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Uzaktan Eğitimde Sanal Laboratuvarlar İle İlgili Sınıf Öğretmen Adaylarının Görüşlerinin İncelenmesi

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ÖZET

Bilişim teknolojilerinin gelişimi, sanal laboratuvarlar gibi geleneksel öğrenme ortamlarına alternatif birçok yöntemi geliştirmiştir. İlköğretim öğrencilerini fen ve bilimsel etkinliklerle tanıştıran sınıf öğretmenlerine fen derslerini yenilikçi uygulamalarla buluşturmak konusunda büyük sorumluluk düşmektedir. Bu olgubilim çalışmasının amacı, sınıf öğretmen adaylarının sanal laboratuvarlar ve sanal laboratuvarların avantaj ve dezavantajları hakkındaki görüşlerini araştırmaktır. Veriler, 2020-2021 güz döneminde Türkiye'de bir üniversitede öğrenim gören 45 sınıf öğretmen adayından toplanmıştır. Araştırmada öğretmen adaylarına uzaktan eğitimde senkron sanal laboratuvar uygulamaları yapılmıştır. Daha sonra öğretmen adaylarına sanal laboratuvar hakkındaki görüşlerini değerlendirmeleri için açık uçlu sorular sorulmuştur. Veriler içerik analizi yöntemiyle çözümlenmiştir. Elde edilen bulgulara göre öğretmen adaylarının çoğu sanal laboratuvarları laboratuvar simülasyonları olarak tanımlarken, bir kısmı da internet tabanlı, çevrimiçi ve bilgisayarlı laboratuvarlar olarak tanımlamıştır. Sanal laboratuvarların avantajları konusunda, katılımcılar çoğunlukla sanal laboratuvarların her zaman ve her yerde erişilebilir olduğunu ve laboratuvar imkanı olmayan okullarda faydalı olduğunu belirtmişlerdir. Dezavantajlara gelince, katılımcılar genel olarak sanal laboratuvar deneylerinin yüz yüze eğitim kadar etkili olmadığını ve eyleme dönüşmedikleri için daha az kalıcı öğrenme sağlayacaklarını belirtmişlerdir. Sanal laboratuvarda kullanılabilecek dersleri yürüten veya yürütecek olan farklı branşlardaki öğretmen adayları ve öğretmenler ile bir araştırma yapılması önerilmiştir.

Keywords: Covid-19, uzaktan eğitim, sanal laboratuvarlar, sınıf öğretmen adayları

Investigation of the Pre-Service Classroom Teachers' Views About Virtual Laboratories in Distance Education

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ABSTRACT

The development of information technologies has brought many alternative methods to traditional learning environments such as virtual laboratories. Classroom teachers who introduce students to science and scientific events have a great responsibility to teach science lessons with innovative applications. The aim of this phenomenological research is to investigate the pre-service classroom teachers' views about virtual laboratories, and the advantages and disadvantages of virtual laboratories. The data was collected from 45 second-year pre-service classroom teachers from a university in Turkey during the fall semester of 2020-2021. In the study, pre-service teachers were made synchronous virtual laboratory

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applications in distance education. Afterward, open-ended questions were asked to pre-service teachers to evaluate their opinions about the virtual laboratory. Data were analyzed through content analysis method. According to the findings, most of the pre-service teachers defined virtual laboratories as laboratory simulations while some others defined as internet-based, online and computerized laboratories. Regarding the advantages, participants mostly stated that virtual laboratories are accessible anytime and anywhere, and are beneficial in schools without laboratory facilities. Regarding the disadvantages, the participants generally stated that virtual laboratory experiments are not as effective as face-to-face education, and they would provide less permanent learning since they did not turn into action. It was suggested to conduct a research with preservice and in-service teachers from different branches who are or will be conducting the lessons that can be used in the virtual laboratory.
Keywords: Covid-19, distance education, virtual laboratories, pre-service classroom teacher

1. INTRODUCTION

As we address the current coronavirus (COVID-19) epidemic that is creating the need to reshape all areas of life, it is inevitable to look for alternatives suitable for traditional learning environments. With the epidemic, most of the students and even teacher education have switched from face-to-face education to distance education, and education has become virtual. In this process, science experiments were also transferred to the virtual environment. Although virtual laboratories do not completely replace physical experiments in traditional laboratories, they provide students with the opportunity to experiment online without any time limit during the COVID-19 pandemic (la Velle et al., 2020; Vasiliadou, 2020). Within this context, "The Virtual Laboratory Project" has been carried out by the Turkish Council of Higher Education (CoHE, 2020), and virtual laboratories were implemented in the general physics and general chemistry courses for a limited number of programs such as science and engineering faculties and vocational schools.

Virtual laboratory applications offer students the opportunity to learn by trial and error. Thanks to these practices, the student does not worry about making mistakes. Experiments that cannot be observed in real life or may be expensive to do can be done over and over again in virtual laboratories (Kollöfel & de Jong, 2013; Potkonjak et al., 2016). Furthermore, virtual laboratories can simplify the reality so that students can focus on key concepts rather than paying attention to detailed and irrelevant information (Trundle & Bell, 2010). It is more economical since consumables in the laboratory are not used. In the virtual laboratory environment, the variables in the experiment can be changed in a very short time. Thanks to these applications, individuals find the opportunity to practice without time and space limitations. On the other hand, there are some limitations of virtual laboratories. For example, some virtual lab applications do not have a Turkish language option. Moreover, individuals cannot gain manual dexterity while using virtual laboratory applications, and they cannot improve their ability to use and recognize experimental tools (Küçüker & Baraklı, 2014, as cited in Günlü, 2019).

Despite the advantages mentioned above, there are a limited number of studies in the literature that examine the cognitive and affective characteristics of pre-service teachers regarding the virtual laboratories. In these studies, pre-service teachers' attitudes, intentions and perceptions towards virtual laboratory (Falode, 2018), their views regarding the virtual laboratory (Ulukok & Sari, 2016); the effects of virtual laboratory applications on pre-service teachers' attitudes

towards science teaching (Ulukok & Sari, 2016) and scientific process skills (Artun, Durukan, & Temur, 2020; Mutlu & Acar Sesen, 2016) were investigated. The study groups of the studies conducted on the virtual laboratory generally consist of pre-service science teachers. No study on the virtual laboratory conducted with the pre-service classroom teachers was found in the literature. However, in order to increase the science achievement of the students in international exams such as TIMSS and PISA, it is of great importance to make students love and learn science course in primary school. Classroom teachers who introduce students to science and scientific events have a great responsibility to teach science lessons with innovative applications. Therefore, it is of great importance to investigate the opinions of the individuals who are studying in the classroom teaching undergraduate program about the virtual laboratory. In line with the current need in the literature, the purpose of this study is to examine the opinions of pre-service classroom teachers about virtual laboratories as a result of the synchronous virtual laboratory application in distance education in the Covid-19 process and the advantages and disadvantages of virtual laboratories. Within this framework, the research questions are as follow:

- What are the pre-service classroom teachers' views on what a virtual laboratory is?
- What are the pre-service classroom teachers' views on the advantages of virtual laboratories?
- What are the pre-service classroom teachers' views on the disadvantages of virtual laboratories?

2. METHODOLOGY

2.1. Research Design

This study was conducted based on the phenomenological research design of the qualitative research approach. In this design, the participants describe their experiences about a phenomenon (Creswell, 2017). The subjects of phenomenology are mostly the feelings, perceptions, and thoughts concerning the participants' experiences (van Manen, 2007). The research was carried out with phenomenology design since it was aimed to describe pre-service classroom teachers' opinions based on their virtual laboratories experiences.

2.2. Study Group

Convenience sampling was used to determine the study group (Fraenkel, Wallen, & Hyun, 2012). The data was collected from 45 second-year pre-service classroom teachers (38 females, 7 males) from a university in Turkey during the fall semester of 2020-2021. In the research, the principle of voluntary participation was taken into consideration and the pre-service teachers' identities were kept confidential by using codes. Ethical principles were taken into consideration in the research. In this context, the participants were encoded as P1, P2, … P45.

2.3. Data Collection

In the study, synchronous virtual laboratory applications, namely "BioNetwork's Virtual Microscope" and "University of Delaware Virtual Microscope" were conducted with pre-service teachers in distance education (Figure 1 and 2). The reason why these virtual laboratories are preferred is that the images look like they were created in a real microscope and give the impression of a real laboratory. Afterward, open-ended questions were asked to pre-service teachers to evaluate their opinions about the virtual laboratory.

Figure 1. *Virtual laboratory activity*
(https://www1.udel.edu/biology/ketcham/microscope/scope.html)

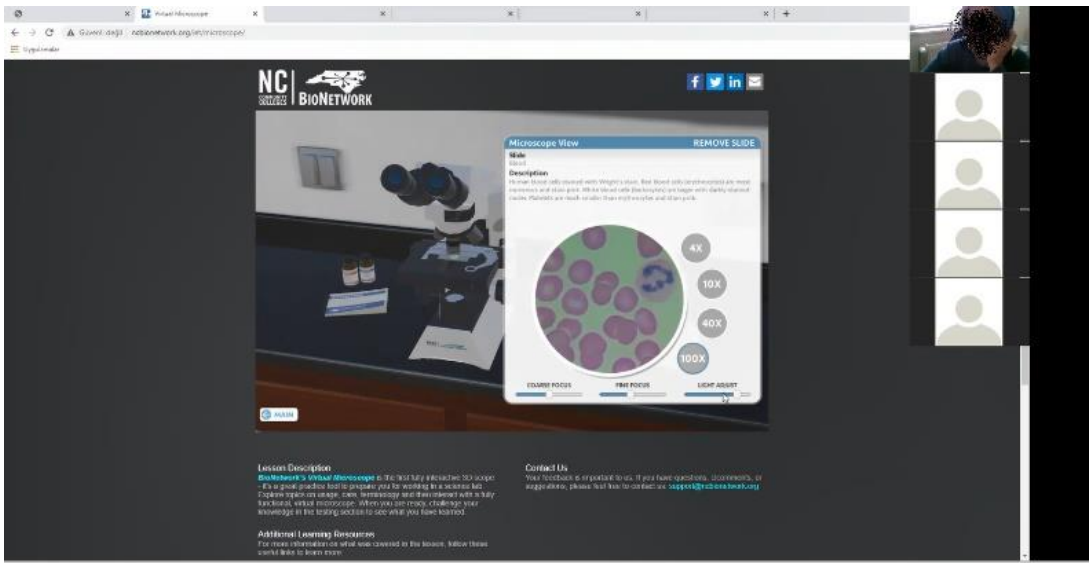

Figure 2. *Virtual laboratory activity* (https://www.ncbionetwork.org/iet/microscope/)

In a qualitative research, in order to reveal knowledge, experience, feelings, thoughts, and perceptions of the interviewees about the research topic, open-ended questions are generally preferred (Patton, 2014). Therefore, in this study, an open-ended questionnaire was used to collect data on pre-service classroom teachers' views on virtual laboratories.

The questions prepared within the scope of the purpose of the research were determined within the framework of certain themes. These themes are; the definition of the virtual laboratory, the advantages of virtual laboratories, and the disadvantages of the virtual laboratories. In line with these themes, the questions were prepared as follow:

- What is a virtual laboratory?
- What are the advantages of virtual laboratories?

- What are the disadvantages of virtual laboratories?

The open-ended questionnaire was filled in approximately 10 minutes by the pre-service teachers.

2.4. Data Analysis

In the study, the answers given to the open-ended questions were analyzed by content analysis. The main purpose of content analysis is to make sense of the data by determining the basic similarities between qualitative data. In this study, an inductive analysis was conducted by determining the similarities in the data and identifying the categories (Patton, 2014).

2.5. Validity and Reliability of Data Analysis

Validity and reliability studies were conducted for the analysis of the qualitative data in the research. Investigator triangulation was carried out to ensure the internal validity (credibility) of the research. In this study, two researchers participated in the data collection, analysis and interpretation processes in order to ensure the internal validity of the data analysis. (Merriam & Tisdell, 2015; Fraenkel et al., 2012).

Detailed descriptions were made in order to ensure the external validity (transferability) of the research, the data were organized by categories, and direct quotations were used. In addition, the use of purposeful sampling strategies in the research contributed to external validity (Sencan, 2005; Fraenkel et al., 2012).

In order to ensure the reliability of the analysis of the data in the study, data were analyzed separately by two researchers, and the agreement level between the experts was checked for consistency. The inter-coder reliability was calculated based on Miles and Huberman's (1994) formula: "Reliability = [Agreement/ (Agreement + Disagreement)]". As a result of the analyses, the percentage of the agreement between the two researchers was calculated as 84%. Since this value is is over 80%, it is concluded that the data analysis of the research is reliable (Buyukozturk, Kilic Cakmak, Akgun, Karadeniz, & Demirel, 2012; Miles & Huberman, 1994; Patton, 2014).

3. FINDINGS

Research findings were presented within the framework of the three themes: the definition of the virtual laboratory, the advantages of virtual laboratories, and the disadvantages of the virtual laboratories.

3.1. Results Regarding the Pre-service Teachers' Views on What a Virtual Laboratory is

The pre-service classroom teachers' answers to the question "What is a virtual laboratory?" were analyzed, coded and categories were created. Some of the pre-service teachers did not answer this question while a total of 40 pre-service teachers answered it. Some of the preservice teachers' answers were coded into more than one category. Some pre-service teachers were not included in the coding because they gave other answers rather than giving answers about what the virtual lab is. For this reason, the total frequency value differs from the number of pre-service classroom teachers. Categories, frequency values and percentages regarding the theme of the definition of the virtual laboratory are given in Table 1.

Table 1. *Pre-Service Classroom Teachers' Views on What A Virtual Laboratory Is*

Categories	Frequency
Laboratory simulation	11
Internet-based laboratory	6
Online laboratory	6
Computerized laboratory	3
Virtual environment	3
Accessible laboratory	3
Laboratory with animations	2
Elektronic environment	2
Total	36

As it is seen in Table 1, the opinions of the pre-service classroom teachers on what the virtual laboratory is are divided into eight categories. Most of the pre-service teachers (30.6%) defined virtual laboratories as laboratory simulations. The pre-service teachers also defined virtual laboratories as internet-based laboratories, online laboratories, and computerized laboratories. Furthermore, three pre-service teachers stated that virtual laboratories are realized in virtual environment. Additionally, some of the pre-service teachers stated that virtual laboratories are accessible everywhere.

Examples of pre-service classroom teachers' answers are given in Figure 1 within the framework of the relevant categories.

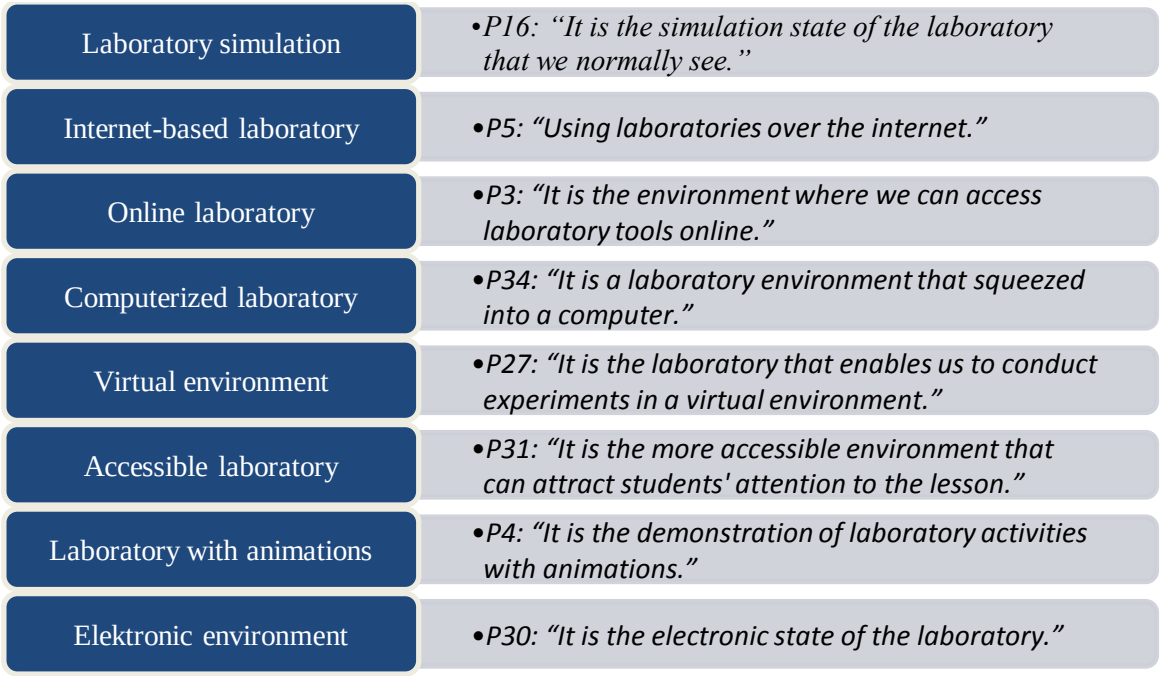

Figure 1. *Sample responses from pre-service teachers on what a virtual laboratory is*

3.2. Results Regarding the Pre-service Teachers' Views on the Advantages of Virtual Laboratories

The pre-service classroom teachers' answers to the question "What are the advantages of virtual laboratories?" were analyzed, coded and categories were created. Some pre-service teachers did not answer this question. A total of 23 pre-service classroom teachers answered the question. Some of the preservice teachers' answers were coded into more than one category. Some of the participants were not included in the coding because they gave irrelevant answers rather than giving answers about the advantages of virtual labs. For this reason, the total frequency value differs from the number of the pre-service teachers. Categories, frequency values and percentages regarding the theme of the advantages of virtual laboratories are given in Table 2.

Table 2. *Pre-Service Classroom Teachers' Views on The Advantages of the Virtual Laboratory*

Categories	Frequency
Accessibility	7
Laboratory facilities	4
Cognitive skills	3
Safety	3
Saving	3
Widespread impact	3
Affective skills	2
Psychomotor skills	2
Total	27

In Table 2, it is seen that the opinions of the pre-service classroom teachers regarding the advantages of virtual laboratories are divided into eight categories. The pre-service teachers generally (26%) stated that the fact that virtual laboratories are accessible anytime and anywhere is a great benefit. Some pre-service teachers (14.9%) stated that virtual laboratories would be beneficial in schools without laboratory facilities. Some of the pre-service teachers stated that virtual laboratories contribute to students' cognitive, affective and psychomotor skills. In addition, virtual laboratories are stated to be more useful in terms of laboratory safety. Also some pre-service teachers' stated that virtual laboratories save time and money, and they have a more widespread effect due to the opportunity to reach more students.

Examples of pre-service classroom teachers' answers are given in Figure 2 within the framework of the relevant categories.

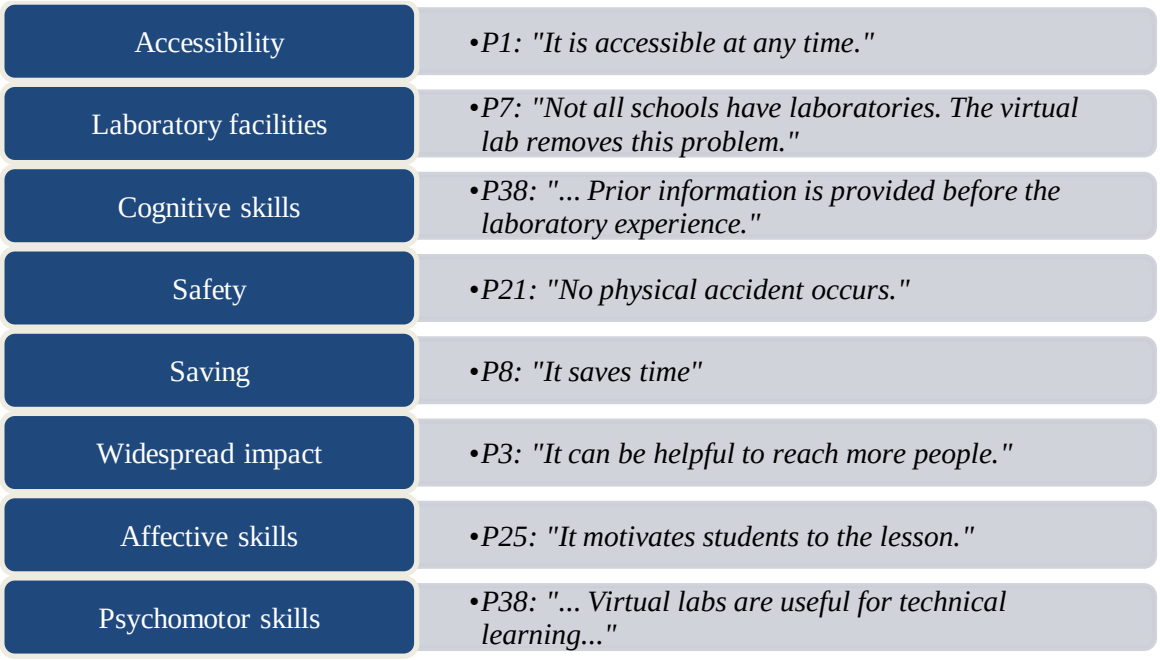

Figure 2. *Sample responses from pre-service teachers regarding the advantages of the virtual laboratory*

3.3. Results Regarding the Pre-service Teachers' Views on the Disadvantages of Virtual Laboratories

The pre-service classroom teachers' answers to the question "What are the disadvantages of virtual laboratories?" were analyzed, coded and categories were created. Most of the participants did not answer this question while only 13 of them answered it. Some of the preservice teachers' answers were coded into more than one category. Some pre-service teachers were not included in the coding because they gave irrelevant answers rather than the disadvantages of virtual laboratories. Therefore, the total frequency value differs from the number of the pre-service teachers. Categories, frequency values and percentages regarding the theme of the disadvantages of virtual laboratories are given in Table 3.

Table 3. *Pre-Service Classroom Teachers' Views About the Disadvantages of the Virtual Laboratory*

Categories	Frequency	Percentage
Less permanent	4	36.4
Ineffective	3	27.3
Interaction problem	2	18.2
Lack of psychomotor skills	2	18.2
Total	11	100

It is seen in Table 3, it is seen that the opinions of the pre-service classroom teachers regarding the disadvantages of virtual laboratories are divided into four categories. The pre-service classroom teachers generally (36.4%) stated that the experiments performed in virtual laboratories would provide less permanent learning because they did not turn into action. Some of the pre-service teachers (27.3%) stated that virtual laboratory activities are not as effective as face-to-face education. Also some pre-service teachers stated that the interaction was less in virtual laboratories and this prevented the development of psychomotor skills.

Examples of pre-service classroom teachers' answers are given in Figure 3 within the framework of the relevant categories.

Less permanent	•*P24: "It is less permanent than learning in physical laboratories."*
Ineffective	•*P10: "I don't think it is effective as face to face laboratories."*
Interaction problem	•*P37: "There is little interaction."*
Lack of psychomotor skills	•*P34: "It is insufficient in terms of motor skill development."*

Figure 3. *Sample responses from pre-service teachers regarding the disadvantages of the virtual laboratory*

4. RESULTS, DISCUSSION AND RECOMMENDATIONS

According the results of the study, most of the pre-service classroom teachers answered the first question while almost half of them did not answer the second question, and most of them did not answer the third question. As a matter of fact, when the findings are examined, it is seen that the participants generally focused more on the advantages of the virtual laboratory, and they have difficulty in determining its disadvantages. Similarly, in Günlü's (2019) study, it was seen that science teachers mostly mentioned the advantages of the virtual laboratory rather than its disadvantages.

Most of the pre-service teachers participating in the study defined virtual laboratories as laboratory simulations. In numerous studies, it has been stated that virtual laboratories are interactive applications that include simulated materials, environments and experiments (Babateen, 2011; Jong, Linn, & Zacharia, 2013). Some pre-service teachers who defined virtual laboratories as internet-based laboratories, online laboratories, and computerized laboratories were also included in the study. Three pre-service teachers stated that virtual laboratories are realized in virtual environment. Some of the pre-service teachers stated that virtual laboratories are accessible everywhere.

When the opinions of the pre-service classroom teachers regarding the advantages of virtual laboratories were examined in the study, it was found that they generally stated that virtual laboratories being accessible anywhere at any time provide great benefits. Some preservice teachers stated that virtual laboratories would be beneficial in schools without laboratory facilities. Some of the pre-service teachers stated that virtual laboratories contribute to students' cognitive, affective and psychomotor skills. Some pre-service teachers stated that the widespread effect of virtual laboratories is greater due to the opportunity to reach more students. Moreover, it was stated in the study that virtual laboratories are more advantageous in terms of laboratory safety, and save time and costs. Zacharia, Olympiou and Papaevripidou (2008) also emphasized that experiments in virtual laboratories require less time and the efficiency increases with the rapid achievement of test results. Thus, students can perform more experiments and collect more data in the time required to do physical experiments.

The pre-service teachers participating in the study stated that the experiments conducted in virtual laboratories would generally provide less permanent learning because they did not turn into action. On the other hand, in the study of Ulukok and Sari (2016), most of the pre-service science teachers stated that the use of virtual laboratories provided permanent learning and made the lesson fun. In the present study, some of the pre-service classroom teachers stated that they thought virtual laboratory activities were not as effective as face-to-face education. Moreover, there were statements stating that the interaction was less in virtual laboratories and the development of psychomotor skills was prevented. In parallel with these findings, in Ekici's (2015) study, science teachers stated that virtual and real laboratory activities should be done together, and that the virtual laboratory was not an alternative but a supporter of the real laboratory. Similarly, in their study Ulukok and Sari (2016) found that pre-service science teachers were of the opinion that virtual laboratories reduced collaboration between individuals.

In this study, 45 pre-service classroom teachers' views about the virtual laboratory were analyzed qualitatively. With the inclusion of quantitative research methods in the research, the opinions of pre-service teachers can be investigated in more detail. By working with a larger sample, results with high generalizability can be revealed.

A wide-ranging research can be carried out by conducting similar studies with preservice and in-service teachers from different branches who are or will be conducting the lessons that can be used in the virtual laboratory.

In the study, it was observed that the opinions of the pre-service teachers about what virtual laboratory is varied quite a lot and a precise definition could not be made. Activities related to what virtual laboratories are and how to use them can be organized for pre-service teachers within the frame of courses such as "Material Design in Science Teaching", "Instructional technologies" and "Science Teaching Laboratory Applications".

In the study, it was found that pre-service teachers gave similar answers and did not have much information about the advantages and disadvantages of the virtual laboratory. Although some limited virtual laboratory applications were carried out with participants at the beginning of the present study, it is necessary to provide pre-service teachers with longer-term virtual lab experiences on different science topics using various virtual laboratory sources in order to realize their disadvantages and advantages. The advantages and disadvantages of virtual laboratories can be explained to pre-service teachers through practical activities.

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6. EXTENDED ABSTRACT

Alan yazında sanal laboratuvar ile ilgili yürütülen araştırmalarda, çalışma grupları genel olarak fen bilgisi öğretmen adaylarından oluşmaktadır. Alan yazında sınıf öğretmeni adaylarıyla gerçekleştirilen sanal laboratuvar ile ilgili herhangi bir çalışmaya rastlanmamıştır. Ancak TIMSS ve PISA gibi uluslararası sınavlarda öğrencilerin fen başarılarını artırmak için ilkokulda öğrencilere fen dersini sevdirmek ve öğretmek büyük önem taşımaktadır. Öğrencileri fen ve bilimsel etkinliklerle tanıştıran sınıf öğretmenlerine fen derslerini yenilikçi uygulamalarla öğretmek büyük sorumluluk düşmektedir. Bu nedenle sınıf öğretmenliği lisans programında öğrenim gören bireylerin sanal laboratuvar hakkındaki görüşlerinin araştırılması büyük önem taşımaktadır. Alan yazındaki mevcut ihtiyaç doğrultusunda bu çalışmanın amacı, Covid-19 sürecinde uzaktan eğitimde senkron olarak yürütülen sanal laboratuvar uygulaması sonucunda sınıf öğretmeni adaylarının sanal laboratuvarlara, sanal laboratuvarların avantaj ve dezavantajlarına ilişkin görüşlerini araştırmak olarak belirlenmiştir.

Sınıf öğretmeni adaylarının sanal laboratuvarlar ile ilgili görüşlerinin incelendiği bu çalışma, nitel araştırma modellerinden olgubilim çerçevesinde yapılandırılmıştır. Araştırmada çalışma grubunu belirlemek için uygun örnekleme yöntemi kullanılmıştır (Fraenkel, Wallen ve Hyun, 2012). Veriler, 2020-2021 güz döneminde Türkiye'deki bir üniversiteden 45 ikinci sınıf öğretmeni adayından (38 kadın, 7 erkek) toplanmıştır. Araştırmada gönüllü katılım ilkesi dikkate alınmış ve kodlar kullanılarak öğretmen adaylarının kimlikleri gizli tutulmuştur. Araştırmada etik ilkeler dikkate alınmıştır. Bu bağlamda katılımcılar K1, K2, … K45 olarak

kodlanmıştır. Araştırmada, sınıf öğretmeni adaylarının sanal laboratuvarlara ilişkin görüşleri hakkında veri toplamak için açık uçlu soruların yer aldığı bir form kullanılmıştır.

Araştırmanın amacı kapsamında hazırlanan sorular belirli temalar çerçevesinde belirlenmiştir. Bu temalar; sanal laboratuvarın tanımı, sanal laboratuvarların avantajları ve sanal laboratuvarların dezavantajları olarak belirlenmiştir. Bu temalar doğrultusunda sorular şu şekilde hazırlanmıştır:

- Sanal laboratuvar nedir?
- Sanal laboratuvarların avantajları nelerdir?
- Sanal laboratuvarların dezavantajları nelerdir?

Çalışmada açık uçlu sorulara verilen cevaplar içerik analizi ile analiz edilmiştir. İçerik analizinin temel amacı, nitel veriler arasındaki temel benzerlikleri belirleyerek verileri anlamlandırmaktır. Bu çalışmada verilerdeki benzerlikler belirlenerek ve kategoriler belirlenerek tümevarımsal bir analiz yapılmıştır (Patton, 2014).

Araştırmada verilerin analizinin güvenirliğini sağlamak için veriler iki araştırmacı tarafından ayrı ayrı analiz edilmiş ve uzmanlar arasındaki uyum düzeyi tutarlılık açısından kontrol edilmiştir. Kodlayıcılar arası güvenirlik Miles ve Huberman'ın (1994) "Güvenilirlik = [Görüş Birliği/ (Görüş Birliği + Anlaşmazlık)]" formülüne göre hesaplanmıştır. Analizler sonucunda iki araştırmacı arasındaki uyum yüzdesi %84 olarak hesaplanmıştır. Bu değer %80'in üzerinde olduğu için araştırmanın veri analizinin güvenilir olduğu sonucuna varılmıştır (Büyüköztürk, Kılıç Çakmak, Akgün, Karadeniz ve Demirel, 2012; Miles ve Huberman, 1994; Patton, 2014).

Öğretmen adaylarının çoğu (%30.6) sanal laboratuvarları laboratuvar simülasyonları olarak tanımlamıştır. Öğretmen adayları sanal laboratuvarları internet tabanlı laboratuvarlar, çevrimiçi laboratuvarlar ve bilgisayarlı laboratuvarlar olarak da tanımlamışlardır. Ayrıca üç öğretmen adayı sanal laboratuvarların sanal ortamda gerçekleştirildiğini ifade etmiştir. Ayrıca öğretmen adaylarından bazıları sanal laboratuvarların her yerde erişilebilir olduğunu belirtmişlerdir.

Öğretmen adayları genel olarak (%26) sanal laboratuvarların her an ve her yerde erişilebilir olmasının büyük fayda sağladığını ifade etmişlerdir. Bazı öğretmen adayları (%14.9) laboratuvar imkânı olmayan okullarda sanal laboratuvarların faydalı olacağını belirtmişlerdir. Öğretmen adaylarından bazıları sanal laboratuvarların öğrencilerin bilişsel, duyuşsal ve psikomotor becerilerine katkı sağladığını belirtmişlerdir. Ayrıca sanal laboratuvarların laboratuvar güvenliği açısından daha kullanışlı olduğu belirtiliyor. Ayrıca bazı öğretmen adayları, sanal laboratuvarların zamandan ve paradan tasarruf sağladığını ve daha fazla öğrenciye ulaşma imkânı nedeniyle daha yaygın bir etkiye sahip olduğunu belirtmişlerdir.

Sınıf öğretmeni adayları genel olarak (%36.4) sanal laboratuvarlarda yapılan deneylerin eyleme dönüşmediği için daha az kalıcı öğrenme sağlayacağını belirtmişlerdir. Öğretmen adaylarının bir kısmı (%27.3) sanal laboratuvar etkinliklerinin yüz yüze eğitim kadar etkili olmadığını belirtmişlerdir. Ayrıca bazı öğretmen adayları sanal laboratuvarlarda etkileşimin daha az olduğunu ve bunun psikomotor becerilerin gelişmesini engellediğini belirtmişlerdir.

Bu araştırmada 45 sınıf öğretmeni adayının sanal laboratuvara ilişkin görüşleri nitel olarak analiz edilmiştir. Nicel araştırma yöntemlerinin araştırmaya dâhil edilmesi ile öğretmen adaylarının görüşleri daha detaylı olarak araştırılabilir. Daha büyük bir örneklemle çalışılarak genellenebilirliği yüksek sonuçlar ortaya çıkarılabilir. Sanal laboratuvarda kullanılabilecek dersleri yürüten olan farklı branşlardan öğretmen adayları ve hizmet içi öğretmenlerle benzer çalışmalar yapılarak geniş kapsamlı bir araştırma yapılabilir. Araştırmada öğretmen adaylarının sanal laboratuvarın ne olduğuna ilişkin görüşlerinin oldukça farklı olduğu ve kesin bir tanım yapılamadığı görülmüştür. Öğretmen adayları için sanal laboratuvarların ne olduğu ve nasıl kullanılacağı ile ilgili etkinlikler düzenlenebilir. Araştırmada öğretmen adaylarının benzer cevaplar verdikleri ve sanal laboratuvarın avantaj ve dezavantajları hakkında fazla bilgiye sahip olmadıkları tespit edilmiştir. Uygulamalı etkinliklerle öğretmen adaylarına sanal laboratuvarların avantaj ve dezavantajları anlatılabilir.