

What do secondary school students think about experimental practices in science lessons taught in distance education?

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Abstract

Following the COVID-19 pandemic, which took the world under its influence, many countries, including our country, switched to distance education. During this period, students did not go to schools and lessons continued to be taught online remotely. In this study, it was aimed to investigate secondary school students' opinions about conducting experiments in science lessons in the distance education process. The study group consisted of 587 secondary school students receiving education in 24 schools located in different regions of Turkey. The form consisting of five open-ended questions used as the data collection tool was developed by the researchers. The descriptive content analysis method was used to analyse the data obtained. In the first question, in which the opinions of students about experiment practices in science lesson were investigated during the distance education process, the answers included in the theme of positive opinion were encountered the most. The greatest difficulty faced by students in conducting experiments in distance education was found to be related to the physical conditions they had. Among the expectations of the students, the most common response was related to increasing experimental practices in distance education. The students stated that they found conducting experiments face to face to be more effective and advantageous compared to conducting experiments in distance education. They also made various suggestions regarding the features of the experimental practices. In line with the results of this study, since it was determined that students found it more effective to do face-to-face experiments, it is thought that it would be appropriate to include experimental practices more, especially in lessons conducted face-to-face, at least in the classrooms where hybrid education is applied.

1. Introduction

Throughout history, people have always tried to find alternative solutions to the extraordinary situations they encountered. While the COVID-19 pandemic period caused great repercussions around the world in 2020-2021, it also created difficult conditions for many people. Especially education carried out in schools has been affected a lot in this respect. In the report published by OECD (2020), it has been stated that around 1.2 billion students worldwide have stayed away from schools, and many countries have interrupted face-to-face education and switched to distance education or continued hybrid education in a controlled manner (OECD.org, 2020). In hybrid education, students continue to face-to-face education activities along

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with distance education (OECD.org, 2020) and many countries adopt the hybrid model in the education system during the pandemic process.

The effects of changing activities in education, which are transformed in line with the needs of people, on the continuity and deficiencies of education, are being investigated by many researchers. (Basilaia & Kvavadze, 2020; Tria, 2020; Toquero, 2021). It has been stated that decisions should be made by considering the moral, ethical and controversial nature of the society during the resolution of COVID-19 related problems, which have been a global socioscientific issue (Evren-Yapıcıođlu, 2020). Although there is a belief that the society's attitude towards distance education is lower than face-to-face education, studies conducted show that, on the contrary, attitudes towards distance education are actually more positive with appropriate materials and flexible studies (Odabařı et al., 2020; Hodges, Moore, Lockee, Trust, & Bond, 2020). In their studies, in which they investigated students' views about distance education, Kahraman (2020) and iek, Tanhan, & Tanrıverdi (2020) determined that students had both positive and negative thoughts, and that they experienced difficulties especially in laboratory and applied lessons, which shows that more studies should be carried out in secondary school groups.

Since the materials to be used in distance education lessons should have a positive effect on students' learning, they should be planned in advance. With the pandemic period, while schools in many countries left the implementation and improvement of the curriculum in the hands of teachers during this crisis, some of them created open education resources (Daniel, 2020). Many teachers have been caught unprepared for this process. Unlike face-to-face education, the use of materials has also changed in the distance education process. For teachers, it has become difficult to increase the participation and motivation of the students, and to support and follow them (Sari & Nayır, 2020). It has been observed that teachers have experienced problems in controlling students and classroom management in virtual classrooms (Alea, Fabrea, Roldan, & Farooqi, 2020; Arslan & Őumer, 2020). The problems experienced by the teachers have also affected the interests and attitudes of the students and changed their interactions in the lessons. Students' interest in lessons has decreased, and as a result, their participation in distance education classes has decreased. Of course, it is not correct to associate this decline only with interest in the lesson. It has also been stated that among the reasons for students not to participate in lessons, there are many reasons such as physical conditions, that is, lack of Internet connection and technological equipment (Adnan & Anwar, 2020; ElSaheli-Elhage, 2021; Henaku, 2020). Distance education period has been realized with the participation of the learners through technological tools such as the Internet network, smart phone, computer, tablet, etc. However, lack of equality of opportunity was observed in many regions (Ramos-Morcillo et al., 2020). Keskin & zer Kaya (2020), in their research on the evaluation of distance education, reported that students experienced shortcomings in terms of communicating, and that there were technical problems during education.

In our country, the continuity of education has been ensured with the Education Information Network (EBA) in distance education (Can, 2020; Kaan & Gelen, 2020; Karakuř & Yanpar Yelken, 2020). In the distance education process, as in face-to-face education, it is aimed to provide students with the cognitive structures and skills determined in the curricula (MoNE, 2018). Especially in science lessons, it is aimed for students to learn by experimenting and discovering. Pınar & Dnel Akgl (2020) stated in their studies on the distance education of science lessons that students found distance education useful due to the pandemic process, and that the lessons held allowed them to repeat and reinforce science subjects, and they also expressed that not being able to conduct experiments in distance education was a major deficiency. The student found experimenting more motivating and fun and social in terms of learning the concepts better, and they claimed that not being able to experiment was the biggest deficiency. Babinkov & Bernard (2020) determined in their study on online chemistry experiments with students that students found these activities instructive. On the other hand, another point that students criticize in distance education is that teaching is carried out with teacher-centered questions and answers and traditional approaches are

mostly used (Koçođlu & Tekdal, 2020). Tanık-Önal & Önal (2020) stated in their study that parents thought that using EBA in science lessons was beneficial for students.

However, researching what students think about experiments that are an integral part of science lessons during distance education and how they conduct experiments in this process are important in terms of identifying and solving existing problems. In this study, it was aimed to determine students' views on the continuity of laboratory experiments in science classes.

1.1. Research Questions

In this study, answers to the following research questions were sought:

1. What are the opinions of the students about conducting the experiments in the science lesson in distance education?
2. What are the difficulties that students are faced with while performing the experiments in the science lesson in distance education?
3. What are the expectations of the students about the experiment practices in the science lesson in distance education?
4. What are the opinions of the students in distance education in terms of comparing the experimental practices in the science lesson with the experiment practices in the real laboratory environment?
5. What are the students' suggestions for conducting experiments in the science lesson in distance education?

2. Methodology

In this part of the research, information is given about the research model, study group, data collection process and data analysis.

2.1. Research Model

Based on the research problem, this research was carried out with the singular screening model, which is one of the screening model types. In studies using singular screening model, the studied event, item, individual, group, subject, etc., it is aimed to describe the variables belonging to the unit and the situation separately (Karasar, 2009).

2.2. Study Group

The study group consisted of 587 students studying in 24 different secondary schools in four cities located in different regions of Turkey. These schools were selected among schools with different socio-economic levels and different achievements in LGS (High School Entrance Exam). While the participants of the study were determined, maximum variation sampling method, one of the purposeful sampling methods, was used. With the maximum variation sampling, it is aimed to find out whether there is a common point between the situations that display diversity, and to reveal the different dimensions of the problem according to this diversity (Yıldırım & Őimsek, 2008). The distribution of the students included in the study group by grades is given in Table 1 below.

Table 1.

Demographic characteristics of the participants in the study group

Variables		N	%
Grade Level	5 th Grade	185	31.52
	6 th Grade	195	33.22
	7 th Grade	117	19.93
	8 th Grade	90	15.33
Gender	Female	289	49.23
	Male	298	50.77

2.3. Data Collection Tool

A form consisting of six open-ended questions was prepared by three researchers to examine the opinions of secondary school students about conducting experiments in distance education. Experimental practices in science lessons in distance education are among the expectations of students to gain their own scientific process skills in a way that they can gain their own experiences and contribute to their lives. With these questions, the ideas of students regarding distance education and hybrid education processes in periods when the number of cases are low during the pandemic process were investigated. Starting from March 2020, when the pandemic began, all classes continued distance education until the end of the term. At the beginning of the 2020-2021 academic year, hybrid education was initiated first in the 8th grades prepared for the exam, followed by the 5th grade, and the distance education was continued at other grade levels. However, after a short time, 5th graders moved to distance education again. Currently, all classes continue distance education. During this time, the students did not have the opportunity to do any experiments face to face. Students individually need a computer, tablet or smart phone, computer access, etc. technological devices and applications in the distance education process. These needs are supplied by the families of the students, and tablets and free internet connections were distributed gradually by the MoNE to the students in need of. Computer and internet access points have been established at some points for students in need by the MoNE. In fact, a virtual laboratory environment was created in schools for students in need of, and students were enabled to continue distance education in this way.

With the questions in this form, it was aimed to determine the students' opinions about conducting experiments in science lessons in the distance education process, the difficulties they encountered while doing experiments, the expectations of the students, the comparison of the real experiment practices and the distance education experiment practices, and the suggestions of the students. This form was then examined in terms of structure, content and scope by two experts who had doctorate degree in the field of science education and two science teachers. In order to determine the compliance and consistency between the experts' opinions, inter-expert compliance was calculated with the reliability formula suggested by Miles & Huberman (1994). This calculation was made as follows:

$$\text{Reliability} = \text{Agreement} / (\text{Agreement} + \text{Disagreement}).$$

As a result of this calculation, the consensus among experts was calculated as .82. The rate above .70 obtained as result of the reliability calculations an acceptable rate (Miles & Huberman, 1994). Three researchers worked again to ensure consensus on the questions in line with expert opinions; as a result, one of the six open-ended questions in the form was removed, and the remaining five questions were finalized. The questions in this form were sent to the secondary school students in the sample via form sharing practices in electronic environment, and the students answered the questions in the form and sent them back through the practice. Thus, the data were collected from the students online.

2.4. Data Analysis

The categorical analysis method, which is one of the descriptive content analysis methods, was used in the analysis of the data obtained from the data collection tool. Descriptive content analysis is a systematic review that aims to identify and explain general trends and research results in a particular research (Çalık & Sözbilir, 2014). The stages of descriptive content analysis are given below.

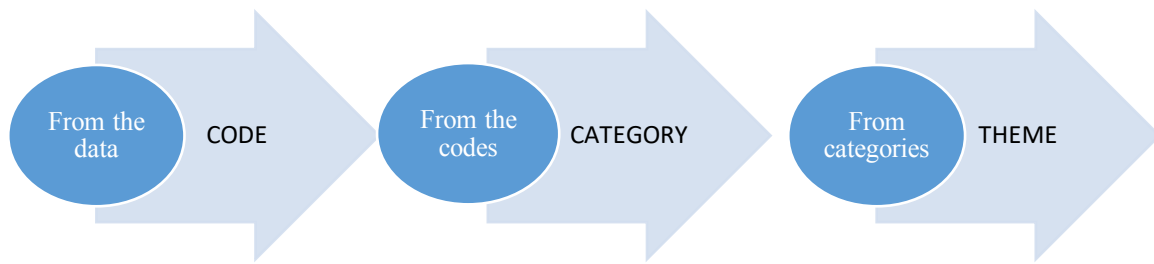


Fig. 1. The stages of descriptive content analysis (Mcmillan & Schumacher, 2010)

In the data analysis process, firstly, the answers given by the students for each question were examined one by one independently by the researchers. After coding was done according to the concepts extracted from the data, it was tried to find common aspects between the codes. Categories were created by combining the codes. In the study, by combining the categories under more general headings, themes were formed. In order to ensure the reliability of the data analysis, the data were analyzed independently by three researchers. The kappa statistic was used to determine the inter-rater reliability for data analysis. In kappa statistic, inter-rater reliability is calculated as follows (Sim & Wright, 2005):

$$k = \frac{\text{Observed rate of compliance} - \text{Incidental compatibility rate}}{1 - \text{Incidental compatibility rate}}$$

The inter-rater kappa statistic value was determined as .87, which quite a high value. Then, the findings obtained as a result of the analysis of the data were converted into percentages and frequencies and presented in charts and tables. While presenting the student answers, the students were coded according to the grade level. 5th grade students were coded as A, 6th grade students as B, 7th grade students as C, and 8th grade students as D, and by writing the student numbers next to these letters, it was shown which grade students gave the relevant answers. For example, code B22 denotes the student numbered 22 at sixth grade level.

3. Findings

In this section, the findings regarding the students' views on experimental practices in the science lesson in the distance education process are included.

3.1. Findings Regarding the First Question of the Study

In this section, the findings obtained from the analysis of the answers of the students regarding the practices of the experiments in the science lesson in the distance education process are included. The themes obtained from the students' answers are shown in Chart 1 below.

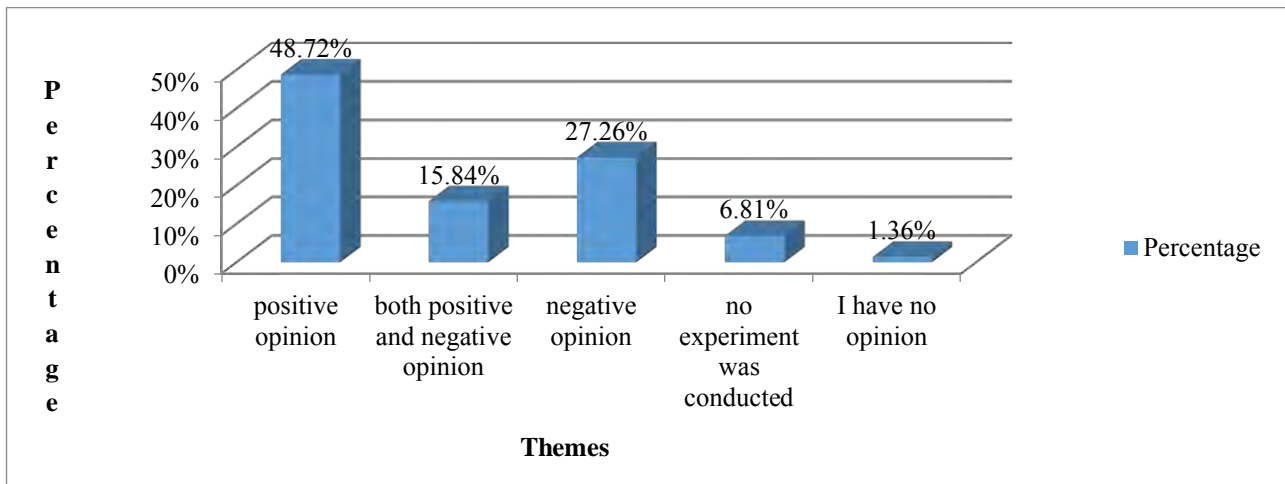


Chart 1. Students' views on the practices of the experiments in the science lesson in the distance education process

When Chart 1 was examined, it was determined that 48.72% of the answers given by students regarding experimental practices in the science lesson in the distance education process were under the theme of positive opinions, 27.26% under the theme of negative opinions, and 15.84% under both the positive and negative opinions themes. 6.81% of the students stated that they did not conduct experiments in the science lesson, and 1.36% stated that they did not have opinions about experimental practices in the distance education process.

According to the grade level, the frequencies of students' views on the implementation of experiments in the distance education process are given in Table 2 below.

Table 2.

Distribution of students' views on the practice of experiments in distance education by grade levels

Themes	5 th Grade	6 th Grade	7 th Grade	8 th Grade	Frequency
positive opinion	110	88	43	45	286
both positive and negative opinion	28	35	16	14	93
negative opinion	36	57	46	21	160
no experiment was conducted	9	12	12	7	40
I have no opinion	2	3	2	1	8

When Table 2 was examined, it was found that 5th grade students had more positive opinions about the experimental practices in the distance education process than the students in other grade levels. It was determined that the students in the 6th grade were the most involved in the negative opinion theme. Opinions were obtained from secondary school students that the experiments were not conducted in different grade levels. It was also found that a small number of students from each grade level did not have opinions about experimental practices in the distance education process.

Among the students' views on experimental practices in the distance education process, some of the students' opinions in the positive opinion theme are as follows:

"Practices were explanatory and instructive. We learned by trying ourselves" (A169)

"Thanks to the experiments conducted in distance education, it is easier for us to learn and we learn better" (B93)

"I've done experiments on my own, my self-confidence has increased, I learned new things" (C33)

"I can say that the lesson is useful and efficient" (D22)

When the expressions of the students in the theme of positive opinion were examined, it was encountered with the answers regarding students' increased motivation for the lesson, their ability to practice individually, facilitation of their learning, and the lesson being more instructive, efficient and permanent with experimental practices in the distance education process.

Among the students' views on experimental practices in the distance education process, some students' responses regarding the negative opinion theme are as follows:

“It is not efficient because we cannot use the materials that we would use in the school environment” (A78)

“In the distance education process, the opportunity to do experiments has been very limited” (B91)

“Because there was no support from the teacher, I had difficulty in getting detailed knowledge about the experiments I did” (C31)

“I don't think it is necessary to conduct experiments in distance education. After all, we do not understand much. Conditions are bad” (D18)

Examining the students' responses in the theme of negative opinion, it was found that the students had individual difficulties in the experimental practices during the distance education process and they needed teacher support. The students stated that the physical conditions of the environment in distance education were insufficient and the experimental practices could not be carried out efficiently. In this process, it was even found that the experimental practices had to be suspended for a while.

3.2. Findings Regarding the Second Question of the Study

In this section, students' views on the difficulties they encountered while conducting the experiments in the science lesson in the distance education process are included. Students' answers are shown in Chart 2 below.

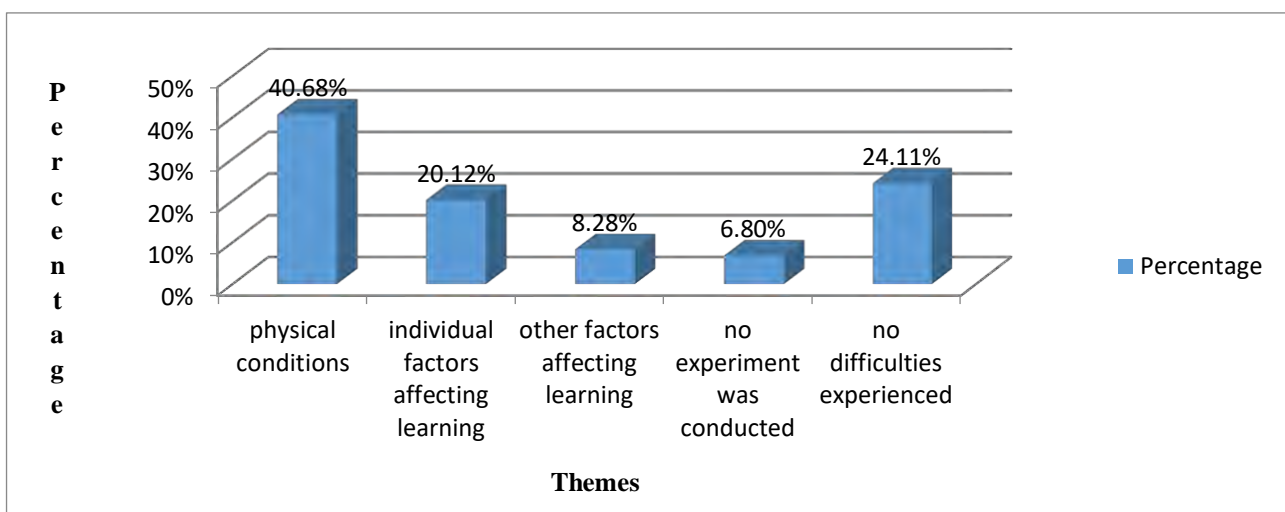


Chart 2. Students' views on the difficulties encountered in the practice of the experiments in the science lesson in the distance education process

When Chart 2 is examined, it is seen that 40.68% of the students stated that they had problems related to physical conditions, 20.12% experienced individual problems, and 8.28% had problems in other factors such as the lack of teacher support in the distance education process which affected their learning. It was determined that 24.11% of the students did not have any difficulties in conducting experiments in the distance education process. 6.80% of the students stated that they did not conduct experiments in the science lesson.

The frequencies of the students' views on the difficulties encountered in the practice of the experiments in the distance education process in the themes according to the grade level are shown in Table 3 below.

Table 3.

Distribution of the students' views on the difficulties encountered in the practice of experiments by grade levels

Themes	5 th Grade	6 th Grade	7 th Grade	8 th Grade	Frequency
physical conditions	75	97	53	50	275
individual factors affecting learning	42	40	30	24	136
other factors affecting learning	22	11	15	8	56
no experiment was conducted	10	17	16	3	46
no difficulties experienced	61	57	21	24	163

When Table 3 was examined, it was determined that students of all grade levels had the most difficulty in physical conditions regarding the difficulties encountered in experimental practices during the distance education process. It was found that 6th grade students experienced more difficulties related to physical conditions than the students in other grade levels. It was found that 5th grade students had more difficulty individually and were more affected by other factors affecting learning, such as the lack of teachers. There were statements of the students in different grade levels expressing that no experiments were conducted in the lessons. There were also students' opinions in different grade levels stating that they did not have any difficulties in the practice of experiments in the distance education process.

Among the opinions of the students about the difficulties encountered in experimental practices in the distance education process, some of the students' views on the physical conditions theme are as follows:

“Lack of experiment materials and environment” (A54)

“Some experiments requiring strength, conditions” (B118)

“I had a hard time choosing the materials, lack of equipment, home environment” (C31)

“The materials used in experiments are not available at home, a dark environment is required or even a bright environment is required to find them, find materials and gather them, they used to be all readily available in the school lab” (D48)

Examining the statements of the students in the physical conditions theme, it was concluded that the home conditions of the students in the distance education process were not suitable for providing the necessary environment and material conditions for their experimental practice. It was observed that there were statements of the students expressing that they experienced technological device problems in the distance education process.

Among the opinions of the students about the difficulties encountered in experimental practices in the distance education process, some of the students' views on the themes of individual and other factors affecting learning are as follows:

“I have a little difficulty because I am not with my teacher and cannot fully understand how to do it.” (A46)

“While conducting experiments in the science lesson in the distance education process, I can sometimes have difficulties. For example, when we are doing experiments, because we are remotely participating, I am having trouble how to do them, but when the lesson is face-to-face, I understand it more clearly” (B108)

“The size of the devices we use to attend the lessons may create some difficulties. I believe we make a lot of effort to see when we attend the lessons through the mobile phone, but when we attend through large screen devices such as computers and tablets, this situation becomes easier” (C89)

“Teacher support” (D22)

Examining the responses of the students in the themes of individual and other factors affecting their learning, it was found that the students had individual difficulties in the experimental practice in the distance education process. In the category of other factors affecting students' learning, the answers such as lack of teacher support, inability to establish eye contact, communication problems and connection problems were found. In addition, it was concluded that the students had difficulty understanding the subject because the learning process was not face-to-face.

Among the opinions of the students about the difficulties they encountered in experimental practices in the distance education process, some of the students' views on the theme of not having any difficulties are as follows:

“I did not encounter any difficulties” (A79)

“No difficulty” (C116)

“Usually we do not experience difficulties” (D32)

When the expressions of the students in the category of not having difficulties were examined, it was found that the students in different grade levels did not encounter any difficulties individually or environmentally in the experimental practice during the distance education process.

3.3. Findings Regarding the Third Question of the Study

This section includes the expectations of the students about the experiments in the science lesson in the distance education process. Students' answers are shown in Chart 3 below.

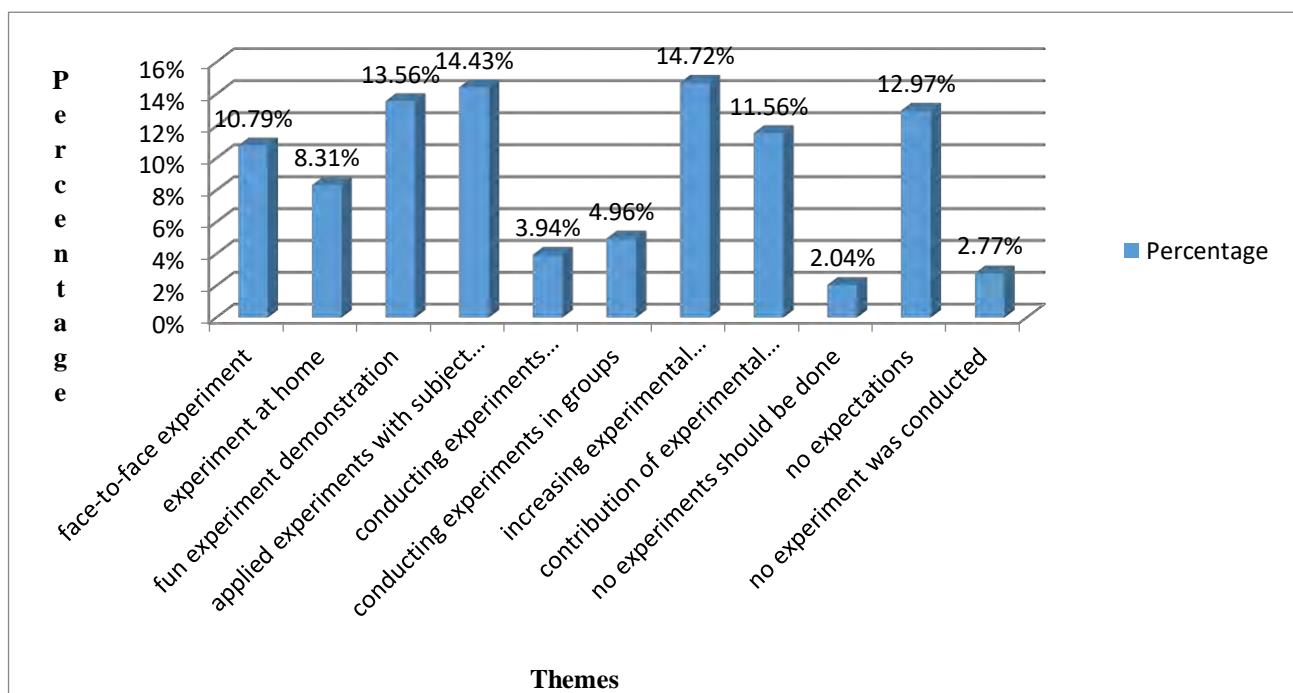


Chart 3. Opinions of students regarding the expectations from experimentation in science lesson during the distance education

When Chart 3 is examined, the expectations of the students in the experiments in the science lesson during the distance education process are as follows: 10.79% of the students expected to be able to do face-to-face experiments, 8.31% to do experiments at home, 13.56% to conduct fun experiments, 14.43% to do subject-content hands-on experiments, 3.94% to do experiments individually, 4.96% to do experiments in groups, while 11.52% wanted experimental practices to contribute to learning, and 14.72% expected the number of experimental practices to be increased. 12.97% of the students stated that they had no expectations, and

2.04% stated that they did not want any experiments to be conducted. 2.77% of the students stated that no experiments were done in the process.

The frequencies of the opinions of students regarding the expectations from the practice of experiments in the distance education process in the themes according to the grade levels are given in Table 4 below.

Table 4.

Distribution of the students' expectations of about the practices of experiments in the distance education by grade levels

Themes	5 th grade	6 th grade	7 th grade	8 th grade	Frequency
face-to-face experiment	23	16	23	12	74
experiment at home	13	25	10	9	57
fun experiment demonstration	31	35	19	8	93
applied experiments with subject content	28	40	22	9	99
conducting experiments individually	11	10	4	2	27
conducting experiments in groups	12	15	5	2	34
increasing experimental practices	41	30	21	9	101
contribution of experimental practices to learning	27	20	18	14	79
no experiments should be done	4	5	2	3	14
no expectations	20	28	19	22	89
no experiment was conducted	3	8	3	5	19

In Table 4, the themes related to the expectations of students regarding experimental practices in the distance education process are included. When the frequency table was examined according to the themes, it was determined that the expectations of the students about the experimental practices in the distance education process were more towards being able to experiment face-to-face rather than being able to do experiments at home. While the 5th, 7th and 8th grade students expressed their expectations about conducting experiments face-to-face, it was determined that the 6th grade students had more expectations of being able to do experiments at home. As for the types of experiments, it was found that the 5th grade students had more expectations for fun demonstration experiments, and that the students in other grade levels had expectations for applied experiments with subject content. The students stated that they expected experimental practices to be increased, and that they expected experimental practices to contribute to learning. Some of the students in different grade levels stated that no experiments were conducted in the lessons, while some stated that the experiments should not be done. It was also found that students in different grade levels did not have any expectations from the experimental practices in the distance education process.

Among the opinions of the students about their expectations from experimental practices in the distance education process, some of the students' views on the theme of experimenting are as follows:

“By experimenting, we can perceive what we have learned better” (A84)

“To be able to do experiments with my teachers and friends” (B74)

“I think experiments can also be conducted in distance education experimental. For example, the teacher can get the experimental material and show the experiment to us practically in the live lesson (conducting the experiment on his/her own)” (C108)

“In my opinion, we have to do at least two experiments on each subject because we personally witness the subject we deal with in the experiments and understand the subject better” (D28)

When the statements of the students in the theme of being able to conduct experiments were examined, it was concluded that the students learned the subject better with the experimental practices and the experimental practices should be increased. Some of the students stated that in the distance education

process, they wanted the teachers to apply the experiments and present them as a demonstration, while some of them wanted to be able to do experiments with their teachers. Students stated that their technological problems should be solved in order to be able to perform experimental practices in the distance education process. In the distance education process, it was found that the experiments should be presented with video and slide, or simpler and easier experiments should be applied at home.

Among the opinions of the students regarding their expectations of experimental practices in the distance education process, some of the students' views on the themes that no experiments should be done and no experiments were conducted are as follows:

“Experiments should not be done” (B163)

“I advocate that experiments should not be conducted in great numbers, because after listening to the lecture, reading the textbook and learning the subject thoroughly, solving related problems is much better than conducting experiments” (D25)

When the statements of the students on the theme that no experiments should be done were examined, they expressed that the experiments applied in the process were not appropriate. The students stated that they preferred problem solutions to reinforce the subject rather than experimental practices. Students stated that their technological problems should be solved in order to be able to perform experimental practices in the distance education process. It was found that in the distance education process, the experiments should be presented with video and slide, or simpler and easier experiments should be conducted at home.

3.4. Findings Regarding the Fourth Question of the Study

In this section, when the experimental practices in the science lesson in the distance education process were compared with the experimental practices in the real laboratory environment, the students stated that they found these two practices different from each other. The themes obtained from the students' answers are shown in Chart 4 below.

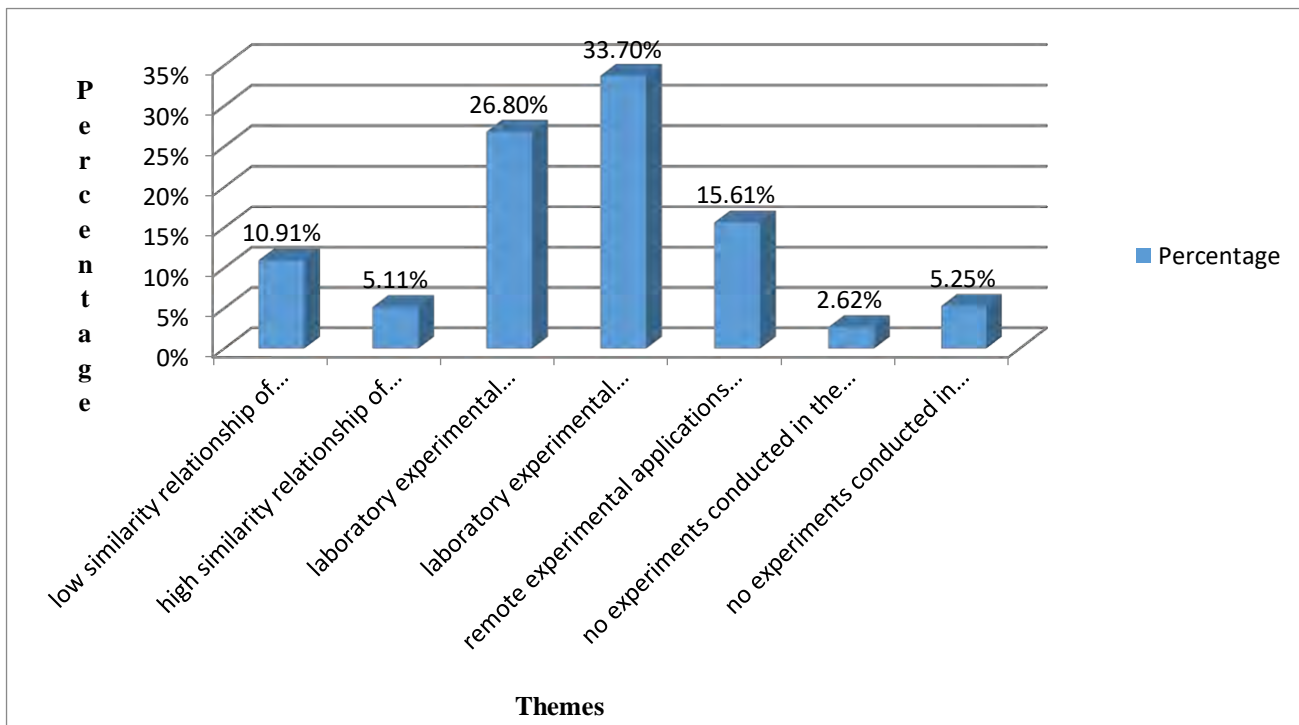


Chart 4. The opinions of the students regarding the differences between the experimental practices in distance education and the experimental practices in the real laboratory environment

When Chart 4 is examined, it is seen that regarding the differences between the experimental practices in the science lesson in the distance education process and the experimental practices in the real laboratory environment, 10.91% of the students stated that the similarity relationship of the experimental practices was low, 5.11% found the experimental practices had a high similarity relationship, 26.80% of the students stated that the experimental practices were effective in the laboratory, 33.70% expressed that the experimental practices in the laboratory were advantageous, 15.61% stated that remote test practices were disadvantageous, 2.62% stated that there were no experiments conducted in the laboratory, and 5.25% stated that there were no experiments conducted in the distance education process. Most of the students stated that the experimental practices in the distance education process and the experimental practices in the real laboratory environment were different, and that the experimental practices in the laboratory were effective and advantageous.

Regarding the comparison of the experimental practices in the science lesson during the distance education process and the experimental practices in the real laboratory environment according to grade levels, the frequency table presenting the differences is given in Table 5 below.

Table 5.

Distribution of the students' views on the differences between experimental practices in the science lesson in the distance education process and real experimental practices by grade levels

Themes	5 th grade	6 th grade	7 th grade	8 th grade	Frequency
low similarity relationship of experimental practices	34	34	5	6	79
high similarity relationship of experimental practices	13	8	5	11	37
laboratory experimental practices are effective	58	76	34	26	194
laboratory experimental practices are advantageous	54	72	61	57	244
remote experimental practices are disadvantageous	33	36	26	18	113
no experiments conducted in the laboratory	5	6	6	2	19
no experiments conducted in distance education	12	9	13	4	38

Table 5 shows the themes related to the comparison of experimental practices in the distance education process with the experimental practices in the real laboratory. When the frequency table according to the themes was examined, it was seen that the 5th and 6th grade students stated that the experimental practices in the distance education process and the experimental practices in the laboratory environment were very different from each other, while the 7th and 8th grade students stated that this difference was not very high. Students at all grade levels stated that experimental practices in the laboratory were effective and advantageous, while experimental practices in distance education were disadvantageous. It was found that some of the 5th, 6th, 7th and 8th grade students did not do any experimental practices either in the laboratory environment or and in the distance education process.

Among the students' views on the comparison of experimental practices in the distance education process with experimental practices in real laboratory environment, some of the students' opinions about the theme of low similarity relationship between experimental practices are as follows:

“It would be a big difference. Because the time is limited in distance education, but if we were at our school, our teacher would better explain the points we do not understand” (A49)

“There is a lot of difference, of lesson; first of all, we do not have the experiment materials and the experiment environment with us; we do the experiments without the supervision of the teacher” (D29)

“In the laboratory, we can perceive with our five senses, but in distance education we only see and hear” (D47)

When the statements of the students regarding the low similarity relationship between the experimental practices were examined, the students stated that there was a big difference between the laboratory environment experiment practices and the experimental practices in the distance education process in terms of environment, material, number of experiments, time, teacher support and practice. Students stated that they learned better by perceiving with five sensory organs in the laboratory. In this theme, students stated that they learned only visually in the distance education process.

Among the students' views on the comparison of experimental practices in the distance education process with experimental practices in real laboratory environment, some of the students' opinions about the theme of high similarity relationship between experimental practices are as follows:

“Our teacher is teaching very well. I cannot see a difference if you listen to him/her very well. There is no difference in terms of place; we should just understand each other” (A178)

“Since we do not conduct experiments at school either, it did not make much difference” (B35)

“It was not so different; it was just the way it was done in the laboratory” (C107)

“In real life, we could make eye contact or show where we got stuck, but in distance education, not much changed for me, we did the same experiments again; even if we were in real life, nothing would change” (D30)

When the statements of the students about the high similarity relationship between the experimental practices were examined, the students stated that there was not much difference between the experimental practices in the distance education process and the experimental practices in the laboratory environment in terms of the effect of the experiments on learning. The minimum difference between experimental practices in the distance and laboratory environment showed that the learning paths, learning environments, opportunities of the students, the method used in teaching and the instructional effect were different. It was found that students' opportunities in the distance education process, their opportunities at school and their technological capabilities were effective on experimental practices.

Among the students' views on the comparison of experimental practices in the distance education process with experimental practices in real laboratory environment, some of the students' opinions about the theme that experimental practices in the laboratory environment are advantageous are as follows:

“In the laboratory, there are more appropriate tools and we as a whole class ask questions to our teacher and learn better. In distance education, on the other hand, sometimes there is a connection problem. We either do not understand the subject or learn it partially” (A136)

“In the real lab, I can get ideas from my friends, I can do my experiments there with my friends, I show my experiment there to my teacher, I can ask my teacher whatever I am curious about. But, in distance education, experiments are usually given as homework, I do the experiment myself at home, sometimes I can get ideas from my family, my family helps in dangerous experiments. Also, in the real laboratory. It is more fun and I feel like a scientist” (B148)

“In a laboratory environment, there are more tools such as microscope, etc. But in our homes, there is no microscope, we could not even examine a cell closely. I think it will be more difficult as the tools and equipment required for every experiment cannot be found in the home environment. With the opportunities of distance education, we can reach less information and more superficial results” (C18)

When the statements of the students in the theme of advantages of experimental practices in the laboratory setting were examined, the students stated that they learned with more fun by exchanging ideas with their friends and teachers in the laboratory environment. The students stated that they did not experience any material shortage in the real laboratory environment, and that they ensured more meaningful learning by

touching the materials. It was found that experimental practices in real laboratory environment were advantageous in terms of students' motivation for the lesson and permanent learning by doing and experiencing.

Among the students' views on the comparison of experimental practices in the distance education process with experimental practices in real laboratory environment, some of the students' opinions about the theme that experimental practices in distance education are disadvantageous are as follows.

“In home environment, a limited number of experiments can be done due to lack of material” (A130)

“There are motivating items in the lab that catch the child's attention; home is insufficient in this regard” (B192)

“Distance education is difficult and there is no teacher support. The experiments in the laboratory environment are meticulously designed with more care, and there is the teacher support, which makes sense” (C43)

When the statements of the students regarding the theme of the disadvantages of experimental practices in the distance education process were examined, it was found that the students were not motivated for the lesson in the home environment, had difficulties in terms of the system, could not understand enough with virtual practices, and that the materials and environment were inadequate. The students stated that they could not do enough experiments due to the environment and lack of materials. The experimental practices in distance education were found to be disadvantageous in terms of students' physical conditions, motivation for the lesson and permanent learning.

Among the students' views on the comparison of experimental practices in the distance education process with experimental practices in real laboratory environment, some students' views on the theme that no experiments were made in distance education and no experiments were conducted in a laboratory environment are as follows:

“I did not do any experiments in a laboratory environment. I have no idea” (A119)

“We did not do any experiments during the distance education process” (B45)

“We did not do any experiments in the laboratory, neither did we do any experiments in distance education. So, I do not know if there is a difference” (C87)

When the statements of the students in the theme that no experiments were conducted in the laboratory environment were examined, it was found that these students did not meet the laboratory environment until the grade level they were in. When the statements regarding the theme that no experiments were done in the distance education process were examined, it was observed that the students did not do any experiments only in the distance education process. It was found that some students were not familiar with experimental practices.

3.5. Findings Regarding the Fifth Question of the Study

In this section, students' suggestions about experimental practices in the science lesson in the distance education process are included. The themes obtained from the students' answers are shown in Chart 5 below.

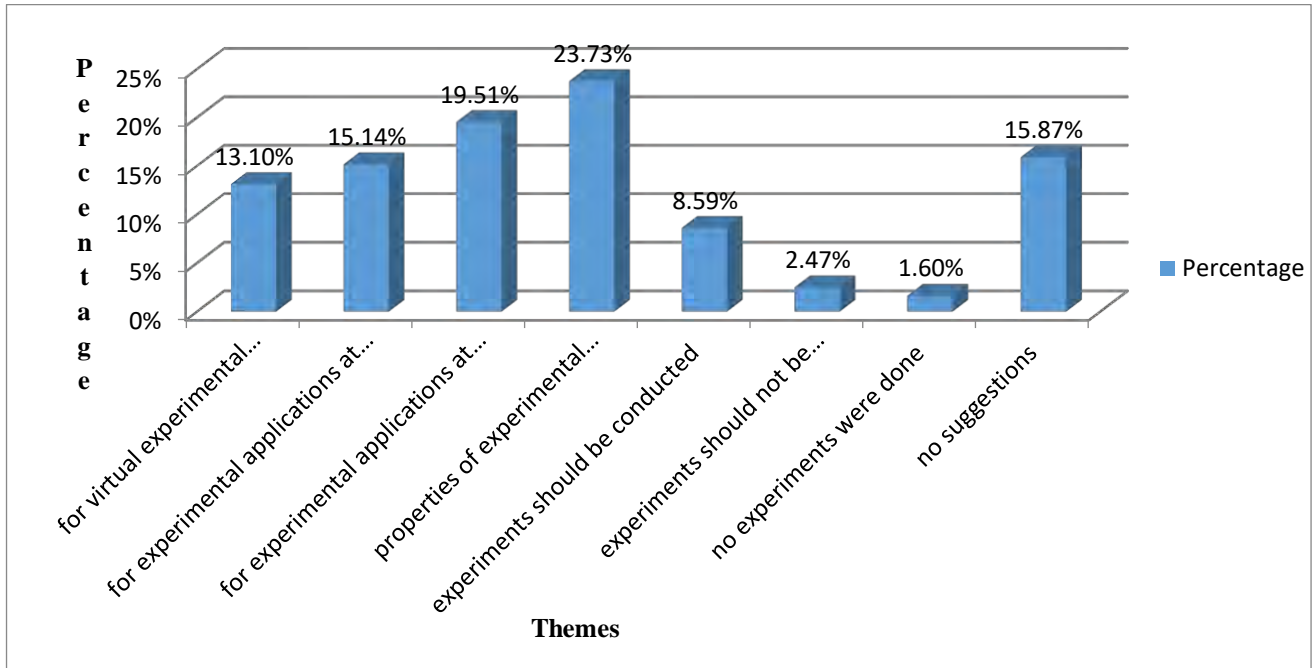


Chart 5. Students' views on suggestions for experimental practices in science lessons in the distance education process

When Chart 5 is examined, it is seen that regarding the experimental practices in the science lesson in the distance education process, 13.10% of the students made suggestions about virtual experiment practices, 15.14% about conducting experiments at home, 19.51% about experiments at school, 28% about the properties of the experimental practices, and that 8.59% of them suggested that experiments should be conducted, while 2.47% of them suggested that experiments should not be conducted. 15.87% of the students stated that they had no suggestions, and 1.60% of them stated that no experiments were conducted.

The frequency table regarding the suggestions for conducting experiments in the science lesson in the distance education process according to the grade level is given in Table 6 below.

Table 6.

Distribution of the students' suggestions regarding experimental practices in science lessons in the distance education process by grade levels

Themes	5 th grade	6 th grade	7 th grade	8 th grade	Frequency
for virtual experimental practices	17	35	22	16	90
for experimental practices at home	43	47	8	6	104
for experimental practices at school	28	57	25	24	134
properties of experimental practices	79	40	21	23	163
experiments should be conducted	11	22	18	8	59
experiments should not be conducted	0	2	9	6	17
no experiments were done	2	5	3	1	11
no suggestions	31	39	24	15	109

In Table 6, the themes related to the suggestions for experimental practices in the distance education process are included. When the frequency table was examined according to the themes, it was determined that the suggestions of the students regarding the experimental practices in the distance education process were related to the virtual experiment, the experiment at home, the experiment at the school, the features of the experiment practices, and the conducting or lack of experimental practices. It was noticed that the students mostly made suggestions for the features of the experimental practices. Some of the students in different

grade levels suggested that experiments should be conducted, while others stated that experiments were not conducted.

Among the opinions of the students about the suggestions for experimental practices in the distance education process, some of the students' views on the themes of virtual experiments, experiments at home, and experiments at school are as follows:

“After the video presentation, the same experiment was performed live by the teacher under laboratory conditions and shown through video conference” (A158)

“Experiments must definitely be done at school in reduced classroom environment. Simple experiments can be done in the home environment” (B91)

“I think a program could be developed to do these experiments. In fact, there are already such programs in the networks such as Morpa campus and EBA” (C89)

“There can be Interactive digital experiments or experiment videos” (D18)

When the suggestions of the students in the theme of virtual experiment practices in the distance education process were examined, it was found that the experiments that the students had difficulty in should be performed and watched in the digital environment in the form of visual examples with different practices. Some students stated that they wanted to do the experiments and prepare their own videos. When the statements of the students regarding the theme of experimental practices at home in the distance education process were examined, it was determined that the suggestions of the students for the conducting experiments at home were to improve the physical conditions in the house, and to conduct simple experiments that can be done with the materials at home. When the suggestions of the students on the theme of experimental practices in the laboratory during the distance education process were examined, it was found that the students wanted the experiments to be carried out face-to-face with their teachers and friends with reduced number of students in the laboratory without any shortage of tools and equipment.

Among the student views regarding the suggestions of experimental practices in the distance education process, some of the students' views on the theme of experiment features are as follows:

“I would like experimental practices to be emphasized. So, it becomes better and more fun” (A2)

“I would recommend doing the experiments with materials that will not be difficult to obtain for the experiments” (B19)

“I think contents could be more fun and more realistic. I am not saying it because they are unrealistic), but for example, there can be more activities and practices in which we can match and observe the results ourselves, I believe” (D35)

When the suggestions of the students regarding the features of experimental practices in the distance education process were examined, it was found that the students suggested that experiments should be simple, instructive, permanent, entertaining, enjoyable, different and more in number.

Among the opinions of the students regarding their suggestions about experimental practices in the distance education process, some of the students' views on the themes that no experiments should be conducted and no experiments were conducted are as follows:

“Let the teacher go to school and do the experiment in a live lesson, there must be experiments” (C83)

“It may be difficult to conduct experiments in the lessons in the distance education process, and students may not be able to comprehend. Instead, rather than doing real experiments the students can be made to understand the subject through solving new generation skill-based experiment problems. We do not do experimental studies in our lessons, but we solve experiment-based problems” (D23)

When the suggestions of the students in the theme that experiments should be conducted in the distance education process were examined, it was found that students wanted the experiments to be conducted in

order for them to comprehend the subject. When the suggestions of the students in the theme that experiments should not be conducted in the distance education process were examined, it was found that the physical conditions of the students were not equal, that conducting experiments was difficult in distance education, and that they did not contribute much to learning. For these reasons, students stated that it was not appropriate to conduct experiments in the distance education process.

4. Discussion and Conclusion

In this study, secondary school students' opinions about conducting experiments in science lessons in distance education were investigated. For this purpose, a form including five open-ended questions was applied to the students. In the first question in which the opinions of the students about the practice of the experiments in the distance education science lesson were investigated, the answers in the theme of positive opinion were found to be the most frequent. It was seen that especially the 5th grade students had more positive views on this issue. The students whose answers were in this theme mentioned that doing experiments in this process facilitated their learning that the lesson was more efficient and useful, and that learning was permanent. They stated that it was beneficial not only to teach science lessons theoretically but also to conduct experiments. The second most common theme for this question emerges as the negative opinion theme. It is seen that 6th and 7th grade students expressed more negative opinions than other grade levels. The students mentioned that they could not access the materials while conducting experiments remotely, and that this process was difficult. Some student responses, though not many, were encountered at every grade level stating that no experiments were conducted in this process.

In the question in which the difficulties students encountered while conducting experiments in distance education were investigated, the students stated that they mostly experienced difficulties related to physical conditions. The students in this theme stated that they could not access the experimental materials and they could not obtain the experimental materials in the home environment. The most answers in this theme were provided by the 6th grade students, while the least answers in this regard were given by the 8th grade students. This result shows that the biggest problem faced by students in doing experiments was to reach the experimental materials. Similarly, in different studies, it was found that the lack of equipment in distance education had negative effects on students' learning (Hebebcı, Bertiz & Alan, 2020; Suri, 2021). On the other hand, students' answers stating that they did not experience any difficulties while performing experiments were also encountered.

When asked about the differences between experimental practices in distance education and experimental practices in face-to-face education, students stated that doing experiments in the laboratory environment was more effective and more advantageous. They stated that the rate of similarity between experimental practices in these two environments was low. Based on this result, it can be said that the students found the experimental practices in face-to-face teaching more effective. Similarly, Pınar and Dönel Akgöl (2020) stated that doing face-to-face experiments in secondary school students' science lessons was effective in terms of their understanding the subjects. Unlike this result, it was found that the technology-based method used in distance education in high school science lessons was more effective than the traditional method (Sofi & Laafou, 2020). Both the physical constraints and low motivation experienced by the students during the distance education process may have influenced this result. There are also studies which concluded that distance education caused a decrease in students' motivation (Niemi & Kousa, 2020; Turner, Hughes & Presland, 2020). The students stated that while experimenting in face-to-face education, they discussed their ideas with their friends and carried out the experiments with their friends. The students stated that they asked questions based on the ideas of their classmates in face-to-face education and that they were influenced by each other's ideas. Moreover, they mentioned that this learning environment did not occur in distance education and that an active learning environment was not created during the experiment. Science teachers stated that there are various difficulties in online collaboration among students in the distance education process (Rannastu-Avalos & Siiman, 2020). Studies show that collaborative learning

environments where students discuss their ideas with their peers are more effective on learning (OkumuŐ & DoymuŐ, 2018; Unal & Cakır, 2021). However, even if students do experiments in distance education, they think it is less fun because they cannot actively communicate with their peers and teacher. As a result, it can be said that the experiments conducted in the laboratory environment are more effective for the students.

When asked about the expectations of the students about conducting experiments in science lessons in distance education, it was determined that the students gave answers in a wide variety of themes. It is seen that the answers in these themes and the frequency of encountering them are close to each other. It is seen that the expectations of the students are mostly to increase experimental practices and to do applied experiments with subject content. Tüysüz and Çümen (2016) found in their study that secondary school students thought that more subject content should be added to the EBA. It is seen that students' expectations are to make the experiments fun and to conduct the experiments face-to-face. Bostan Sariođlan (2015) obtained the result that secondary school students thought that science experiments should be made more fun in face-to-face education. Considering that experiments are an integral part of science lessons, it is not surprising to get these results. Students stated that they would like to continue conducting experiments in science lessons, even from a distance. Tarık-Önal and Önal (2020) determined that parents thought that more experiments should be conducted in science lessons in distance education.

Finally, when the students were asked for suggestions about experimental practices in distance education, they emphasized the importance of doing experiments at school. However, in cases where this was not possible, they suggested using some software that can compensate for experimental practices. Ray and Srivastava (2020) stated that virtual classes and online resources were seen as a possible alternative way of learning science from home in science classes. It was found that students who used virtual laboratory activities in science lessons achieved higher success than students in traditional lessons (Ambusaidi, Al Musawi, Al-Balushi & Al-Balushi, 2018; Rowe, Koban, Davidoff & Thompson, 2017). Studies conducted show that the use of virtual laboratories in science education has a positive effect on the achievements and attitudes of students at all educational levels (Kaba, 2012; Karamustafaođlu, Aydın & Özmen, 2005; Tüysüz, 2010). It is also among the suggestions that the existing infrastructures should be improved, the content of experimental practices should be enriched, and these practices should be expanded.

In all the questions asked to the students, some of the students answered that no experiments were conducted in distance education as well as in face-to-face education. Conducting experiments, which is an integral part of science lessons, seems to have been neglected in some cases during distance education. The students mentioned that they had difficulties with conducting experiments in distance education among the reasons for these. Students who responded in this manner stated that they did not conduct experiments in science classes during face-to-face education. Studies show that teachers do not experiment in science lessons for various reasons (GüneŐ et al., 2013; Yıldız et al., 2006). For these reasons, some students have adopted not experimenting in the distance education process as a normal situation and stated that also they do not experiment in face-to-face education. As a result, experimentation, which is an important part of science lessons, is overlooked by some teachers both in face-to-face education and in distance education. This result is a situation that will negatively affect the students' opinions about experimenting in distance education, and the students have offered various suggestions for experimenting in distance education and offered solutions to this situation. In fact, it seems that most of the students were willing to do experiments and had ideas to compensate them even if they experienced physical difficulties. Students stated that it would be useful if teachers to make experiments using experimental materials in distance education. The fact that teachers can practice more in science lessons by using different techniques in distance education is effective in increasing students' interest in the lesson (Bostan Sariođlan & Őentürk Özkaya, 2021; Sarwoto, Jatmiko & Sudibyo, 2020). Students consider experiments in science lessons as entertaining, instructive and effective in terms of permanent learning.

5. Suggestions

In the light of these results obtained from the study, the following recommendations have been made:

Students stated that they had problems in accessing experimental materials at home during the distance education process. For this reason, it would be appropriate to design the experiments with simple and inexpensive materials that are available at homes. At the same time, practices should be developed to enable students to access technological tools so that they do not have problems in accessing technological tools.

It was determined that the students had positive opinions about conducting experiments in science lessons, but they had some difficulties in this regard. There were answers that the students could not make experiments in distance education. It is thought that it would be appropriate for teachers to do more experiments in distance education and also in face-to-face education in science lessons. It would be appropriate to make virtual laboratory practices widespread and open to students' use in order to enable students to have access to more experiments. In this way, students' curiosity will be supported.

Students stated that doing experiments in face-to-face education is more beneficial than in distance education. It will be especially beneficial for students to conduct experiments in classes where face-to-face education is conducted in classrooms where hybrid education is applied. In future studies, it would be appropriate to investigate the effects of not being able to do face-to-face experiments for a long time at science lessons on students' achievements, motivations and cognitive factors etc.

6. Limitations of the Study

In this study, it was attempted to have access to secondary school students receiving education in schools located in cities in different regions of Turkey with different socio-economic characteristics and LGS (High School Entrance Exam) achievements. However, it was not possible to increase the diversity and reach a sample that can represent all of Turkey within the scope of this study. This problem can be eliminated with studies with larger samples. Thus, it can be determined what students think about conducting experiments in the distance education process in every school type. At the same time, since face-to-face education was not continuing, the data collection form was sent to the students online and the students filled these forms online. It was assumed that the data obtained from students were sincere and reliable. However, the themes obtained from the students' answers suggest that the students' answers to the questions reflect their views on doing experiments.

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