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Pre-service science teacher's opinions on virtual labs and their use in biology

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Abstract

This study sought to investigate pre-service science teachers' opinions about using virtual laboratories and virtual laboratories for biology. The study group of the research consisted of four pre-service science teachers (two girls and two boys) who had virtual laboratory experience by taking at least one of the courses related to technology integration at a state university located in the Central Anatolia region in Türkiye. The research used a semi-structured interview form with open-ended questions, a common data collection method in qualitative research. The data were examined using the content analysis method. The usage of virtual laboratories in science lectures in terms of the teacher, student, and educational processes was mentioned by pre-service science teachers. Pre-service teachers claim that virtual laboratories help students gain experience and strengthen their critical thinking and research skills. According to pre-service teachers, biology, cells, and the study of onion skin and bacteria are only a few examples of virtual laboratory applications that can be used in science teaching. They emphasized that it included biology-related themes, offered opportunities for lab work, dispelled misconceptions, and allowed students to use a microscope.

Keywords: *Virtual Laboratories, e-learning, Education Technology, Learning with Technologies.*

Introduction

Science education must make extensive use of laboratories. People can embody abstract and complex concepts in science laboratories and learn for life by doing and experiencing things. Science education laboratory work significantly contributes to students' relevant learning (Akdeniz et al., 1999; Ergin et al., 2005). According to Shulman and Tamir (1973, cited in Kogseolu & Tumay, 2010), the goal of laboratory applications is to develop technical and cognitive skills, support the scientific method, enhance conceptual understanding and problem-solving abilities, and foster a positive attitude toward science by piquing interest. No science branch can be fully taught without using experiments according to Cepni and Ayvaci (2006). Students' laboratory research is crucial for learning scientific process skills such as seeing, classifying, documenting data, describing, and experimenting (Aydogdu & Kesercioglu, 2005). With laboratory experiments, students learn new information and can verify the veracity of their previously acquired knowledge (Korkmaz & Kaptan, 2001).

People have had to adjust to the changing and evolving environment in the 21st century as information and technology have advanced. The transition of educational activities from conventional to virtual environments has been hastened by the change and development of information and technology. Students, teachers, course materials, and educational institutions can all see this transformation. With each passing day, information and communication technologies undergo change and development, creating a chance to provide instruction in a wide range of subjects. With disciplines based on knowledge and theory, disciplines requiring extensive application are also influenced by the potential of advancing and changing technologies, and solutions like virtual laboratories are created (Civril, 2018).

Virtual laboratories use various tools to create detailed simulations of actual lab settings. Without the use of actual laboratory supplies or the guidance of teachers while using the application, students can conduct their experiments in a virtual setting. As a result, students learn how to operate equipment and vehicles (Lyall & Patti, 2010). The usage of virtual laboratories in this regard has grown recently. Much research on the topic has been done and is documented in the

literature. Virtual laboratories are mostly used for chemistry and physics disciplines according to the literature assessment (Barab et al., 2000; Borgi, 1991; Bozkurt & Sarikoc, 2008; Buyukkara, 2011; Cinici et al., 2013; Civril, 2018; Duman & Avci, 2016; Erdan, 2014; Herga et al., 2012; Hudson, 2010; Karagoz & Saka, 2016; Mutlu, 2015; Trundle & Bell, 2010; Wilson & Redish, 1989; Yang & Heh, 2007). Not many studies on virtual laboratories in biology instruction are found in the literature. In light of this, it is crucial to interview potential science educators who will help students grasp biology concepts practically. In addition, this study will emphasize the importance of virtual laboratories, especially in biology, by revealing the advantages and disadvantages of virtual laboratories compared to traditional laboratories. In this situation, the research study aimed to investigate pre-service science teachers' opinions on using virtual laboratories and virtual laboratories in biology. The following were identified as the research's questions:

1. What do pre-service science teachers know about virtual laboratories?
2. What are pre-service science teachers' opinions about using virtual laboratories in science lessons?
3. What do pre-service science teachers know about virtual laboratory applications that can be used in science lessons?
4. Which science subject do pre-service science teachers think that virtual laboratory applications are suitable for?
5. What do pre-service science teachers think about using virtual laboratories in biology subjects?
6. What do pre-service science teachers think about the advantages of using virtual laboratories in biology subjects?
7. What do pre-service science teachers think about the disadvantages of using virtual laboratories in biology subjects?

1. Method

1.1. Research design

One of the qualitative research techniques, phenomenology (phenomenology) pattern, was used to structure this study. The phenomenology design is considered a qualitative research technique that enables people to communicate their sentiments, ideas, viewpoints, and perceptions regarding a specific phenomenon or idea and is employed to explain how they perceive it (Rose et al., 1995). The research approach for this study was phenomenology because pre-service science teachers' opinions on the utilization of virtual laboratories in biology classes were being investigated.

1.2. Research group

Four pre-service science teachers (two girls and two boys) who had taken at least one course on integrating technology at a public university in the Central Anatolia region of Türkiye comprised the study group for the investigation. One of the purposive selection techniques, the criterion sampling approach, was employed to choose the research group. The criterion sampling method examines cases that satisfy certain importance criteria (Yildirim & Simsek, 2011). The requirements for this study are that participants have experience with virtual laboratories and have taken at least one course on technology integration. Pre-service teachers received information about virtual laboratories and some virtual laboratory applications in these courses. In order to get opinions about the virtual laboratory, pre-service teachers must have at least partial knowledge of the subject.

1.3. Data collection tool and data collection

A semi-structured interview form with open-ended questions, a common tool for gathering data in qualitative research, was utilized in this study (Creswell, 2012). The pre-service teachers' opinions and ideas regarding the problem were investigated through the interview questions.

While preparing the semi-structured interview questions, the researchers first conducted a literature review. After the scanning, the researchers prepared the questions. The research questions were created and submitted to three teacher education and instructional technology experts. After the feedback, five drilling questions were included in the data-gathering tool's questions. The questions in the data collection tool are as follows:

1. Can you share with us what you know about virtual laboratories?
2. What are your views on using virtual laboratories in science lessons?
    a. Can you evaluate the use of virtual laboratories in science from the point of view of students?
    b. Can you evaluate the use of virtual laboratories in science from the point of view of teachers?
3. What do you know about virtual laboratory applications that can be used in science lessons?
    a. Can you tell us about the virtual laboratories that you know or have experienced used in the field of science?
4. Which science subject do you think that virtual laboratory applications are suitable for?
5. What do you think about using virtual laboratories in biology subjects?
    a. What do you think about the advantages of using virtual laboratories in biology subjects?

b. What do you think about the disadvantages of using virtual laboratories in biology subjects?

1.4. Data analysis

This study used content analysis to examine the information gathered from individual interviews with pre-service teachers. The primary goal of the content analysis method is to thoroughly investigate the data to identify codes and themes that may be used to interpret the data (Yildirim & Simsek, 2011). The research's first steps involved transcription of the interviews and coding of the studied data. The codes were categorized based on their similarities and differences. The pre-service teachers' names were concealed and denoted as T1, T2, T3, and T4 while the research findings were presented.

1.5. Validity and reliability

The participants' responses were not steered in any way in order to maintain the validity and reliability of the study and avoid having an impact on it. The participants' genuine viewpoints were recorded. The researchers carefully coded each set of data they had collected. The codes among the researchers revealed agreement. The proportion of agreement provided by Miles and Huberman (2016) was determined to determine the coding reliability. The researchers' codes were determined to be 88% in agreement with one another. When the number is 0.88, there is a high level of coding agreement across researchers and good reliability in the data analysis.

2. Results

The research's conclusions were outlined in the data collection tool's context of five questions.

2.1. Pre-service teachers' information about the virtual lab

Virtual laboratories for pre-service science teachers are a program (T1) that is utilized for distance learning (T1, T3) in a virtual setting (T2) with technical access (T3) and application (T4) codes. Examples of expressions:

T1: “I believe that virtual laboratories are courses that energize students for the lesson, foster their creativity, and spark their interest.”

T4: “I think that virtual laboratories are applications that help us to study micro-level creatures and substances that contribute to our learning.”

2.2. Opinions on the use of virtual laboratories in science classes

Pre-service science teachers participating in the research expressed the use of virtual laboratories in science lessons regarding teacher, student, and educational process (Table 1).

Table 1. Opinions on the use of virtual laboratories in science classes.

Categories	Codes	Participants
In terms of student	Language problem	T1
	Critical thinking skill	T1
	Research skill	T1
	Attract attention	T2
	Fun	T3
	Easy access to information	T4
	Experience	T1
In terms of teacher	Teacher guidance obligation	T1
	Provides ease	T2, T4
	Trustworthy	T3
In terms of the educational process	Necessary	T1
	Distance learning	T2
	In the absence of material	T2

	Observation	T4
	Real-like	T2
	Economic	T4
	Concretization	T2
	Saving on time	T4
	Access from anywhere	T3

There are pre-service teachers who claim that virtual laboratories help students gain experience and strengthen their critical thinking and research skills. Using virtual laboratories in science lectures is convenient for teachers, is reliable, and requires guidance according to participant perceptions. Also, the pre-service teachers' perspectives included statements that using virtual laboratories is essential for science education, is affordable, and offers learning that is close to reality. These are some examples of participant statements:

T1: "…it is a great opportunity for students as I think it awakens and develops their critical thinking skills and investigative spirit…"

T2: "I think it is easy for the teacher as well…"

2.3. Opinions on virtual laboratories that can be used in science classes

The pre-service science teachers who participated in the research revealed their virtual laboratory experiences, even if they did not disclose the names of the applications that may be utilized in the science class. Pre-service teachers described the characteristics of the virtual laboratories and subjects they encountered in this context (Table 2).

Table 2. Opinions on virtual laboratories that can be used in science classes.

Categories	Codes	Participants
In terms of features	Image quality	T3
	Distance learning	T2, T3
	Real-like	T1, T2, T3
In terms of subjects	Biology	T1, T2, T3
	Cell	T3, T4
	Onion skin	T2, T3, T4
	Bacterium	T1

According to pre-service teachers, biology, the study of cells, the study of onion skin, and the study of bacteria are only a few examples of virtual laboratory applications that can be used in science teaching. Pre-service teachers reported that the virtual laboratory program they used during the distance learning process had good visual quality and was fairly accurate to reality. These are some examples of participant statements:

T1: "Our instructor provided us with two virtual laboratory experiences in the biology lab as part of the distance education process. I really loved one microscope because it appeared to be a real microscope; for instance, they did not even skip the fact that immersion oil is necessary to obtain an image in 100x ocular lens."

T4: "For the lab lesson, we used a virtual lab application with a high zoom level to inspect the onion skin."

2.4. Opinions on science subjects where virtual laboratories can be used

Participants in the study said that virtual laboratories are typically more appropriate for biology subjects (Table 3).

Table 3. Opinions on science subjects where virtual laboratories can be used.

Categories	Codes	Participants
Biology subjects	DNA	T1
	Cell	T1, T3, T4
	Plants	T2
	Genetic	T4
	Gene	T4
	Living things	T1, T2
Other subjects	Physical	T3

	Chemical	T3

According to pre-service teachers, virtual laboratory applications can be utilized in biology to study DNA, cells, plants, genetics, genes, and living things. These are some examples of participant statements:

T2: "I believe it is appropriate for studying plants and other living things."

T3: "I believe that virtual laboratories will be highly beneficial to the cell when evaluating its structure or the structure of an onion shell. Given that it is not limited to biology, we may also use this in physics and chemistry."

2.5. Opinions on the use of virtual laboratories in biology subjects

Table 4. Opinions on the use of virtual laboratories in biology subjects

Categories	Codes	Participants
Advantages	Less cost	T1, T3, T4
	Time-saving	T1, T4
	Equality of opportunity	T1
	Portability	T1
	Resolving misconceptions in biology	T1
	Biology laboratory opportunity	T2
	Concretizing biology subjects	T2
	Memorability	T2, T4
	Using a microscope	T2, T3
	Harmless to living creatures	T3
	Easy access to information	T4
Disadvantages	Language problem	T1
	Finding images in the microscope	T2
	Far from reality	T1, T3
	Classroom management	T4
	False learnings	T4

Participants in the study who were pre-service science teachers spoke of the advantages of the use of virtual laboratories in biology classes overall (Table 4).

The use of virtual laboratories in biology lessons has a number of benefits according to pre-service teachers. They emphasized that it included biology-related themes, offered opportunities for lab work, dispelled myths, and allowed students to use a microscope. Considering the advantages expressed about virtual laboratories, they stand out compared to traditional laboratories in terms of advantages as they require less cost, provide portability, are harmless to living things, and provide easy access to information. In this sense, virtual laboratories provide practicality and convenience in learning environments for students.

When we look at the disadvantages expressed about virtual laboratories, we can see that there are language problems, a laboratory environment far from reality, and the possibility of incorrect learning, especially in virtual laboratories prepared in a foreign language. Traditional laboratories are strong, and virtual laboratories are limited.

These are some examples of participant statements:

T2: "We have learned how to use a microscope, how to be catchy, how to prepare an apparatus even from a distance, and how to make abstract things concrete."

T3: "We do not need to get a microscope. I speak in terms of money when I say this. It is unlikely that lenses may crack or scratch. They will not risk hurting themselves while studying live things."

3. Discussion, conclusion, and recommendations

This study examined pre-service science teachers' opinions on virtual laboratories and their use in science and biology instruction. Pre-service instructors characterized the virtual laboratory in the study as a technical tool utilized in a virtual setting for remote learning.

The research's pre-service science teachers discussed the implications of virtual laboratories in science lectures on the teacher, student, and educational process. Virtual laboratories claimed in science lessons by pre-service teachers help students gain experience and strengthen their critical thinking and research skills. Using virtual laboratories in science lectures is convenient for teachers, is reliable, and requires guidance according to participant perceptions. Additionally,

the pre-service teachers' perspectives included statements that using virtual laboratories is essential for the science course, is affordable, and offers learning close to reality. These findings from the literature review are consistent with findings from other investigations. Due to a lack of resources and laboratories in schools or the difficulty of conducting demonstration experiments because of crowded classrooms, Cinici et al. (2013) found that virtual laboratories can be a good and cost-effective substitute. Ozdener (2005) concluded in his study that simulation is instructive and increases motivation for students and teachers.

The pre-service science teachers who participated in the research revealed their virtual laboratory experiences, even if they did not disclose the names of the applications that may be utilized in the science class. Pre-service teachers described the characteristics of the virtual laboratories and subjects they encountered in this context. According to pre-service teachers, biology, cells, and the study of onion skin and bacteria are only a few examples of virtual laboratory applications that can be used in science education. They said that the visual quality of the virtual laboratory program that pre-service teachers used during the distance learning process was quite good and realistic.

According to pre-service science teachers who participated in the study, virtual laboratories are often more appropriate for biology classes. According to pre-service teachers, virtual laboratory applications can be utilized in biology to study DNA, cells, plants, inheritance, genes, and living things. The use of virtual laboratories in biology lessons has a number of benefits according to pre-service teachers. They emphasized that it included biology-related themes, offered opportunities for lab work, dispelled misconceptions, and allowed students to use a microscope. According to Tatli and Ayas (2011), virtual laboratory environments enable students to do experiments anytime they choose, regardless of location or time, and to utilize as much equipment as they need without running out. The advantages of not posing a security risk, making tasks enjoyable and perceived as games, and saving time were all mentioned when taking into account the results of the literature review (Domingues et al., 2010; Georgiou et al., 2007; Kirlar, 2007; Mueller & Erbe, 2007; Piccolo & Mingrino, 2023; Richards vd. 1992). In order to research the effects of simulations in science education, Rutten et al. (2012) looked at 510 papers written between 2001 and 2010. According to the data gathered through the examination, it has been observed that the use of simulation has a positive effect in all articles, but that it will have a greater positive impact on understanding the tasks in the laboratory when used during the preparatory stage for conventional laboratory environments. This research exposes the opinions of pre-service science teachers about the virtual laboratory and the usage of virtual labs in science education and biology education when considered in conjunction with the pertinent literature studies.

3.1. Limitations and suggestions

Making recommendations is possible while considering the study's limitations and the findings. A small sample of pre-service science teachers was interviewed for the study through a semi-structured interview form to learn their opinions. Larger sample sizes and various data collection methods in studies may yield conclusions that are generalizable. Investigations into the experimental effects of virtual laboratories are possible.

Some pre-service instructors in the study indicated that applications' support for foreign languages can lead to issues. Applications for virtual laboratories that support the Turkish language can be created in this situation.

Pre-service teachers stated that virtual laboratories are generally more suitable for biology subjects. More virtual lab applications can be developed and used in science education subjects such as physics or chemistry.

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