of the students were female and 16 of them were male. Besides, three of the faculty members were male and one of them was female.

When students' grades are considered, it is seen that there were 72 freshman students, 13 sophomore students, three junior students and a senior student.

Students from different universities participated to this study; 22 of the participants were from Gümüşhane University, 31 of them from Tokat Gaziosmanpaşa University, 12 of them from Hitit University, four of them from Çankırı Karatekin University, two of them from Amasya University, 11 of them Adıyaman University and 6 of them Kütahya Dumlupınar University.

The faculty members were from Kütahya Dumlupınar University, Adıyaman University, Tokat Gaziosmanpaşa University and Hitit University.

According to the survey results, 63 (71,6%) of the students have a computer at home. 19 (21,6%) of the students have no computer at home. The rest of the students have a shared computer.

68 of the students can use computer. 61 of the students do not play games on computer. Working with a computer does not scare 68 of the students. 25 of the students partially scare working with computer. Only five of the students scare working with computer. 90,9 percent of the students have computer certificates.

The table containing the students' previous experiences and thoughts about computers, laboratories and virtual laboratories is presented below.

Table 3. 1 Background Information about Students

	Yes (f)	Partially (f)	No (f)
Computer Ownership	63	6	19
Ability to use computer	68	14	6
Playing games on computer	8	19	61
Anxiety in working with computer	5	25	58
Computer certificate ownership	3	5	80
Thinks it is easy to do research using computers	62	26	0
Uses computers in the school	18	25	38
Have computer labs in their school	45	21	12

Thinks that the computer will weaken their communication with their teacher	10	18	56
Thinks using colorful shapes, moving images and sounds in science lessons make learning science subjects easier	70	14	4
Likes to learn science topics using computers?	30	29	29
Interest toward the science increases when studying in a computerized environment	30	29	29
Finds it is easy to learn science courses in a computerized environment	25	36	26
Thinks teacher-student and student-student interaction increase in science education when classes are taught in a computerized environment	13	42	33
Enjoys experimenting or watching a demonstration of an experiment in science classes	58	22	8
Thinks that it would be more enjoyable, fun and permanent to do experiments by using computer.	21	34	21
Thinks that doing experiments in computerized environments is safer than doing experiments in a laboratory environment.	69	14	5
Thinks that the results of science experiments would be more accurate and more reliable when conducted using a computer.	30	48	10
Has knowledge about virtual laboratories	48	33	7

Thinks that using a computer while doing evaluations in physics and chemistry courses is more comfortable due to the fact that the evaluations are between the computer and you?	27	43	17

4.4 Data Collection Instruments

Two different surveys were used to gather data from participants. “Students’ perceptions on VL survey” was applied to students and had 28 three choice questions (Yes, Partially, No) and 17 open-ended questions. The “Faculty’s perceptions on VL survey” survey was applied to faculty members and had 26 three choice questions (Yes, Partially, No) and 17 open-ended questions. Surveys were developed by Çevik (2006), and were used in a study that investigate faculty’ and students’ opinions concerning computer supported chemistry education. These surveys and open-ended questions were chosen because the questions were able to to answer the research questions of this study. The open ended questions were developed by Tatlı, (2011). Open-ended questions were used in a study which intended to develop, implement and evaluate VL experiments on chemical changes unit.

For the “Students’ perception on VL survey”, some adaptations were made. Three choice questions were adapted by the researcher. There were 30 questions at the beginning. Two questions were taken out from survey because they were not suitable for the activities performed in the VL labs. These questions were directly related with that study. Besides, the chemistry expressions in the questions were changed to "science courses". As a result, 28 questions remained for this section of the survey. Some changes were made for the open-ended questions as well. There were 22 questions at the beginning and they were specific to experiments. Not all of the questions suitable for VL used in this research. For this reason, these questions were taken out. As in the three choice questions, “chemistry education” phrases were converted to “science education” here too. As a result, 17 questions remained for the open-ended question part. (Appendix A)

For the “Faculty’ perception on VL survey”, some adaptations were made. Three choice questions and open-ended questions are adapted by the researcher. “Chemistry” expressions in the questions were changed to "science courses" here too. No changes were made in the number of questions for both three choice questions section and open ended-questions section. (Appendix B)

Before adaptations were made, permission was obtained from the authors of the related research studies. While adapting the questions, a science teacher except the researcher was consulted. The modifications and changes were made according to his consultation. In addition, the questions were reviewed by a professor from the computer education and instructional technology department.

4.5 Procedures of the Study

In this part of the study, data collection procedure and VL usage procedure explained.

4.5.1 Data Collection Procedure

The study was conducted during 2020-2021 fall and spring semesters. Students and their faculty had experienced virtual physics and chemistry laboratory activities during 2020-2021 fall semester and beginning of the 2020-2021 spring semester. Every week a new experiment was uploaded to the the system. The students had the opportunity to conduct an experiment on the subject in parallel with the course content every week. Laboratory assignments were mandatory. During this period, the virtual physics and chemistry laboratory activities were used by 18 universities within the scope of general chemistry and general physics courses. Approximately 1600 students were enrolled in these courses. After allowing students to experience VL during a semester, data was collected. Ethics committee approval was obtained by sending data collection tools and information about the population to the human research ethics committee before starting data collection. Participants were informed about the study and their consent to participate in the study was obtained. Data collection from students and faculty was carried out online. There was a confirmation part on survey. In this section, after obtaining the consent of the participants, the questions were opened to the participants. At the end of the 2020-2021 fall semester, surveys were sent to the faculty for students to fill out. The return rate was approximately 3,3%. This number was not sufficient to interpret the data sufficiently. For this reason, at the beginning of the 2020-2021 spring semester, reminders were made for the participants who did not fill the survey. After the reminder, return rate increased to 5,5%. Participants voluntarily answered the questions. After the data collection procedure was completed, the data analysis process was started.

4.5.2 Virtual laboratory Usage Procedure

In order to enter the experiment, participants first logged into "https://yoksanlab.yok.gov.tr/" with their predefined username and password. Before starting the experiment, an informative part about the laboratory and experiments was displayed. Afterwards, the preliminary evaluation questions, the list of chemicals and the execution of the experiment were presented to the students. After that, experiment was conducted. There is a results screen where they can save the results they find at the end of the experiment or during the experiment. After the values to be entered here are completed with accuracy, the experiment ends. Students followed the steps below to conduct virtual chemistry and physics experiments.

1. Firstly, students are enrolled to the general chemistry and general physics courses.
2. Then, registered students were identified to the system where they can log in to the VL by their faculty. (This happens only once at the beginning of the semester.)

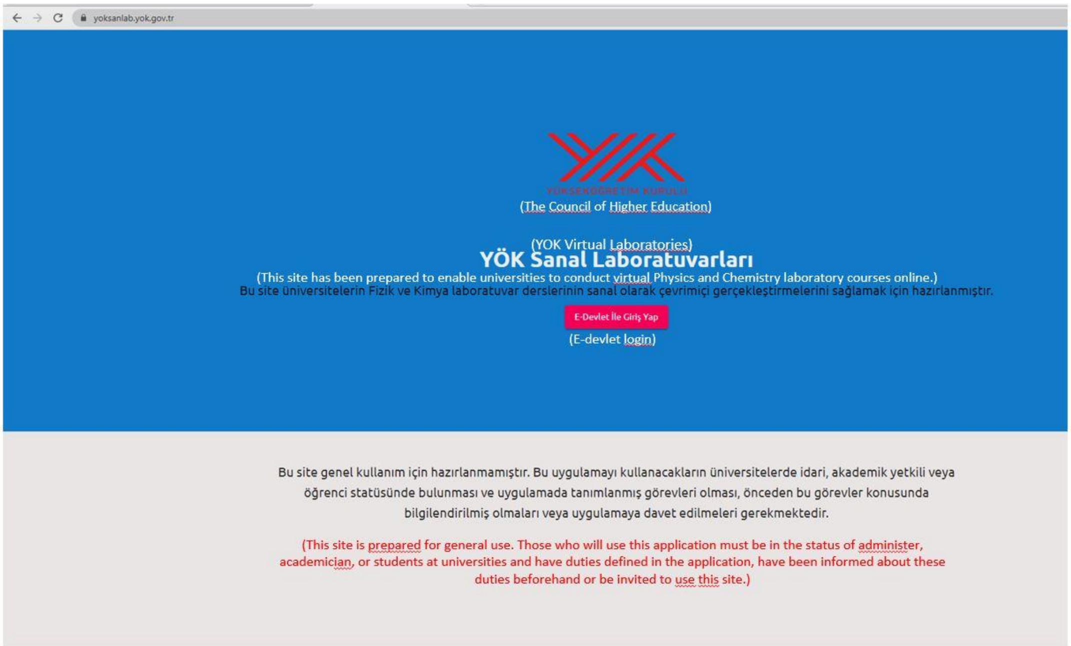

Figure 3. 1 *Virtual laboratory login screen*

3. Before starting the experiments, general informative information was given to the students with sounded animations.

Figure 3. 2 *Virtual laboratory warning screen - 1*

Figure 3. 3 *Virtual laboratory warning screen - 2*

4. Then, pre-laboratory questions appear on the screen that will make the student aware of what they have already know and don't know about laboratory.

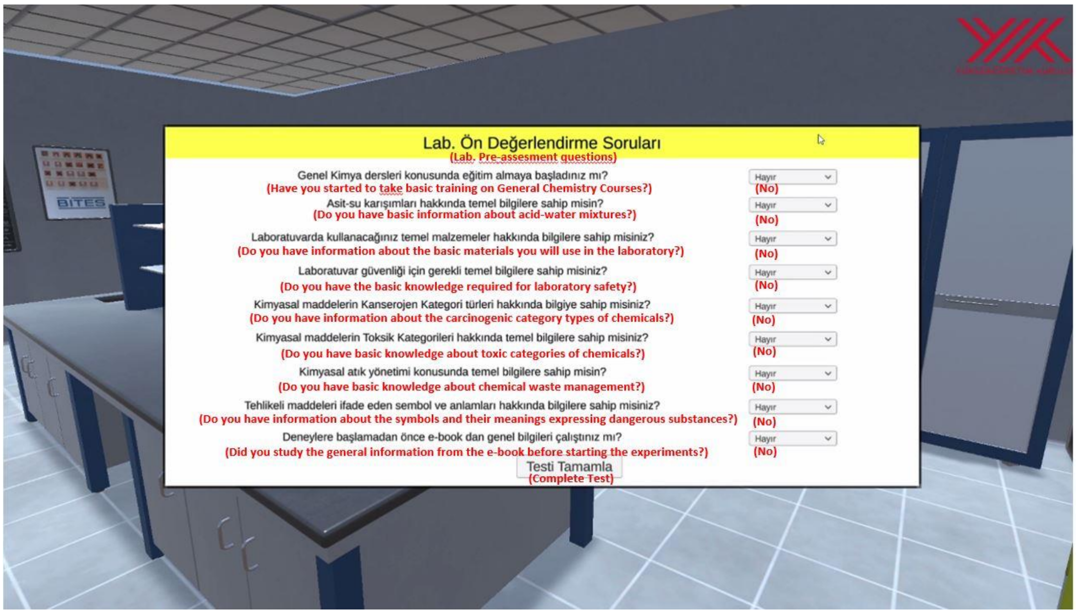

Figure 3. 4 *Virtual laboratory pre-assessment*

5. Afterwards, the leaflet and materials of the experiment which belongs to that week are displayed on the screen. On this screen, students make their own selection of chemicals to use in the experiment.

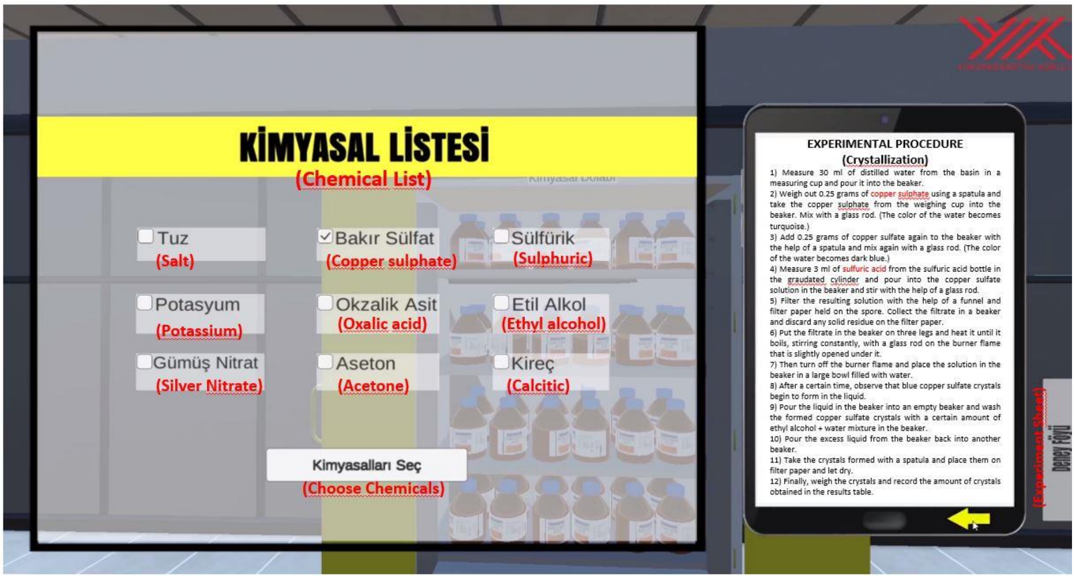

Figure 3. 5 *Chemicals and leaflet*

6. Then, students move on with the experiment. Screenshots of the experiments are as follows.

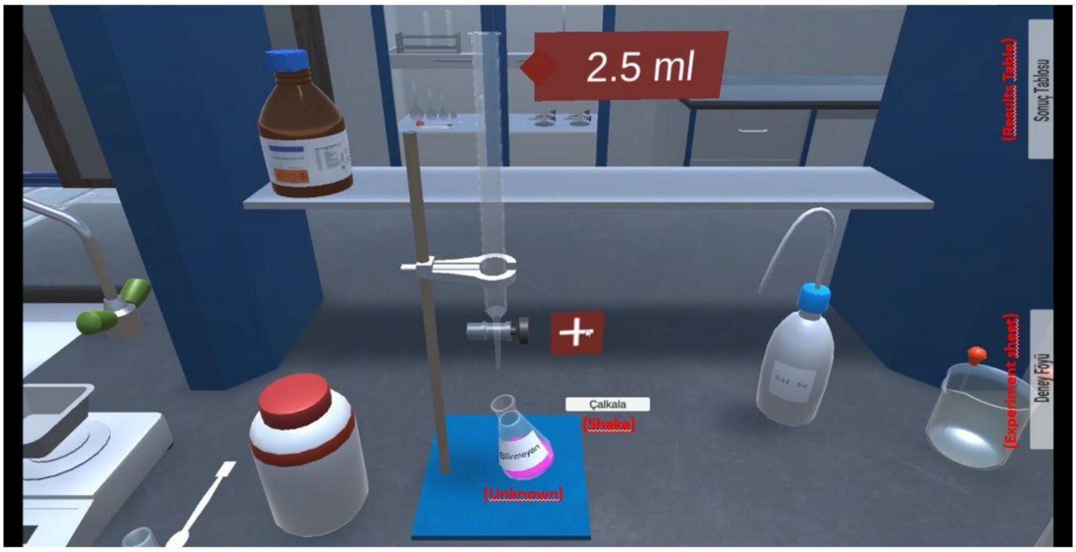

Figure 3. 6 *Experiment - 1*

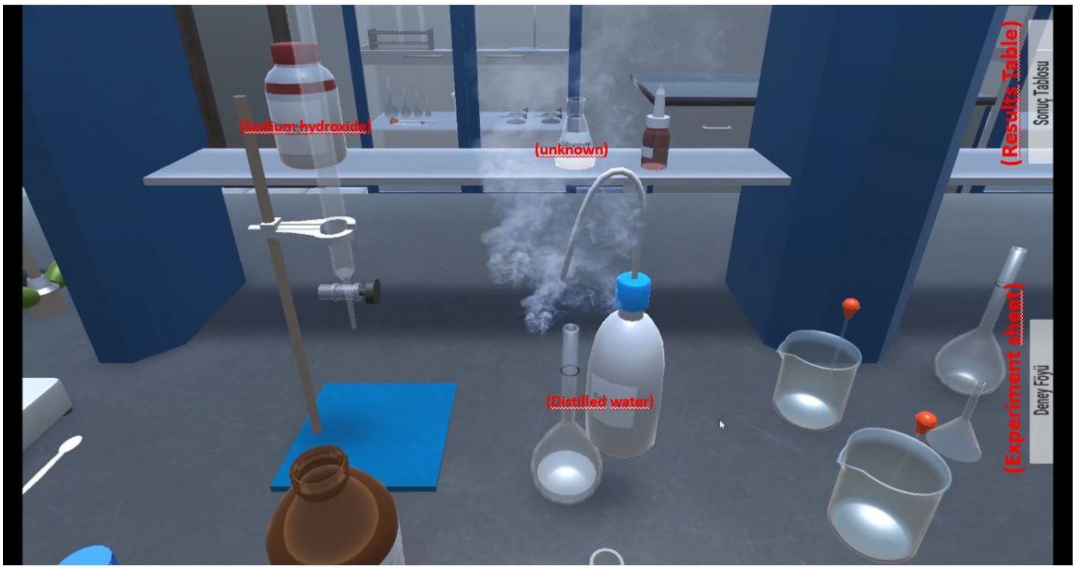

Figure 3. 7 *Experiment - 2*

7. After the experiment is finished, the value obtained is entered on the screen.

Figure 3. 8 *Results of experiment*

8. If the result is correct, the experiment is completed. If it is wrong, it is directed to the missing part.

9. Detailed video about virtual chemistry and physics laboratory can be accessed by clicking the given link:

https://www.yok.gov.tr/video/yok-sanal-laboratuvar-projesi-tanitim-videosu.mp4

4.6 Data Analysis

In this study, two different types of data analysis methods were used for three-choice questions and open-ended ended questions in the survey. The data gathered from three-choice question surveys were analyzed by using descriptive statistical techniques; frequencies and percentages. The data gathered from the open ended questions were analyzed with the content analysis method. Firstly, the researcher read the answers of the participants several times. Coding was done according to the concepts derived from the data. For example, a student's answer was "Experiments are learned in physical laboratory but, in VL, experiments are forgotten.". This answer was coded as forgettable. Afterwards, these codes are gathered under categories that remind the same meaning. And, categories are converted to themes that represens a more general idea about the answers. The study took a qualitative approach to identify students' and faculty' perception about virtual physics and chemistry laboratory activities. The data was collected via two version of the questionnaire namely; "Students' perceptions on VL survey" and "Faculty' perceptions on VL survey". Students answered the questions in Turkish. For this reason, their answers were translated into English. Coding reliability was ensured with interrated reliability. The answers were asked to be coded by a person who is both a doctoral student and an English teacher at the same time. In this qualitative study, the agreement between the coders was calculated using the formula (Reliability = Consensus / (Consensus + Disagreement) X 100) proposed by Miles and Huberman to determine the reliability (Çivril,2017). The researcher and the person's coding overlapped each other by 80%. Participants were already available for the researcher who starting to use VL in 2020-2021 fall semester in 18 different state universities. The participants have answered the questions voluntarily.

CHAPTER 4

RESULTS

This chapter reveals the analysis of the data obtained from "students' perceptions on VL survey" and "faculty' perceptions on VL survey" after a semester students had experienced the virtual physics and chemistry laboratory activities. Both of the surveys include three-choice questions and open-ended questions.

The results both provide information about the students' views and their current situation. The computer is an essential tool to make use of the virtual lab.

The research questions of this research are as follows:

1. What are the perceptions of students toward the virtual physics and chemistry laboratory activities?

2. What are the perceptions of faculty toward the virtual physics and chemistry laboratory activities?

5.1 Results Students' Perceptions

The data obtained from the answers given by the students to the questions in the three-option perception determination questionnaires analyzed. The findings are presented as percentages (%) and frequencies (f) under the related question.

1. Do you have difficulty in using the virtual physics and chemistry laboratory?

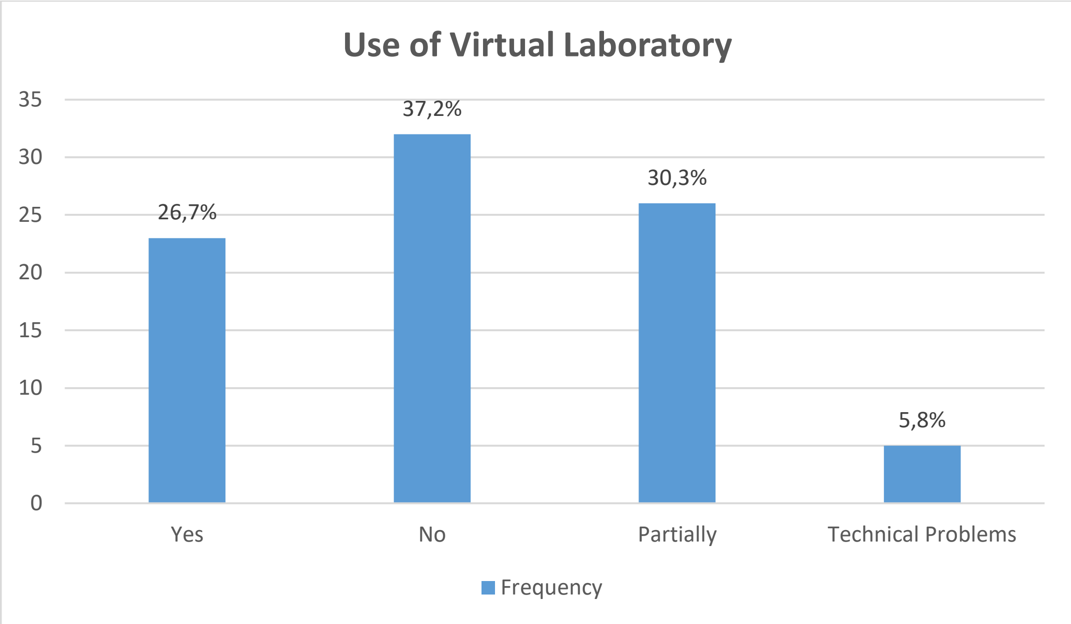

Figure 4. 1 Using virtual laboratory

Figure 4. 1 includes findings on distribution of usage difficulty of VL. Examination of these findings shows that 23 (26,7%) of the students have difficulty in usage of VL. 32 (37,2) of the 86 students did not encounter any difficult in using VL. 26 (30,3) of the students partially have some difficulty. Five (5,8%) of the students have technical problems.

2. Is the VL effective?

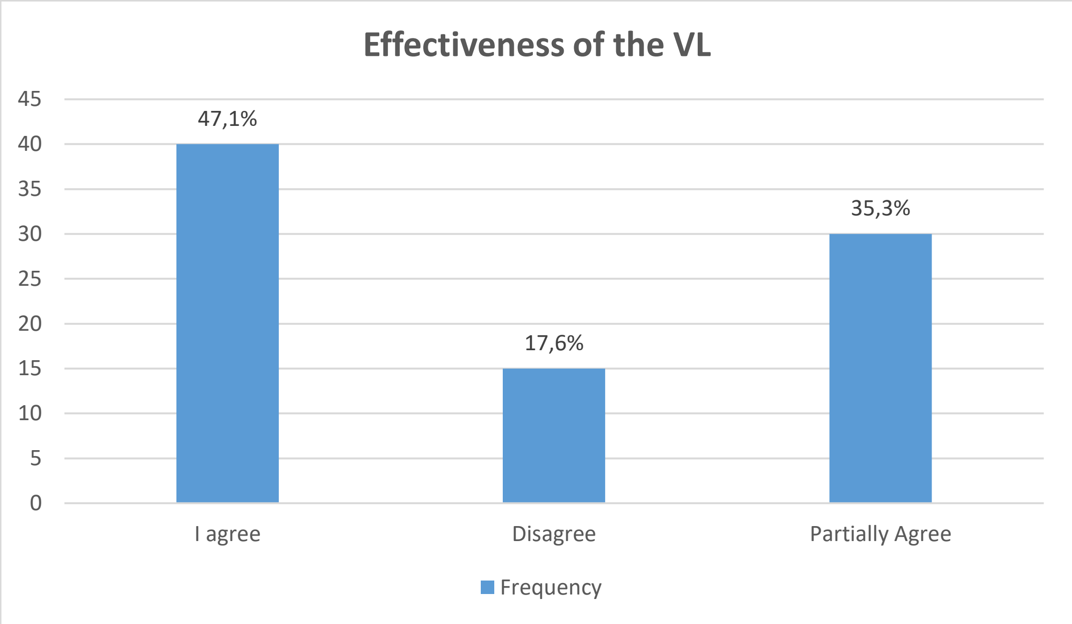

Figure 4. 2 Effectiveness of the VL

According to the data in the Figure 4. 2, it is understood that 40 (47,1%) of the students think that VL is effective. 15 (17,6%) of the students think that VL is not effective. 30 (35,3%) of the students think that VL is partially effective.

3. Could you learn by conduct experiments with the VL?

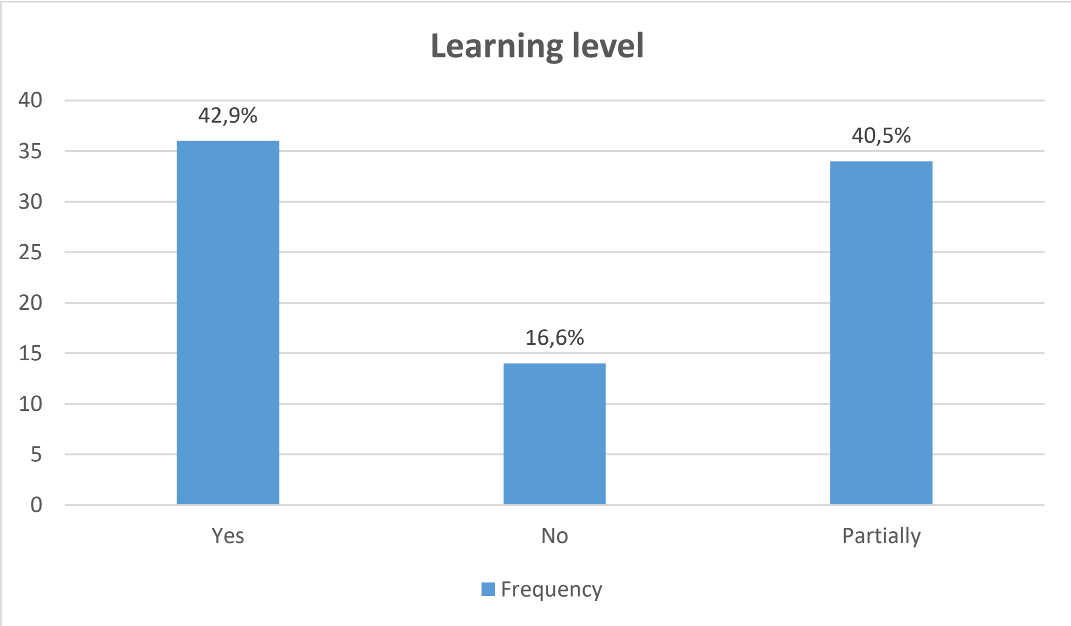

Figure 4. 3 Learning Level

Figure 4. 3 shows descriptive findings on learning level of students when conducting experiments with VL. 36 (42,9%) of the students think that they have learned experiment when they conduct experiment in VL. 14 (16,6%) of the students think that they did not learned the experiment when they use VL. 34 (40,5%) of the students think that they can partially conduct experiments with VL.

4. **Could you learn what you should pay attention to while doing real laboratory experiments by using VLs? (Like what safety precautions you should take.)**

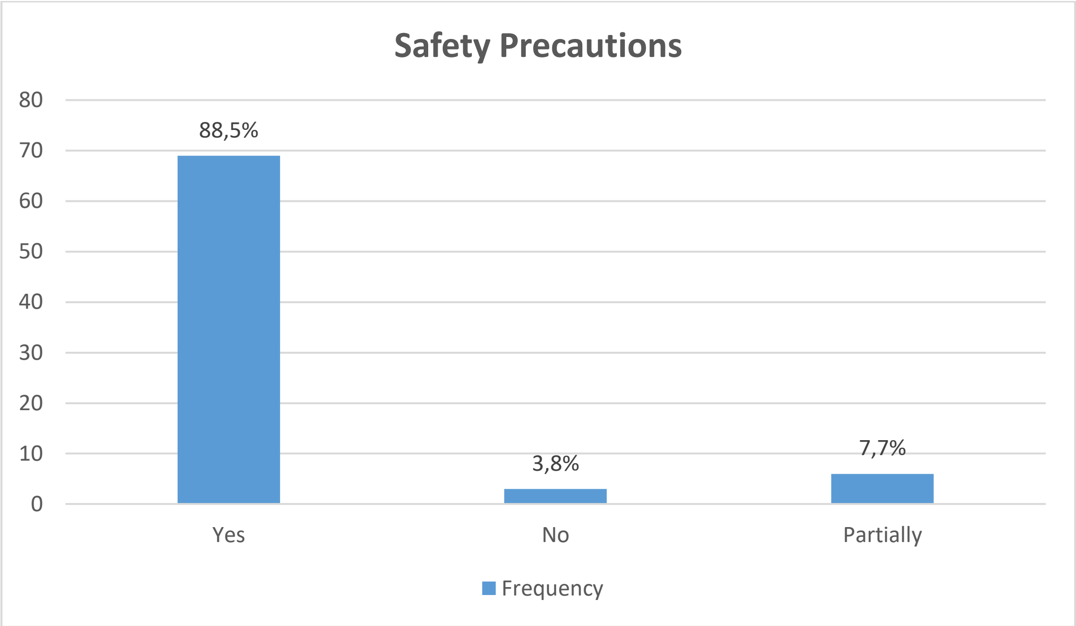

Figure 4. 4 Safety precautions

Figure 4. 4 shows frequency and percentages of the number of participants who expressed their opinions about the laboratory precautions. Present study has revealed that 69 (88,5%) of the students know what precautions they should take while being in physical laboratory. Three (3,8%) of the students does not know what precautions they should take. Six (7,7%) of the students partially know what precautions to take.

5. **If you were asked to conduct these experiments in a physical laboratory, can you do it without facing any difficulty?**

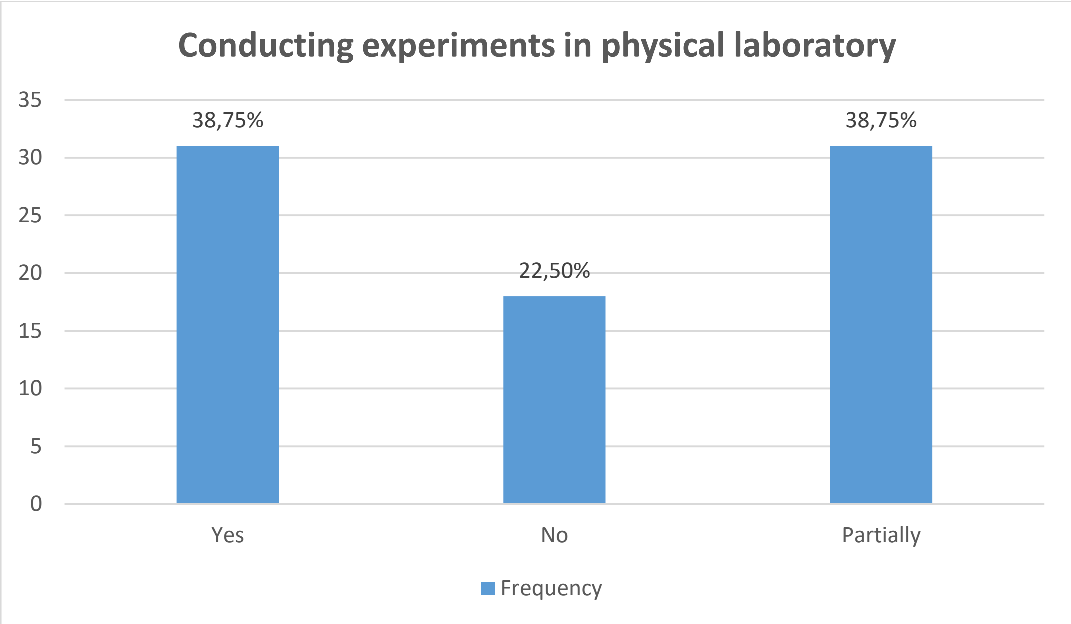

Figure 4. 5 Conducting experiments in physical laboratory

Figure 4. 5 shows frequencies and percentages of students who can conduct experiments which are done in VL in physical laboratory. It can be seen that 31 (38,75%) of the students can conduct experiments without difficulty. 18 (22,5%) of the students stated that they cannot conduct experiments which they have already completed in VL physical laboratory. 31 (38,75%) of the students partially agree with that.

6. If you had a choice, which would you choose? (VL or PL?)

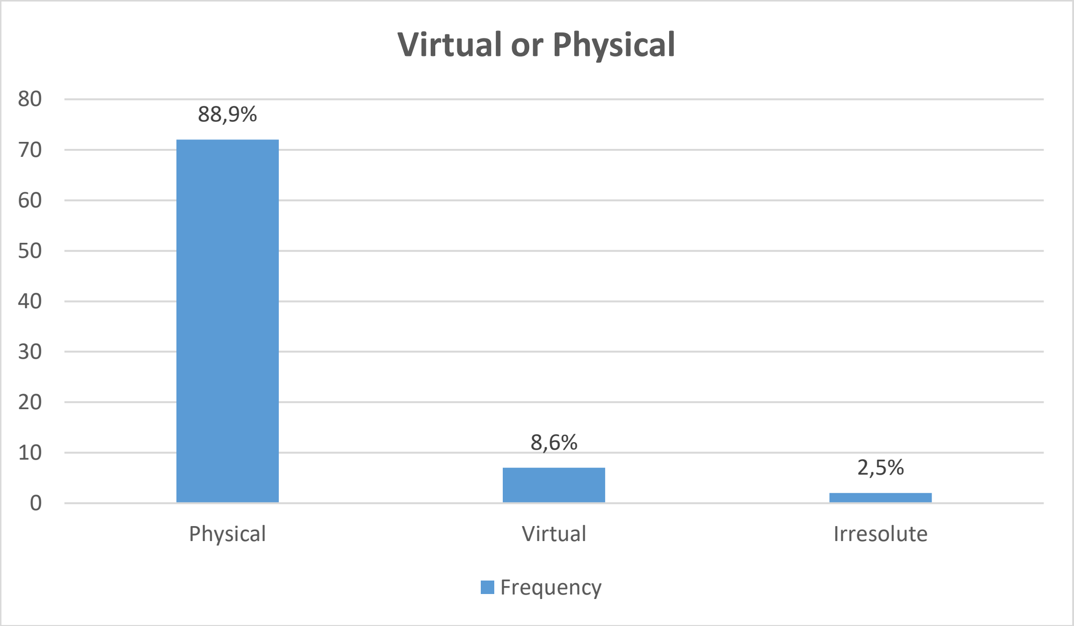

Figure 4. 6 Virtual and physical laboratory preference

The above presented figure represents the descriptive data of the students who make a choice between physical laboratory and virtual laboratory. 72 (88,9%) of the students prefer physical laboratory. Seven (8,6%) of the students prefer VLs. Two (2,5%) of the students are irresolute.

7. Did you had any physical lab experiments before?

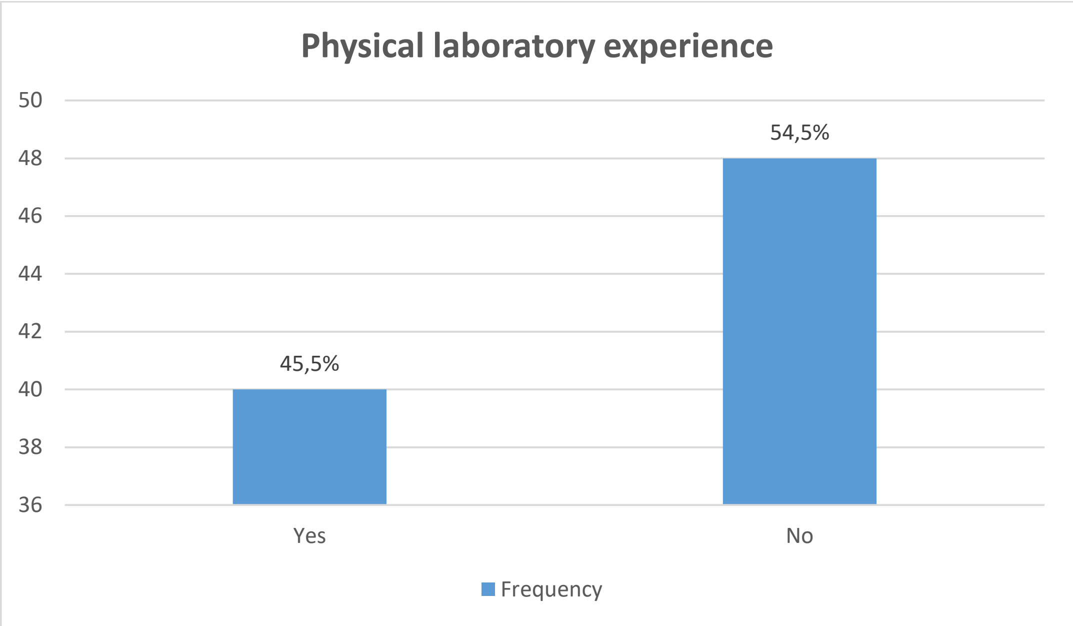

Figure 4. 7 Physical laboratory experience

Figure 4. 7 shows descriptive findings on physical laboratory experience. 48 (54,5%) of the students have no physical laboratory experience. 40 (45,5%) of the students experienced physical laboratory at least once.

8. Would you use VL outside of class (even without your instructor telling you)?

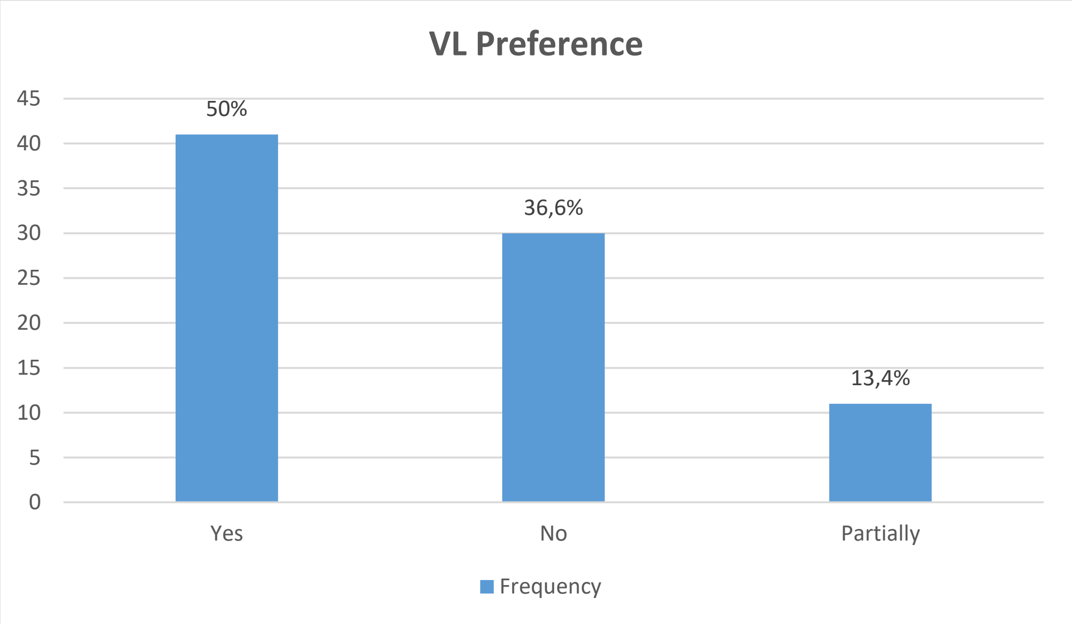

Figure 4. 8 Virtual laboratory preference

Figure 4. 8 shows that 41 (50%) of the students prefer to use VL outside the class. 30 (36,6%) of the students does not prefer VL outside class. 11 (13,4) of the students partially agree with that.

5.2 Results on Students' Answers to Open-ended Questions in VL Survey

Students' views about "Virtual Physics and Chemistry Laboratory" are presented in this study. The VL includes the subjects of general chemistry laboratory and general physics laboratory courses. Perceptions of students are gathered by using "Students' perception on VL survey". There were open-ended questions about their VL experience. Participants answered the questions voluntarily. The data were analyzed through content analysis. Firstly, answers were compiled in a separate file. The data were organized and interpreted on the basis of strengths and weaknesses. Afterward, the coding was done according to the concepts extracted from the data. Then, these concepts are grouped under themes which are more general and abstract from the concepts. These themes were created based on the answers of the students by using inductive method. It was aimed to obtain students' perceptions about virtual general chemistry and virtual general physics laboratory.

As a result of the content analysis, the perceptions of the students were themed. The students generally expressed positive opinions, but stated that they would prefer the real laboratory environment because the VL environment did not met the real laboratory environment conditions. There are eleven main questions to figure out students' opinions after experiencing VL. In this part, the data was categorized as strengths and weaknesses of the experience and further suggestions.

5.3 Strengths of Virtual Physics and Chemistry Laboratory

First of all, students generally expressed positive opinions about VL. According to the students' answers virtual physics and chemistry laboratory has a variety of educational and personal benefits. The strengths of the VL are grouped under two main themes. These themes are educational methods and VL experience.

Table 4. 1 Strengths of virtual physics and chemistry laboratory activities

EDUCATIONAL METHODS				**VL EXPERIENCE**	
Content	**(f)**	**Utilities**	**(f)**	**VL Experience**	(f)
Easy to learn	1	Allows repetition	2	Increases self-responsibility	1
No margin of error	2	Safe	11	Gaining experience	3
Meaningful learning	8	Easy to reach	1	Enhancing ability to find solutions	1

Constructing knowledge	9	Give opportunity to experiment virtually	4	Increases sense of curiosity	2
Permanent Learning	5	Time saving	1	Increases analytical thinking abilities	1
Reinforcement	3	Give opportunity to observe uncommon experiments	1	Efficient before real laboratory	1
Conceptual understanding	8	Give opportunity to experiment remotely	4	Laboratory experience	1
Facilitates learning	6	Equality in opportunities	1	Laboratory skills	8
Increases productivity	1	Gives opportunity to conduct unseen experiments	1	Satisfaction	15
Instructive	8				
Learning oriented	1				
Visually enriched content	1				
Conceptual learning	4				

The first theme created based on students' answers is educational methods. This theme also divided into 2 categories. The first one is “Content”, and the second one is “Utilities”. These categories are determined based on the coding made on the answers of the students. For example, one of the students thought that the experiments in the virtual laboratory were safe. This answer was coded as “safe”.

Safety was one of the utilities of the virtual laboratory and therefore it was placed under the "Utilities" category. Since the utilities mentioned here are the utilities handled from an educational point of view, this category is included under the theme of educational method.

The first category under this theme is the content. By considering students answers, virtual chemistry and physics laboratory has various advantages in terms of content. These benefits are listed in Table 4. 1. Students have plenty of opinions about the content. Some of the students' thoughts about this category is presented below.

The first one is that there is no margin of error in VL. Some of the students' answers are listed below.

> Interviewee: "There is no margin of error in the results and we can repeat the experiments over and over again."

> Interviewee: "There is no margin of error in VL."

Students' answers shows the virtual laboratory contributes to meaningful learning. Some of the students' answers are listed below.

> Interviewee: "Since we could concretely see the experiments in the online education process, the lessons became more meaningful".

> Interviewee: "I got to know materials and chemicals better"

> Interviewee: "I learned the tricks of experimenting"

Virtual laboratory helps students to construct their knowledge about general chemistry and general physics. Some of the students' answers are listed below.

> Interviewee: "Helped me better understand physics."

> Interviewee: "In experiments, I learned how important proportions are."

> Interviewee: "I learned about the experiments."

> Interviewee: "Learning of certain experiments."

Interviewee: “Contribution to the course increased.”

Students’ answers show that the virtual laboratory contributes to permanent learning. Some of the students’ answers are listed below.

Interviewee: “It became more permanent because it offered visual content.”

Interviewee: “Catchy, memorable.”

Interviewee: “It stays in mind.”

Interviewee: “Increases the memorability of the subject.”

Interviewee: “Increasing the permanence of the subjects with experiments.”

According to students’ answers, virtual laboratory has contribution to reinforcement. Some of the students’ answers are listed below.

Interviewee: “It reinforced the things I learned.”

Interviewee: “It helps to reinforce what we have learned.”

Students’ answers show that the virtual laboratory contributes to conceptual understanding. Some of the students’ answers are listed below.

Interviewee: “I can say that my knowledge of laboratory materials has gained me a lot about the laboratory.”

Interviewee: “Knowledge/competence on the subject.”

Interviewee: “I learned the laboratory environment.”

Interviewee: “Teach the subject with experiments.”

According to students’ answers, virtual laboratory facilitates learning. Some of the students’ answers are listed below.

Interviewee: “Makes learning easier.”

Interviewee: “A good application to learn the subjects better.”

Interviewee: “I think it's supportive.”

Interviewee: “I got to know the laboratory devices better. I was able to learn more or less how to do some general experiments.”

According to students’ answers, virtual laboratory increases productivity. One of the students’ answer is listed below.

Interviewee: “It made it possible to conduct laboratory experiments more efficiently during the pandemic process.”

Students’ answers show that students think the virtual laboratory is instructive. Some of the students’ answers are listed below.

Interviewee: “It is effective in learning.”

Interviewee: “Effective for learning.”

Interviewee: “The conditions that are not fulfilled due to the pandemic are somewhat instructive for students.”

Interviewee: “Good for learning.”

One of students’ think that virtual laboratory is learning oriented.

Interviewee: “Learning-oriented practice if the lesson and experiments are mastered.”

One of students’ think that the virtual laboratory has visually enriched content.

Interviewee: “Represents visual content.”

Students’ answers show that the virtual laboratory contributes to conceptual learning. Some of the students’ answers are listed below.

Interviewee: “Learning experiment materials and equipment.”

Interviewee: “Information about laboratories.”

The second category under the educational content theme is “Utilities.” This category is determined on the basis of the coding made on the answers of the students. By considering students answers, virtual chemistry and physics laboratory has various educational utilities. These utilities are listed in Table 4. 1.

The first utility of virtual chemistry and physics laboratory is allowing repetition. Some of the students’ answers are listed below.

> Interviewee: “I think we don't have the luxury of not learning because we can watch it again.”

> Interviewee: “We can experiment as much as we want in the virtual laboratory.”

Students’ answers show that the virtual laboratory is safe. Some of the students’ answers are listed below.

> Interviewee: “Less dangerous”

> Interviewee: “No danger”

> Interviewee: “The positive side is that the danger that may occur in the experimental environment is reset.”

> Interviewee: “But we learn many things we need to learn without risk, without danger.”

> Interviewee: “It does not allow accidents that may occur only while experimenting in a virtual environment.”

One of the students think that VL is easy to reach.

> Interviewee: “Easy to reach”

According to students’ answers, the virtual laboratory allows experimenting virtually. Some of the students’ answers are listed below.

> Interviewee: “Gave opportunity to experiment in a virtual environment”

> Interviewee: “At least we can make sense of experiments and purposes in general, albeit virtual”

One of the students think that VL is time saving.

> Interviewee: “In making measurements and warming up, etc. I need to wait. Virtual lab doesn't make you wait too long, everything happens in a short time.”

One of the students think that VL allows observing uncommon experiments.

> Interviewee: “It helps us to observe experiments that we cannot do in real life.”

According to students’ answers, virtual laboratory allows experimenting remotely. Some of the students’ answers are listed below.

> Interviewee: “Enabled the experiment to be done remotely.”

> Interviewee: “To be able to experiment, albeit remotely.”

> Interviewee: “Being able to teach something even from a distance.”

One of the students think that VL gives equal opportunities to the students.

> Interviewee: “Helped me not to fall behind in lab class.”

One of the students think that VL gives opportunity to conduct unseen experiments.

> Interviewee: “The chance to do laboratory experiments that we do not know and do not see.”

The second theme created based on students' answers is experience. After experiencing virtual laboratory activities, students are gained experience about VL. This theme is explained under nine categories.

The first category is self-responsibility. One of the students think that VL increases self-responsibility.

Interviewee: “Gained the awareness of homework in distance education period.”

According to the students answers VL help students to gain experience. Some of the students’ answer is listed below.

Interviewee: “I can't say that it has much of an effect, but it creates a little experience about the laboratory.”

Interviewee: “Gained experience.”

One of the students’ think that VL enhanced the ability to find solutions.

Interviewee: “Teach me finding solutions to gain knowledge.”

Two of the students’ said that VL increases the sense of curiosity.

Interviewee: “It increased the sense of curiosity.”

Interviewee: “Curiosity.”

One of the students’ think that VL increases analytical thinking abilities.

Interviewee: “Taught me to think more analytically”

One of the students’ think that VL is efficient before the real laboratory.

Interviewee: “Preparation before real lab.”

One of the students’ think that VL gained laboratory experience.

Interviewee: “Gained laboratory experience.”

According to the students’ answers VL helped to develop laboratory skills. Some of the students’ answer is listed below.

Interviewee: “Teaching how to do experiments.”

Interviewee: “I learned how to do experiments.”

Interviewee: “I saw experimenting in a lab setting.”

Interviewee: “Gained the ability to experiment.”

Interviewee: “Dealing more closely with chemical materials.”

Some students also gave answers about their virtual laboratory satisfaction. Some of the students’ answer is listed below.

Interviewee: “It's not very good, but it'll do.”

Interviewee: “I am very satisfied with the virtual chemistry lab.”

Interviewee: “It is an advantage that we can do many things, although not as much as a real chemistry laboratory.”

Interviewee: “It has had an impact on us to have a healthier life.”

Interviewee: “I like it well.”

5.4 Weaknesses of Virtual Physics and Chemistry Laboratory

Students also have negative opinions about virtual physics and chemistry laboratory activities. Many of the students who gave negative opinions stated that the VL was not effective and interesting. According to the results, students think that the virtual physics and chemistry laboratory needs to be improved to be more effective and interesting. There are also problems caused by hardware inadequacy. VL has weaker aspects than real laboratory in terms of educational benefits and personal benefits. By considering students’ answers, weaknesses of the VL are grouped under three main themes. These themes are technical constraints, educational constraints and personal experience.

Table 4. 2 Weaknesses of virtual physics and chemistry laboratory

TECHNICAL CONSTRAINTS		EDUCATIONAL CONSTRAINTS		PERSONAL EXPERIENCE	
Hardware	**(f)**	**Content**	**(f)**	**Personal Experience**	**(f)**

Lack of computer	7	More information needed	1	Not distinctive	1
Incompatible with computer	1	Physical more permanent	2	Not interesting	3
Suffering from computer	1	Less memorable	6	Touching materials	1
Hardware of computer	2	Forgettable	1	Using materials	1
Virtual Laboratory	**(f)**	Decreases learning	1	Less funny	1
Incompatibility with smartphones	2	Makes learning difficult	1	Effectiveness is zero	1
Login error	2	Difficulty in understanding	2	Not effective	10
Using too much RAM	1	Inadequacy in teaching	2	Useless	1
Freezing	1	Not instructive	1	Effectiveness is weak	20
Progress slowly	1	Destroy interaction	3	**Satisfaction**	**(f)**
Trouble in watching	1	Absence of teacher	1	Satisfaction	12
Very slow	1	Too abstract	1		
Needs improvement	2	**Structure of the virtual laboratory**	**(f)**		
		Difficult to observe	1		
		Computer guides us	1		

The first theme created based on students’ answers is technical constraints. According to the students' answers, it seems that there can be two types of technical problems. One of them is caused by the hardware itself, and the another one is encountered while entering the system and while using it.

The first technical constraint is caused by hardware. Students who stated that they did not have a computer could not access the experiments at all, or they could only view some of the experiments by borrowing computers from other people for a limited time. Also, VL is incompatible with smart phones. According to the results, the hardware features of the students' computers are not sufficient to carry out the experiments. Some of the students' answers are presented below.

> Interviewee: "I did not do the experiments myself because I don't have a computer."

> Interviewee: "I can't use the virtual lab because I don't have a computer.

> Interviewee: "I want experiments to be done by using phone."

> Interviewee: "I'm really suffering from my computer which is not have capability to conduct experiments virtually and I hope universities will open soon."

> Interviewee: "The homework given is done, of course, thanks to the Internet, but I don't think it could have a contribution to my learning since I could not enter the 'experiment' section and I could not learn how to conduct an experiment.

> Interviewee: "Due to the infrastructure of my computer, I cannot do it at home, I need to try from other computers."

The second technical constraint is caused by VL itself. Two of the students stated that there was login error and this should be corrected. Besides, according to students' answers VL uses excessive amount of RAM, which slows down the experiments. Some of the students stated that the system has a freezing issue both while watching the experiments and while performing the experiments. Two of the students think that VL needs improvement. Some of the students' answers are presented below.

> Interviewee: "Some bugs in the VL should be fixed. For example, I get an error whenever I enter the system to test the lesson. After trying 5-6 times, I can enter. Sometimes it doesn't work at all, I think this problem should be solved. But it is an efficient system."

> Interviewee: "The program needs to be improved so that it does not give errors."

> Interviewee: "Virtual labs use too much ram on the computer and the computer crashes. It takes my whole day to finish an experiment. That's why I would like the application to be developed. "

> Interviewee: "There is constant freezing and the test hours should be removed and we should enter whenever we want."

> Interviewee: "We are having difficulties logging into the system. The VL does not open on every computer and sometimes progresses very slowly."

> Interviewee: "A system that needs improvement."

The second theme created based on students' answers is educational constraints. Students stated that the VL has some educational limitations. Educational constraints are grouped under two categories. First one is about the content and the other one is related with the structure of the VL.

The first category under this theme is the content. Students have plenty of opinions about the content. Some of the students' answers are listed below.

> Interviewee: "More information should be provided about the use of the application and the reports prepared at the end of the experiments. Students should be assisted more about the distance education process."

> Interviewee: "Experimenting gives the person sleight of hand. I believe it will be more memorable, so I don't know how to take precautions."

> Interviewee: "Face-to-face instruction is more effective and permanent."

> Interviewee: “The subject is learned in the real laboratory, but forgotten in the virtual.”
>
> Interviewee: “Makes learning difficult.”
>
> Interviewee: “Decreases learning.”
>
> Interviewee: “Difficulty in understanding.”
>
> Interviewee: “Experiments could be explained with their reasons.”
>
> Interviewee: “You can ask anything you want in the real chemistry lab, but it is not possible in the virtual environment. For this reason, it is not instructive.”
>
> Interviewee: “Too abstract.”

The second category under this theme is related with structure of the VL. Students have plenty of opinions about the content. Some of the students’ answers are listed below. One of the students thinks that in VL computer guides students. This is another educational constraint of virtual physics and chemistry laboratory. One of the students thinks that in real laboratory environment, observation is easier.

> Interviewee: “We don't do the experiments, the computer guides us.”
>
> Interviewee: “Real is more fun. Observation is better in real laboratory environment.”

Personal experience is another theme created based on students’ answers. Students think that in VL environment materials and tools are not distinctive. Also, the laboratory environment is not interesting. Moreover, lack of sense of touch is another disadvantage of VL examined under this theme. This theme is divided into two categories which are personal experience and satisfaction.

The first category under this theme is the personal experience. Students have different perceptions about their personal experience. Some of the students’ answers are listed below.

Interviewee: “Experiments do not excite us. It is hard to distinguish laboratory materials and tools.”

Interviewee: “Would be more interesting and easy to learn if it becomes real”

Interviewee: “Real laboratory is better. It is better to use machines and materials on my own in real laboratory.”

Interviewee: “In the actual setting, it would be more efficient to live our excitement, stress, unforgettable memories and events, experiencing and touching the materials.”

Interviewee: “Its effectiveness is not too bad, but not too good either.”

Interviewee: “Doesn't have much effect on learning.”

Interviewee: “We're just watching. I don't think it's as effective as it is.”

Another theme created based on students’ answers is satisfaction. Some of the students think that VL does not satisfy students’ needs. Some of the students’ answers are listed below.

Interviewee: “I don’t use”

Interviewee: “Not being able to see objects and things alive.”

Interviewee: “Being abstract”

Interviewee: “Frankly, I think that nothing can replace coming to the university and doing experiments in the physical laboratory.”

Interviewee: “I find it more appropriate to conduct experiments in a physical laboratory.”

Interviewee: “All I want to point out is real chemistry lab is the best”

5.5 Answers to the Open-ended Questions in Faculty' Perception on VL Survey

Data obtained from answers given to open-ended questions to the "Faculty perceptions on VL survey" is presented in this section.

What were the effects of the VL activities on your students? What were the advantages and disadvantages of the VL for your students? (Answer based on your observations)

> Teacher 1: "Remarkable positive feedback was received from the students who are active in face-to-face education. But, the same feedback was not obtained from students who were not interested in the course."
>
> Teacher 2: "Although experiments are compulsory for students, the participation level was low."

What are the positive and negative aspects of VL activities for students?

> Teacher 1: "The inability to solve the problems in terms of accessibility (due to the fact that computers or phones do not support the program), some of the students are restricted from taking full advantage of the VL. However, after a certain point, online lessons were created and temporary solutions were created by the students who had difficulty in entering."
>
> Teacher 2: "Students have some problems with the experiments. I think the problem is related to the Internet infrastructure. They are trying to conduct experiments by using phone. Students make mistakes in the results because they are careless while doing the experiments. In fact, they cannot concentrate fully to the experiments."
>
> Teacher 4: "Does not replace physical laboratory."

What are the features of the VL that you like?

Teacher 1: “Explaining the preliminary information about the experiment audibly and visually under the supervision of the teacher, having a ready-made leaflet, including questions about the experiment that provide an opportunity for students to test themselves, requesting reports from students and returning them within the system, also the repeatability of the experiments and the routing signal etc.”

Teacher 2: “It's a good application. It guides you to the steps to be taken.”

Teacher 4: “Needs to be more detailed.”

What are the features of the VL that you don't like?

Teacher 1: “When mouse is over the glass material and chemical used, there could be an explanatory sentence about the device or chemical. We are not able to change the order of the experiments downwards. We can increase dates forward, but we cannot change it backwards.”

Teacher 2: “It might be possible to repeat the experiment without directing the student.”

Do you think that teaching science by using VL can provide benefits to the science teacher? Why?

Teacher 1: “Moving in a certain order and getting feedback can have a contribution to the science teacher”

Teacher 2: “Yes, it will be beneficial for the teacher while planning what needs to be done before the experiment.”

Teacher 4: “Yes”

Would you recommend VL to the faculty in other schools? Why?

Teacher 1: “There may not be a laboratory in every school or its conditions may not be sufficient. In this respect, of course, it can be recommended. At least, the student who gains confidence in the virtual environment can move more comfortably in the laboratory in face-to-face education in the future. In addition, students will have the opportunity to get education under the same conditions with many universities."

Teacher 2: "Yes, I think that it will be a useful practice to the student who are in schools with a lack of laboratory infrastructure."

Teacher 4: "Yes"

What is the benefits of using VL to students and faculty? What is the disadvantage of VL to the students and faculty?

Teacher 1: "Of course, gains of the physical laboratory is not equivalent to the gains of the VL. However, due to the pandemic, I think it is a very important and valuable resource for students within the possibilities."

Teacher 2: "It will provide benefits in preparation for the physical laboratory experiments with real chemicals and materials. It will reduce the possibility of making mistakes."

Teacher 4: "Speed and time. More experience."

Did you encounter any difficulty while your student swere using the VL?

Teacher 1: **"S**ome of the smartphones and computers do not support the virtual experiments. For this reason, we used the VL together by creating online lessons every week for students who are in this situation."

Teacher 2: "No"

Teacher 4: "Exciting"

In your opinion, did the VL impose a burden on you? Or did it support your class?

Teacher 1: "Due to the pandemic, it has made a very important contribution in a positive way."

Teacher 2: “It supported my lecture.”

Teacher 4: “It supported my lecture.”

What are the advantages of activities/experiments conducted at VL when you compare with the experiments conducted at physical laboratory?

Teacher 1: “Repeatability of the experiments at any time and absence of any safety risk.”

Teacher 2: “The accidents and chemical consumption they may encounter in the physical laboratory environment will be avoided.”

Teacher 4: “Opportunity to experiment more and opportunity to gain more experience.”

What are the disadvantages of activities/experiments conducted at VL when you compare with the experiments conducted at physical laboratory?

Teacher 1: “I think the gains like working by touching, developing different ideas and creating solutions against possible risks that may be encountered will be lacking in this sense.”

Teacher 2: “Students' abilities cannot be fully developed.”

Teacher 3: “Cannot replaceable with live experiment.”

Do you think the activities in the VL provide an environment where students could experiment on their own, experience the laboratory process and create their own knowledge?

Teacher 1: “Not exactly, but it is well prepared for pandemic period, and it is acceptable to have deficiencies.”

Teacher 2: “In my opinion, the virtual environment will not be able to provide the achievements of the real laboratory environment to the students.”

Teacher 4: “Partially true”

Do you think that classes can be taught by creating a constructivist environment with the VL?

Teacher 1: "Maybe for a particular period."

Teacher 2: "In part, the virtual environment can only be complementary."

Teacher 4: "Yes"

What kind of arrangements would you recommend to make in the VL?

Teacher 1: "In Question 4, this was answered."

Teacher 2: "For example, let's say he mixed two chemicals during the experiment, the chemical reaction that occurred at that time can be shown or physical event can be represented."

Teacher 4: "Definitely."

At which stage of the lesson would you like to use the VL?

Teacher 1: "I believe that it will make a great contribution to the students before the application."

Teacher 2: "In preparation"

Teacher 4: "Preliminary preparation for physical laboratory"

Is there anything else you would like to point out?

Teacher 1: "Thank you"

Teacher 2: "No"

Teacher 4: "It needs improvement"

CHAPTER 5

DISCUSSION

6.1 Introduction

This chapter presents the discussion of the findings obtained with regards to two main research questions, the implications for practice and recommendations for future studies and limitations of the study by making a comparison with the previous studies.

6.2 Summary of the Study

In this study, perceptions of the students and faculty about virtual physics and chemistry laboratory activities. This study aimed to figure out participant's perceptions about VL activities after experiencing it throughout a semester. Virtual physics and chemistry laboratory is developed in partnership with engineers and field experts. Afterward, students started to use virtual physics and chemistry laboratory for the first time at the beginning of the 2020-2021 fall semester. Meanwhile, the researcher started to research the questionnaire and open-ended questions that she would apply to the students after they experienced VL.

6.3 Discussion

Research questions in this research aimed to inquire students' and faculty' perceptions about virtual physics and chemistry laboratory activities after they experienced the VL environment throughout a semester. Three choices survey which includes open ended questions is applied to the participants. Participants' overall answers indicated that positive or negative opinions did not outweigh to each other.

Their feedback was valuable to determine possible challenges to make revisions, modifications and implications for future practices.

Consistent with the prior research, (Olympiou & Zacharia, 2012), some of this students and faculty stated that VLs provides risk free environments. It can be said that users' perception about security is in line with previous studies.

When students are asked to reveal their current situation about computers, computerized education and VL. It can be seen from the answers that five of the students do not have a personal computer at home. Moreover, five students had technical problems while using the VL. As Makransky et al. stated there might be technical issues. (2016) As can be understood from the answers of the students, there was no polarization in the answers. The students were not clustered in only one part. 47,1 % of the students think that VL was effective. 17,6% of the students are disagree with that and 35,3% of the students are undecided. Nearly half of the students think that they have learned experiments when conducting experiments in VL. As Ekmekci and Gulacar stated, VL and physical laboratory have different affordances which providing students unique learning experiences. (2015) Consistent with the prior research (Faour et al., 2018), a choice does not have to be made between both types. Each type has different educational outcomes and instruments/methods to measure the effectiveness. Although 54.5 percent of the students have no laboratory experience, 88.9% of them say that they would prefer the physical laboratory. This indicates that positive affordances of virtual physics and chemistry laboratory activities are not dominant enough to make them prefer VL. This idea supported by a study in the literature stating that more technology does not guarantee the improvement, result could be inadequate for developing educational laboratory experiences. (Brinson, 2015) Although 79.5% of the students think that colorful shapes, animated visuals and sounds will facilitate learning in science, they do not prefer to learn science through computers.

From the students' answers to the open-ended questions, it was inferred that students are favor of physical laboratory. The advantage of the VL under the certain themes with a frequency of 128 and a disadvantage with a frequency of 112. In other words, there are some students who do not find VL useful as much as they find it useful. Contrary to a study from the literature, instances used in VL are not beneficial as much as PL. (Olympiou & Zacharia, 2012) There are students who have completely opposite views about virtual physics and chemistry laboratory activities. For example, four of the students think that VL is memorable but, nine of the students think that VL is not memorable. Eight of the students think that VL is instructive but, three of the students think that VL is not instructive. This finding aligned with another study with Olympiou and Zacharia's combination of virtual manipulatives and physical manipulatives. In VL, students have a limited view on experimentation. (Olympiou & Zacharia, 2012) Studies have shown that combination of VL and PL results better in content knowledge. (Kapici et al., 2020) Moreover, three of the students think that VL is understandable but, two of the students think that VL is too abstract to understand. One of the students think that VL triggers the sense of curiosity but, three of the students think that VL is not interesting. In addition, seven of the students think that VL helps to distinguish chemical materials, but one of the students think that materials and tools are not distinctive in VL. Both types of laboratories have their strengths and weaknesses. (Ekmekci & Gulacar, 2015) It is important to carefully select and integrate the technological tools. Participants' perceptions changes accordingly with the how technology is integrated into teaching and learning process. (Ekmekci & Gulacar, 2015) Combination of VL and PL could yield better learning gains. (Ekmekci & Gulacar, 2015)

Piaget and Vygotsky asserted that, as well as many others, learners construct their own understanding. (Ma & Nickerson, 2006) Therefore, consistent with the study conducted by Puntembekar et al., Combining the VL and PL may complement and supplement relative weaknesses of each. (2021). In this study, findings showed that 23 of the students prefer to use VL during the lesson, 27 of the students prefer after the lesson, 18 of the students prefer before the lesson and 12 of the students for repetition. According to the students' preferences, it may be more beneficial to use it together with the physical laboratory. These findings are supported by Ekmekci and

Gülacar’s study. Both VL and PL could be effective when utilized in the right classroom environment. (Ekmekci & Gulacar, 2015) It seem the future of the science education to combine VL and physical laboratory exercises. (Makransky et al., 2016)

One important point to be emphasized before moving forward is, in line with students’ educational backgrounds and thoughts, 11,9% of the students thinks that computer weakens the relationships between students and teacher. Also, three of the students mentioned from this as disadvantage.

14 of the students have negative opinions about effectiveness and memorability of virtual laboratory, but only four of the students thinks using colurful shapes, moving images and sounds in science lessons make learning science subjects easier.

One of the faculty member stated that participation level was low to the experiments although they are compulsory and students were careless while doing experiments. The fact that students have to continue compulsory distance education due to the pandemic may have caused such a self-discipline problem in students. There are students who develop their self-discipline skills through distance education, and students who actively use their existing skills as well as students who have never gained self-discipline skills before. Students with underdeveloped self-discipline skills played a more passive role in this process. These students need more direction and have more expectations from the external environment. The characteristics of the students affected the research results.

6.4 Conclusion

Virtual applications dates back to 1980’s in Turkey, but it is still in its infancy. There are some applications used as a substitute for real laboratory exercises in abroad. (Dyrberg et al., 2017) There is a need for time to develop VL’s that have been developed locally for our students. If a VL is presented to students that is more interesting, memorable and provides freedom to students, students’ views can change in a positive way. In addition, many of the students who did not have the chance to go to the physical laboratory during the pandemic period experienced a laboratory environment for the first time, albeit from afar. Accessibility from remote locations is the major advantage of VL (Alkhaldi et al., 2016) Now, educators should focus on finding new methods by synthesizing the advantages of VL and PL. (Ekmekci & Gulacar, 2015)

It can be seen that the students gave different answers to the questions on the same subject regarding their thoughts and experiences. For example, although only four out of 88 students think that teaching with colors and shapes does not make the subject easier to understand, the number of students who state that the virtual laboratory experience makes learning the result difficult or forgettable is 14. This difference between students' thoughts and experiences about the virtual laboratory is due to the design of the virtual laboratory. If the expectations of the participants that will lead to positive development are met, more efficient and positive results will be obtained in terms of learning and memorability.

This disagreement among the participants about the main issues like effectiveness of virtual laboratory activities due to the fact that students come from different backgrounds. If a study was conducted among students with a uniform and similar background, the opinions of the students about the virtual laboratory would be similar. However, the presence of participants from schools in different regions of the country prevented the accumulation of positive or negative sides. While it was not interesting for students who were exposed to teaching in environments such as virtual laboratories before, it was more interesting for students who encountered it for the first time. The experiments in the virtual laboratory were not instructive for the students who had knowledge about the experimental topics covered before.

Experiments were opened to students in different regions of Turkey at the same time. Meanwhile, none of the students have the same entry level. For this reason, it was not surprising that different opinions were included in this study.

6.5 Implications for Practice

In this study, virtual chemistry and physics laboratories created by the field experts and university students and faculty were used. The number of participants who expressed positive and negative opinions was almost equal. It is expected that companies that design virtual laboratories will come up with new solutions to eliminate disadvantages arising from the structure of the VL itself. VL and physical laboratory could be used together. In this manner, physical laboratory could fill the gap of the parts that are perceived as a disadvantage of VL. Researchers, students and faculty can benefit from new VL applications especially in this evolving digital World by including VL to their curriculum.

One of the disadvantages of VLs is lack of interaction. Consistent with the literature, some of the students think that virtual laboratory decreases interaction (Diker, 2011). Especially, one of the students thinks that computer guides students throughout the experiment. By increasing the interaction between the user and the experiments while designing virtual laboratory, the need for interaction between students could be eliminated.

There are also weaknesses that are not related to the educational content or hardware, but only due to the VL itself like freezing problems. Even if there is no problem with the content and hardware, the disconnections faced during the experimentation can discourage the student's enthusiasm for learning. At least, eliminating such deficiencies by institution who provide VL opportunity to students will eliminate negative opinions toward VLs.

According to results of open-ended questions, virtual chemistry and physics laboratory is not instructive and interesting for some of the students. Although, virtual labs are designed by field experts, sometimes a student perspective is needed. Many negative thoughts mentioned here can be turned into positive if a pilot study is conducted with a group of students and experiments are revised according to feedback before the experiments are opened to all participants.

Although students from 18 different universities who takes general chemistry and general physics courses experienced the VL, participation rate was low to study. For this reason, generalization of that study to the population may be risky.

A few of the students stated that while doing experiments computer guided them. If there are unguided versions of the experiments, students will have the opportunity to self-test.

In this study, virtual chemistry and physics laboratories were only operated with computers. For future studies, it is recommended to choose both computers and mobile phones as a tool to conduct experiments virtually.

6.6 Limitations and Recommendations for Future Research

Although it was expected to get high rate of return from participants, return rate was low. The data first started to be collected in 2020-2021 fall semester, but, the return rate was low. For this reason, it was repeated at the beginning of the 2020-2021 spring semester. Although there was an increase in the students' answers, there was not enough return from the faculty. It would have been better if there was a higher participation rate, especially for faculty. Effective feedback could be obtained for both VL designers and future studies.

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APPENDICES

A. Students' perceptions on virtual laboratory survey

Sanal Laboratuvar Uygulamalı Fen Eğitiminde Oğrenci Görüşleri Anketi

Sayın katılımcı,

Bu anket Orta Doğu Teknik Universitesi Bilgisayar ve Oğretim Teknolojileri Eğitimi bölümü Yüksek Lisans Programı kapsamında Prof. Dr. Omer DELIALIOGLU danışmanlığında Hilal GULER tarafından yürütülen bir tez çalışmasının parçasıdır. Sanal laboratuvar (uzaktan eğitim materyali) uygulamasına yönelik tutumlarla ilgili bilgi toplanması amaçlanmaktadır.

Çalışma kapsamında toplanan veriler sadece söz konusu araştırmaya hizmet edecek şekilde kullanılacak, başka kişi, kurum ve kuruluşlarla paylaşılmayacaktır ve paylaşılması mümkün değildir. Verilen cevapların doğru ve samimi olması sağlıklı veriler toplanması açısından önem arz etmektedir. Bu yüzden sizden cevaplarınızda samimi olmanızı rica ediyoruz.

Araştırmaya gösterdiğiniz ilgi ve yardımlarınızdan dolayı teşekkür ederiz.

Herhangi bir sorunuz olursa hilal.guler@metu.edu.tr adresinden ulaşabilirsiniz.

Yukarıdaki bilgileri okudum ve bu çalışmaya tamamen gönüllü olarak katılıyorum. ☐

Cinsiyetiniz : Kadın ☐ Erkek ☐

Sınıfınız : 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5☐

Okulunuz:

SORULAR	EVET	KISMEN	HAYIR
1. Evinizde bilgisayar var mı?	☐	☐	☐
2. Bilgisayar kullanabiliyor musunuz?	☐	☐	☐
3. Bilgisayarda oyun oynar mısınız?	☐	☐	☐
4. Bilgisayarla uğraşmak sizi ürkütür mü?	☐	☐	☐
5. Bilgisayar sertifikanız var mı?	☐	☐	☐
6. Bilgisayar dersi aldınız mı?	☐	☐	☐
7. Bilgisayarla araştırma yapmak sizce kolay mı?	☐	☐	☐
8. Bilgisayar kullanımı sizleri okuldan uzaklaştırır mı?	☐	☐	☐

9. Okulunuzda bilgisayar var mı?	☐	☐	☐
10.Okulunuzdaki bilgisayarlar idari işlerde mi kullanılıyor?	☐	☐	☐
11.Okulunuzdaki bilgisayarlardan yararlanabiliyor musunuz?	☐	☐	☐
12.Bilgisayar dersiniz var mı?	☐	☐	☐
13.Okulunuzda bilgisayar laboratuvarı var mı?	☐	☐	☐
14.Bilgisayar kullanımı öğretmenleriniz ile olan ilişkilerinizi azaltır mı?	☐	☐	☐
15.Bilgisayar destekli eğitim hakkında bilginiz var mı?	☐	☐	☐
16.Dersi renkli şekiller, hareketli resimler ve seslerle işlemek öğrenmeyi kolaylaştırır mı?	☐	☐	☐
17.Okul yaşantınızın herhangi bir döneminde bilgisayar ve bilgisayarlarda kullanılan paket programları kullandınız mı?	☐	☐	☐
18.Bu dersi bilgisayarlar aracılığı ile öğrenmek ister miydiniz?	☐	☐	☐
19.Bilgisayar ortamlarında fen derslerine olan ilginizin artacağını düşünüyor musunuz?	☐	☐	☐
20.Bilgisayar ortamlarında dersi öğrenme kolaylaşır mı?	☐	☐	☐
21.Bilgisayar ortamları, bu dersin eğitiminde öğretmen-öğrenci ve öğrenci-öğrenci etkileşimini artırır mı?	☐	☐	☐
22.Bilgisayar ortamları, bu dersin eğitiminde daha derin, daha açık, geniş düşünen, çözümleyici, yaratıcı öğrenci yetişmesini sağlar mı?	☐	☐	☐

23.Bu ders kapsamında deney yapmak veya yapılan bir gösteri deneyini izlemek hoşunuza gider mi?	☐	☐	☐
24.Hoşunuza giden bu deneyleri bilgisayar ortamlarında yapmak daha zevkli, eğlenceli ve daha kalıcı olmaz mı?	☐	☐	☐
25.Bilgisayar ortamlarında deney yapmak, laboratuvar ortamında deney yapmaya göre tehlikesiz midir?	☐	☐	☐
26.Simülasyon aracılığıyla bilgisayar ortamlarında yapılan deneylerin sonuçları daha doğru ve daha güvenirliği yüksek midir?	☐	☐	☐
27.Sanal laboratuvarlar hakkında bilginiz var mı?	☐	☐	☐
28.Bilgisayar ortamlarında ders değerlendirmenin, siz ve bilgisayar arasında olması sizi rahatlatır mı?	☐	☐	☐

1. Sanal Laboratuvar (uzaktan eğitim materyali) uygulamasını kullanabiliyor musun?
2. Bu uygulamayı kullanırken zorluk yaşıyor musun?
3. Sanal laboratuvarı uygulaması etkili oldu mu?
4. Bu uygulamanın gerçek laboratuvardan farkı ne (Olumlu ya da Olumsuz olabilir.)
5. Deneyleri simülasyon ya da animasyon ile yaptığında öğrenebildin mi?
6. Öğrenemedi ise nasıl önlemler alınabilir?
7. Bu uygulama sana ne kazandırdı?
8. Bu uygulamayı kullanarak yaptığın şeyleri, gerçek ortamda yaparken nelere dikkat etmen gerektiğini biliyor musun? (Hangi güvenlik önlemlerini alman gerektiği gibi.)
9. Bu uygulama kapsamında gerçekleştirilen etkinlikleri gerçek ortamda yapman istenirse zorluk çekmeden yapabilir misin?
10. Hangi bölümlerde zorluk yaşayacağını düşünüyorsun?
11. Bu uygulama ne şekilde yapılsa daha verimli olur? (Dersten önce derse hazırlık, ders esnasında, dersten sonra, tekrar)
12. Sence sanal laboratuvar uygulamasının etkililiği nedir?
13. Seçme şansın olsa hangisini seçerdin? (Sanal laboratuvarı mı? Gerçek laboratuvarı mı?)
14. Bu uygulamadan önce kaç defa laboratuvara gittiniz? Kaç deney yaptınız?
15. Bu uygulamayı ders dışında (öğretmenin sana söylemeden de) kullanır mısın?
16. Senin belirtmek istediğin bir şey var mı?

B. **Faculty members'** perceptions **on virtual laboratory survey**

Sayın katılımcı,

Bu anket Orta Doğu Teknik Üniversitesi Bilgisayar ve Öğretim Teknolojileri Eğitimi bölümü Yüksek Lisans Programı kapsamında Prof.Dr. Omer DELIALIOGLU danışmanlığında Hilal GULER tarafından yürütülen bir tez çalışmasının parçasıdır. Sanal Laboratuvar uygulamasına yönelik tutumlarla ilgili bilgi toplanması amaçlanmaktadır.

Çalışma kapsamında toplanan veriler sadece söz konusu araştırmaya hizmet edecek şekilde kullanılacak, başka kişi, kurum ve kuruluşlarla paylaşılmayacaktır ve paylaşılması mümkün değildir. Verilen cevapların doğru ve samimi olması sağlıklı veriler toplanması açısından önem arz etmektedir. Bu yüzden sizden cevaplarınızda samimi olmanızı rica ediyoruz.

Araştırmaya gösterdiğiniz ilgi ve yardımlarınızdan dolayı teşekkür ederiz.

Herhangi bir sorunuz olursa hilal.guler@metu.edu.tr adresinden ulaşabilirsiniz.

Yukarıdaki bilgileri okudum ve bu çalışmaya tamamen gönüllü olarak katılıyorum. ☐

Cinsiyetiniz : Kadın ☐ Erkek ☐

Görev Yaptığınız Okul :

Tecrübe: 0-10 ☐ 11- 20 ☐ 21-30 ☐

SORULAR	**EVET**	**KISMEN**	**HAYIR**
1. Bilgisayarlar hakkında yeterli bilgiye sahip misiniz?	☐	☐	☐
2. Bilgisayar ve bilgisayarlı ortamlarda çalışmaktan çekinir misiniz?	☐	☐	☐
3. Bilgisayar teknolojisi ilginizi çekiyor mu?	☐	☐	☐
4. Görev yaptığınız okulda bilgisayar kullanılıyor mu?	☐	☐	☐
5. Görev yaptığınız okulda bilgisayar destekli eğitim yapılıyor mu?	☐	☐	☐

6. Bilgisayar destekli eğitim okula karşı olumsuz bir tutum yaratır mı?	☐	☐	☐
7. Bilgisayar destekli eğitim yapan bir okulda çalışmak ister misiniz?	☐	☐	☐
8. Fen bilimleri derslerinde bilgisayar kullanılırsa derse olan ilgi artar mı?	☐	☐	☐
9. Bilgisayarın fen bilimleri derslerinde kullanılması derse olan dikkati arttırır mı?	☐	☐	☐
10.Bilgisayarın bu derslerde kullanılması öğretmen ve öğrenci arasındaki ilişkiyi azaltır mı?	☐	☐	☐
11.Bilgisayar yardımıyla bu dersi öğrenmek öğrenmeyi kolaylaştırır mı?	☐	☐	☐
12.Bilgisayar destekli eğitimle bu dersi öğrenme kolaylaşır mı?	☐	☐	☐
13.Bilgisayarın bu derste kullanılması başarıyı arttırır mı?	☐	☐	☐
14.Bilgisayar destekli eğitiminde grafikler, ses ile uyarı ve renk olanakları çok kullanıldığı için ders daha zevkli hale gelir mi?	☐	☐	☐
15.Laboratuvardaki birtakım deneyler bilgisayar aracılığı ile daha ilgi çekici hale getirilebilir mi?	☐	☐	☐
16.Bilgisayar destekli eğitiminde her konunun sanal deneylerle pekiştirilmesi öğrenci açısından daha kalıcı mıdır?	☐	☐	☐
17.Bilgisayar ekranı üzerinde deney yapmak daha net ve doğru sonuçlar verir mi?	☐	☐	☐

18.Bilgisayar destekli ortamlardaki sanal laboratuvarlar, gerçek laboratuvarlara alternatif olabilirler mi?	☐	☐	☐
19.Bilgisayar destekli fen bilimleri eğitiminde öğrenci denetimi ve değerlendirilmesi daha kolay yapılabilir mi?	☐	☐	☐
20.Bilgisayar kullanılarak öğrenci seviyelerinin tespiti daha kolay yapılabilir mi?	☐	☐	☐
21.Bilgisayar ortamları aracılığı ile öğrenmede öğrencinin denetlenebileceğini düşünüyor musunuz?	☐	☐	☐
22.Bilgisayar destekli fen öğretiminde bilgisayar ortamlarının yönlendirici olduğuna inanıyor musunuz?	☐	☐	☐
23.Fen bilimleri dersleri bilgisayar yardımı ile işlenmeli midir?	☐	☐	☐
24.Evinizde bilgisayarınız varsa fen bilimleri ders yazılımınız var mı?	☐	☐	☐
25.Bilgisayarda kullanılmak üzere fen bilimleri konuları ile ilgili yazılımlara ulaşabiliyor musunuz?	☐	☐	☐
26.Bilgisayar destekli fen bilimleri eğitimi ile ilgili bakanlıkça düzenlenen herhangi bir hizmet içi eğitim kursuna katıldınız mı?	☐	☐	☐

1. Kullanılan sanal laboratuvar uygulamasının öğrencilerinizin üzerindeki etkileri neler olmuştur? Materyalin öğrencilerinize ne gibi getirilerini ya da olumsuzluklarını gözlemlediniz? (Öğrencilerin derse ilgisi, konuya odaklanma, ders dinleme, derse katılım.)
2. Bilgisayar destekli öğretimin (Sanal laboratuvarın) öğrenciler açısından olumlu ve olumsuz yönleri nelerdir?
3. SL uygulamasının beğendiğiniz özellikleri nelerdir?
4. SL uygulamasının beğenmediğiniz özellikleri nelerdir?
5. Bu uygulama ile ders işlemenin bir fen bilimleri öğretmenine yarar sağlayabileceğini düşünüyor musunuz? Neden?
6. Bu uygulamayı diğer okullardaki öğretmenlerin kullanmasını tavsiye eder misiniz? Neden?
7. Bu uygulama öğrenci ve öğretmenler açısından ne fayda/zarar getirir?
8. Sanal laboratuvar uygulamasını öğrencileriniz kullanırken siz herhangi bir güçlükle karşılaştınız mı?
9. Sizce, sanal laboratuvar uygulaması size bir yük getirdi mi? Yoksa ders anlatımınıza destek mi oldu?
10. Sanal laboratuvar uygulamasındaki deneyleri gerçek laboratuvarda yapılan deneylerle kıyasladığınızda ne gibi avantajları var?
11. Sanal laboratuvar uygulamasındaki deneyleri gerçek laboratuvarda yapılan deneylerle kıyasladığınızda ne gibi dezavantajları var?
12. Sizce sanal laboratuvar uygulamasındaki deneyler, öğrencilerin kendi kendilerine deney yapabildikleri, laboratuvar sürecini yaşayabildikleri ve kendi bilgilerini oluşturabildikleri bir ortam sunmakta mıdır?
13. Sizce sanal laboratuvarı uygulaması ile yapılandırmacı bir ortam oluşturularak dersler işlenebilir mi?
14. Bu uygulamanın yapılandırmacı öğrenme yaklaşımına uygun olduğunu düşünüyor musunuz?
15. Bu sanal laboratuvar uygulamasında ne gibi düzenlemeler yapılmasını önerirsiniz?
16. Sanal laboratuvar uygulamasını dersin hangi aşamasında kullanmak istersiniz?

C. Approval of Ethical Committee

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
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Sayı: 28620816 /

21 ARALIK 2020

Konu: Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Ömer DELİALİOĞLU

Danışmanlığını yaptığınız Hilal GÜLER'in ***"Üniversite Öğrencilerinin ve Öğretim Üyelerinin Sanal Kimya Laboratuvarına karşı tutumları"*** başlıklı araştırmanız İnsan Araştırmaları Etik Kurulu tarafından uygun görülmüş ve **382-ODTU-2020** protokol numarası ile onaylanmıştır.

Saygılarımızla bilgilerinize sunarız.

Prof.Dr. Mine MISIRLISOY
İAEK Başkanı