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Comparison of science teachers' thoughts on face-to-face and online STEM-based activities

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Highlights

- The study tried to determine the experiences of teachers who received STEM Education regarding face-to-face and distance education.
- What are the Disciplines/Learning Areas where teachers do STEM activities and how do they prepare for STEM Activities in Online and Face-to-Face Education
- Teachers' thoughts about the Feasibility of STEM Activities in Online and Face-to-Face Education
- Teachers' thoughts about the benefits, limitations, advantages and disadvantages of STEM activities in online and face-to-face education were determined.

Article Info: Research Article

Keywords: D*istance education, phenomenology study, science teachers, STEM*

Abstract

This study aims to compare the views of science teachers on face-to-face and online STEM-based activities. The study was carried out with phenomenology; one of the qualitative research methods. Five science teachers (three female, two male) participated in the study. Data were collected with a structured interview form. Since they were in the distance education process, audio and video recordings were taken during the interviews. Descriptive and content analysis methods were used to analyze the data. In the interviews, STEM-based activities of science teachers; It is seen that they mostly associate with "Physical Events" and "Science, Engineering and Entrepreneurship" from the learning fields. Teachers stated that it is easier to provide classroom management, group work, and collaboration in face-to-face STEM activities. However, in some large group studies, classroom management becomes difficult. They mentioned the physical exhaustion and the difficulty of completing the program. However, in STEM-based activities in the distance education process, the teachers stated that being in cooperation with the family is an advantage, and the problems in terms of materials, time, technological infrastructure, and mobile devices are disadvantages. According to the results of the research, it can be ensured that STEM activities can be better structured in face-to-face lessons than in the distance education process. Because in face-to-face education the characteristics of the students can be determined in advance and the course contents and teaching strategies can be prepared accordingly, communication problems (lack of technical infrastructure, internet speed problems, etc.) can be resolved.

1. Introduction

One of the aims of education is to prepare individuals for the competencies needed in the 21st century and to raise them well-equipped in this sense. Various revisions are made in different education programs worldwide to develop skills such as creativity, critical thinking, problem-solving, and digital literacy (Ahonen & Kinnunen, 2015). The increasing needs of individuals and the necessity of getting them into these programs lead to the differentiation of teaching methods and strategies. Within the scope of revision studies carried out in the Science Curriculum in Türkiye; constructivist philosophy-based practices (MoNE,

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2005), inquiry-based teaching (MoNE, 2013), and Science, Technology, Engineering, and Mathematics (STEM) approach (MoNE, 2017) were added. STEM applications were included in the program for the first time under a separate unit named in 2017 (MoNE, 2017), and with the update made in 2018, science, engineering, and entrepreneurship applications were included in each unit in the program (MoNE, 2018).

1.1. STEM Education

National Research Council [NRC] (2010) stated that it is an approach that includes integrated instructional applications of science, technology, mathematics, and engineering. In this approach, it is expected that science, technology, engineering, and mathematics, which are taught as separate disciplines, will be integrated by individuals in at least two fields and produce new products (Corlu, Capraro, & Capraro, 2014).

Since the world is having more populations, global connectivity, technological advancement, and large-scale problems than ever before; it requæires complex problem-solving skills and the ability to produce innovative solutions (Madden, 2013). In this context, STEM education; Is expressed as an approach that includes applications to provide individuals with the opportunity to solve complex problems they encounter in daily life (Denson, 2011; White, 2014). In addition, it is emphasized that STEM education improves students' problem-solving skills, allows them to make inventions, and offers opportunities to raise self-confident, logical thinkers and technology-literate individuals (Morrison, 2006). In addition, it is stated that STEM education exposes students to problems in daily life, by researching and questioning, providing the opportunity to work together in cooperation in different environments, and contributing to the society they live in by using their experiences in entrepreneurship (Wang et al., 2011; Wang, 2012). In this way, STEM education; enables individuals to acquire interdisciplinary knowledge, and skills and to gain multiple perspectives, thus providing innovative ideas for economic development (Lacey & Wright, 2009).

Although it is desired to encourage students to invent innovative ideas in STEM, the fact that STEM is generally interpreted as science or mathematics does not connote with technology or engineering is an issue that needs to be resolved (Bybee, 2010). In many schools, STEM education seems to focus heavily on science and mathematics, the role of engineering and technology is often overlooked (Mcdonald, 2016). As the results of the studies conducted with the teachers, it is emphasized that the field that is least associated with STEM is the field of engineering and there is no clear idea about how integration can be realized between engineering and various disciplines (El Deghaidy et al., 2017; Wang et al., 2011).

The engineering design process includes defining the problem and solving the problem (National Research Council, NRC, 2010). Engineering design activities are often seen as productive environments for science, because they enable students to develop and apply scientific knowledge (Pleasnats, 2021). It is desired to provide educational environments where students can gain interdisciplinary skills and knowledge to solve real-life engineering or technology problems through STEM education (Fan et al., 2020). Technology and Engineering Education is the problem-based learning method using the principles of mathematics, science, engineering and technology (White, 2014). STEM educators are also asked to create meaningful learning opportunities by using problem and project-based, collaborative and context-based learning, taking into account certain acquisitions, to increase students' knowledge and skills (Kennedy & Odell, 2014).

The most important factor in the application and teaching of STEM in the world is the teachers who have received qualified training in this field and can practice (Wang, 2012). To train qualified and well-equipped STEM teachers, the necessity of giving courses on STEM education (Blackley & Howell, 2015) is important. As an interdisciplinary approach, STEM requires changing teachers' pedagogical approaches to support students' learning.

Teachers who will provide STEM education are expected to carry out teaching activities encouraging students to innovate and invent STEM education. Recently, many different educational applications have been made for STEM education due to some global reasons.

1.2. Online Education and STEM

Since the birth of humanity, there have been many disasters and crises in the world. One of these situations is epidemics. The cases of coronavirus, called Covid-19, were declared a "pandemic" in 2020. After this date, health, communication, economy, and education sectors have been adversely affected throughout the world. One of the sectors most affected by this negative change is education (Dhurumraj et al., 2020). It has been announced that as a precaution against the Covid-19 pandemic, education would continue through "distance education" at all education levels. Because of this change, distance education, is defined as a teaching activity when teachers and students are physically apart from each other (Schlosser & Anderson, 1994).

Distance Learning; is carried out in the form of synchronous and asynchronous education (Uşun, 2009). In asynchronous education, students learn at the time they choose and at their own pace. In synchronous education, learning takes place via live videos and/or audio conferences with instant feedback (Hrastinski 2008). Along with this, students have started to interact with teachers and friends through online tools through both synchronous and asynchronous training (Wang, 2008). Online education has been adopted as voluntary in educational activities or compulsory in cases such as the Covid-19 pandemic (Hsaj, 2021). Online education is a kind of distance education that takes place over the internet (Kim, 2020). When compared with face-to-face education, the physical conditions of teachers and students are separate in online education and they benefit from technology instead of providing face-to-face communication (Johnson, 2003). One of the most important complements of online education is the interaction between teacher, student, and content (Bond, 2020; Kuo, Walker, Belland, & Scroder, 2013). Many educational activities can be made online. One of them is Online STEM education, which has attracted attention recently. An active interaction environment is created by increasing the variety of teaching methods and techniques applied with the digital tools used in online STEM education (Niemi & Kousa, 2020). The opportunities provided by online education have shown their effect on STEM applications, and Online STEM education has gained value during the pandemic period. For this reason, school administrators and policymakers are expected to play an important role in this process by educating teachers about using technological tools, facilitating their smooth transition to online learning, and supporting them throughout the process when necessary (Dhurumraj et al., 2020; Milara et al., 2020).

2. Literature

When the literature is examined, there are STEM applications in face-to-face education (Ashkar et al., 2012) and there are studies examining the views of teachers on STEM education (Can & Uluçınar Sağır, 2018; El Deghaidy et al., 2017; Eroğlu & Bektaş, 2016; Siew et al., 2015; Wang et al., 2011). In addition, it is seen that various studies on STEM education in online environments are carried out (Dhurumraj et al., 2020; Evagorou and Nsıforou 2020; Hsaj, 2021; Jeong and González-Gómez, 2021; Wladis et al., 2014). However, a limited number of studies have been found on the comparison of face-to-face and online STEM education applications in the distance education process (Özdemir, 2021). Özdemir (2021) conducted a study that determined the views of teachers on online STEM applications. However, there are no studies in the literature to compare the similarities and differences between these two practice methodologies of teachers who carry out STEM practices face-to-face and online. In this regard, there is a need for studies comparing the STEM practices of teachers who practice STEM both face-to-face and online. However, in the literature, STEM applications, which are widely used in face-to-face education, are also requested to be used in the distance education process. In this aspect, it is important to determine the opinions of teachers who apply STEM face-to-face and online in science courses during the transition to distance education during the COVID-19 pandemic. In this context, the aim of this study is to determine the views of science teachers on the feasibility of face-to-face and online STEM-based activities in the distance education process. In this regard, it is thought that it is important to compare the data to be obtained from the teachers who regularly carry out STEM practices in distance education courses and these data to be compared with

the face-to-face education data. It is thought that the results of the study will contribute to science teachers who want to integrate STEM into their courses in distance education.

3. Methodology

3.1. Research Design

This study was carried out with phenomenology; one of the qualitative research methods. Phenomenology is used to reveal the concepts that individuals are aware of in daily life but cannot explain clearly because they do not have detailed information (Creswell, 2007). Phenomenological research aims to describe the phenomena that occur as a result of the interaction of people with their environment. The reason for choosing the phenomenology method in the research is to examine the opinions of teachers who are practitioners of online STEM-based activities through distance education during the Covid-19 pandemic.

3.2. Study Group

The sample of this research consists of science teachers who have received STEM education before. While determining the participants of the research, the criterion sampling type, which is one of the purposeful sampling methods, was used. The criterion sample is used in cases that meet the criteria determined in accordance with the purpose before starting the study (Yıldırım & Şimşek, 2011). The criteria determined in this context are as follows: (1) to have received STEM education, (2) to be a science teacher, (3) to participate in the research voluntarily, and (4) to have done both online and face-to-face STEM activities with their students. The study group consists of five science teachers who received STEM education and participated in the study voluntarily working in various cities of Türkiye. In the study, the names of the teachers were coded as T1, T2, T3, T4 and T5 in accordance with ethical rules. Information on the descriptive characteristics of the participants is shown in Table 1.

Table1

Information on the Descriptive Characteristics of the Participants

Gender	**Frequency**
Female	3
Male	2
Age	
24-30 years	2
31-40 years	3
Professional Experience	
1-5 years	1
5-10 years	2
15-20 years	2
Type of School Studied	
State Secondary School	2
Private Secondary school	1
Science and Art Center	1
The type of study that have taken / Done on STEM	
Online education	2
Face to face education	2
In postgraduate education	1
Distance Education Experience	
Between 6-9 months	1
Between 9-15 months	4

3.3. Data Collecting Tools

One of the most basic data collection tools in phenomenological studies is an interview (Merriam, 2013). An interview is an interactive data collection method based on the researcher's questioning method and receiving answers from the participant within the framework of a predetermined purpose and plan (Çepni, 2017). In this study, data were collected with a semi-structured interview form. While preparing the interview form, previous studies in the literature, which were in line with the purpose of the research, were examined (Can & Uluçınar Sağır, 2018; Eroğlu & Bektaş, 2018; Niemi & Kousa, 2020; Özdemir, 2021; Siew et al, 2015). An interview form consisting of 10 questions was developed by the researchers, taking into account the interview questions obtained from the literature. Expert opinions of two science educators, a language expert and a teacher with STEM education were sought regarding the developed interview form. Substances in the form from experts; were asked to evaluate their suitability, serving the purpose of the research, comprehensibility, correctness of the expressions, etc., and to report any deficiencies in the form, if any. Based on the opinions and the suggestions of the experts, the interview questions consisting of seven items were arranged as five items. The pilot trial of the interview form was carried out with one person and its operability was tested. After the expert opinion and the pilot trial, the form was given its final shape by making corrections and additions to some items. Interview questions consisting of five questions are kept in the appendix.

3.4. Data Collection Process

Before the interview, the teachers were informed about the subject and the purpose of the study. After the necessary information, an appointment was made to interview the volunteer teachers on the specified day and time. Due to the Covid-19 epidemic, the interviews were conducted by one of the authors on line through the ZOOM program, and the interviews were recorded by obtaining the necessary permissions from the teachers for video and audio recording. Interviews lasting between 20 and 45 minutes were held with the teachers. It was done in a single session, in an environment where the teachers would feel comfortable; until they ended the interview voluntarily.

3.5. Data Analysis

The data obtained from this study were analyzed based on descriptive and content analysis. While descriptive analysis includes describing and interpreting the data obtained in line with the previously determined themes in the research, it is a type of analysis that focuses more on the answer to the "what" question in research questions (Merriam, 2013, p. 125; Yıldırım & Şimşek, 2018, p. 239). Content analysis, on the other hand, involves presenting data similar to each other within the framework of previously unclear themes and interpreting them in an order that the reader can understand, while also focusing on the answers to questions such as "why and how" (Creswell, 2007, p. 73; Yıldırım & Şimşek, 2018, p. 242). Therefore, in the questions in the interview form, data analysis was diversified by using the descriptive word "what" and content analysis because the word "why" was used. During the analysis of the data in the study, first of all, the interview records were converted into text by one of the authors. By comparing the text and audio recordings by other authors, differences were determined, and the text was edited. In order to comply with the ethical rules in the documented data, the names of the participating teachers were coded as T1, T2… T5. The audio recordings, which were turned into text, were read in detail by the authors. In order to see the answers of the teachers as a whole, the answers given by all the teachers to each question were tabulated. In the tables created, participants, answers, codes, and final codes sections were created and the data were examined in detail.

After the examination, the codes that were seen as similar were combined to form the final codes; the relevant categories of all codes were determined and combined under appropriate themes. Similarly, other researchers determined and arranged the codes and themes independently of each other. The researchers came together to provide the codes, categories, and themes and created the data in line with the consensus.

3.6. Validity and Reliability

In order to ensure the validity and reliability of the study, expert opinion such as Two academicians who have studies on STEM, a Turkish language expert and a measurement and assessment expert was taken about the scope of the interview form, its suitability for the quality to be measured, and the intelligibility of the questions, and the interview form was arranged according to expert opinions. In addition, the selection of the sample group to be interviewed taking into account criteria such as gender, age, professional experience, type of school, education/type of work he/she has done in STEM and distance education experience, and the differences of teachers according to these criteria contributed to the diversity of the data obtained in the study. In this way, the data obtained in the study was desired to be more valid. During the interviews, each stage of the research process was clearly explained to the teachers. In addition, the fact that one of the authors participated in many STEM's training with teachers also allowed the researcher to interact with the participants for a long time. In addition, audio recordings were taken in order to avoid data loss in the interviews with the teachers, and after the audio recordings were documented, the participants were confirmed by allowing the teachers to read them again. In addition to these, the researchers presented examples showing one-to-one quotations about the views of the teachers in creating the codes. The researchers created codes, categories, and themes by analyzing the textual interviews differently from each other. Later, the researchers came together to verify the codes, categories, and

3.7. Findings

In this section, the findings that emerged after the interviews with the science teachers are included. In some questions, teachers' ideas in open-ended questions were also written under more than one code.

3.7.1. Theme: STEM Related Disciplines/Learning Fields

Table 2

Opinions on the Disciplines/Learning Fields Associated with STEM

Codes	T1	T2	T3	T4	T5
Interdisciplinary integration	X		X	X	X
Physical Events	X	X		X	
Science, Engineering and Entrepreneurship	X	X			
Earth and Universe	X	X			
Matter and Nature		X			
Creatures and Life		X			
Suitable for all learning areas			X	X	

As seen in Table 2, it is understood that the participants, who are science teachers, give priority to ensuring interdisciplinary integration in STEM-based activities. In the answers given by the participants about which of the learning areas STEM-based activities are more appropriate, the Physical Events learning area comes first. This statement is followed by responses from Science, Engineering and Entrepreneurship, Earth and Universe, suitable for all learning fields. Sample teacher opinions regarding this question are as follows:

> *T2: "Since it is engineering-based by nature, science, engineering, and entrepreneurship can of course be considered as the basis of STEM-based activities. However, we can say that there are areas of application much more clearly with physical events, events that we can match with physics, in terms of content."*

T3: "I think it is suitable for all of them because there is a science in all of them. In other words, what we call STEM is, at first, I take the word "Science" as a science. As science, that is, since we are dealing with science, I think that since all of these learning areas are included in science, I think it is suitable for all of them. It can be created very easily in a STEM activity with all of them. As long as we give interdisciplinary integration, I say all."

3.7.2. *Theme: Implementation Dimension of STEM Activities in Online and Face-to-Face Education*

Table 3

Opinions on the implementation of STEM activities with online and face-to-face education

Codes	Online education					Face- to- face education				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
The teacher comes to the lesson prepared		X		X			X		X	
Student taking responsibility	X									
Student reactions (irritability)	X									
Teacher support	X	X		X		X	X		X	
Inability to create an atmosphere of discussion				X						
Loss of communication/connection				X						
Ability to create virtual applications			X							
Using different teaching methods					X					
Group work/collaboration						X	X	X	X	
Experimental type activities								X		
Student Readiness										X
Cognitive, affective and psychomotor skills										X

When Table 3 is examined, science teachers think that it is important for applications to make preparations before coming to the classes in the application dimension of STEM-based activities in the online education process. There is also a teacher who states that they can support students less in online applications and that students should take responsibility for their learning. One of the teachers in the online education process states that he cares about group work, so he divides his students into rooms during the discussion phase while teaching in the Zoom application. Another teacher states that students learn by seeing each other when they have group work done in the face-to-face education process, whereas cooperative learning is more difficult in distance education. The opinions of the teachers regarding this question are as follows:

T1: "The majority of the work in distance education falls on the student himself. When we were face to face, the tasks were a little lighter as we shared the responsibility of the task."

T3: "The teacher should have arranged the materials to be included in the program in distance education according to the steps in advance."

T4: "I am someone who attaches great importance to group work. In group work, we divide into rooms and discuss with the children in the dimension of discussion, but this is not enough. So being face to face and discussing, and collaboratively developing the product is one thing.

T2: "Children could learn from each other more easily by seeing each other in face-to-face education. We can't give this situation too many chances in distance education, especially applying the cooperative learning method is a little more difficult."

Science teachers stated that they can provide more support, interfere with students and create the opportunity to work together in the application dimension of STEM-based activities in the face-to-face education process. In addition, a teacher stated that experiment-type activities can be done more in face-to-face education. In addition, one of the teachers answered that students' readiness, cognitive, affective and psychomotor skills are important in the face-to-face education process. The answers given by the teachers regarding the application dimension of STEM-based activities in the face-to-face education process are as follows:

T2: "We have the chance to intervene with children during the practice in face-to-face education, but this intervention is difficult in distance education, so of course, it is not."

T3: "Some activities, especially experiments that student need to do, can be done more easily in face-to-face education."

T5: "First of all, you need to examine the readiness process of the student's cognitive, affective and psychomotor skills.

3.7.3. *Theme: usefulness' Situations of STEM Applications in Online and Face-to-Face Education*

Table 4

Opinions on the usefulness' situations of STEM applications with online and face-to-face education

Codes	Online education					Face to face education				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
Providing interdisciplinary integration in STEM		X	X	X			X	X	X	
Product reveal??		X		X			X			X
Difficulties with classroom management		X			X					
Interest/motivation-enhancing activities		X		X						
Paying attention to students' needs					X					
Content knowledge/pedagogical domain dominance			X					X		
Digital tool use		X		X						
Lack of group work opportunity			X	X						
Ease of providing classroom management							X			X
Coursework according to the curriculum										X
Dexterity development								X		

According to Table 4, some considerations are taken into account to ensure efficiency in the implementation of STEM applications in the online education process. Three teachers mentioned the necessity of being able to write the STEM lesson plan appropriately, to ensure interdisciplinary integration, and to be able to choose a problem very well as an answer to this question. One of the participating teachers states that when students start STEM applications and prefer an example event; when they encounter a problem in daily life, the event interests them more, and a product can be produced at the end of the process. Another teacher states that the way to ensure efficiency in STEM practices is to have a command of their own field, to have the pedagogical content knowledge, and to integrate the disciplines that make up the initials of STEM. Two of the teachers think that due to the sudden transition to online education with the Covid-19 epidemic, the use of digital tools by students has increased and some tools are useful in this process. Some teachers' views on how STEM applications can be effective in online education are as follows:

T4: "The problem needs to be chosen very well. I usually like to start such events with a case study. A good case study should be in daily life, that is, in the style that one can encounter. a problem that is very far from the student's world, I think it is already failing. A good case study surrounds the student and I think the student definitely produces a product at the end of the process."

T3: "Teacher's field knowledge must be very good. At the same time, he should know the pedagogical field. Then I think that it should be combined with science and produce an interdisciplinary product

T2: "When we moved to the digital environment, they had to learn a new platform, for example. They had to learn Padlet or Kahoot. They had to learn new digital tools."

There are points that teachers attach importance to ensuring efficiency while performing STEM practices in the face-to-face education process. The majority of teachers attach importance to providing integration between disciplines in the STEM lesson plan, as in distance education, in the face-to-face education process.

A teacher's view on this subject is that a previously prepared lesson plan can be used in STEM applications, but when using this lesson plan, it will be necessary to adapt it according to the current class level and classroom climate. In Table 4, some teachers stated that it is easier to provide classroom management in face-to-face education. Teachers' views on how to ensure the efficiency of STEM applications in face-to-face education are as follows:

T4: "Of course, it is not correct to say that I had STEM done with only one discipline or that I prepared an activity suitable for the STEM approach."

T5: "It is necessary not to bring a ready-made STEM plan directly to the classroom. Yes, you can be inspired. But the teacher has to adapt it to his/her classroom environment, class level and classroom climate. Otherwise, saying that I should apply it directly and call it STEM is definitely one of the biggest mistakes made."

T2: "We knew how the flow would be in face-to-face education, so it could become very easy for us to manage the classroom with the slightest movement. Classroom management can be difficult sometimes, as the tools we will use in distance education have changed now."

3.7.4. *Theme: Preparation for STEM Activities in Online and Face-to-face Education*

Table 5

Opinions on pre-preparation for STEM activities in online and face-to-face education

Codes	Online education					Face to face education				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
STEM lesson plan preparation and implementation	X	X	X		X	X	X		X	X
Easily accessible material selection	X	X		X			X	X	X	
Web 2.0. use of tools	X	X		X	X	X			X	
Inability to adapt the physical conditions of the classroom					X		X			X

It is known that the preliminary preparation stage is very important before implementing STEM-based activities. In Table 5, almost all of the teachers emphasized that a STEM lesson plan should be prepared and implemented as a preliminary preparation. One teacher stated that she has a draft plan, that she creates a STEM lesson plan that includes the achievements of the subject to be covered every week, and that she also uses the 5E teaching method in the lesson plan. Another teacher stated that she prepares lesson plans, and although she can't stick to the time in some lessons, she conducts her lesson by adhering to the plan stages. It is understood from the statements of the teachers that during the online education process, the list of materials required in the lesson is shared with the students before the lesson and efforts are made to ensure that the materials requested from them are easily accessible. In addition to these, it is seen that the use of Web 2.0 tools in online education has increased and teachers benefited from these digital tools while preparing before the lesson. The views on how pre-preparation is carried out in online education in STEM-based activities are as follows:

T3: "Preliminary preparation should be done for each lesson. I usually have a draft plan in the lesson plan. I write a separate plan for each lesson. I try to write separately for the achievement of each subject in the science course. I use the 5E teaching method in the lesson plan."

T1: "I am preparing a lesson plan. While I am implementing the STEM plan, I try to stick to the phases, even though I am not very attached to the time."

T4: "In distance education, children must acquire materials from their immediate surroundings. If possible, they should be from home."

T5: "Our observation of children in this process is very limited. I am sending some preliminary questions to students in distance education. For example, via Google form or another web 2.0. I use their tools."

The views on how pre-preparation is carried out in face-to-face education in STEM-based activities are as follows:

T5: "Preliminary preparation is of course different in face-to-face education. I'll say this. It is very different in terms of time.

T1: "Since we enter the classroom environment face-to-face, we cannot completely stick to the lesson plan because in this case there is also the class factor. Since physical conditions also came into play, we were experiencing difficulties in terms of time or implementation."

T4: "I always have to prepare my class. If there will be group work, the tables must be combined or each student must provide materials accordingly. I mean, I can't imagine a lesson without preparation."

T3: "I am trying to reveal the students' prior knowledge at the beginning of the lesson. Usually here I love to ask questions to children. Because there is confusion in their minds. I'm trying to make a connection with their prior knowledge or daily life."

T2: "I was trying to arouse curiosity for students. I wanted them to talk about the process and design a product.

3.7.5. *Theme: Challenges in STEM Activities in Online and Face-to-face Education*

Table 6

Opinions on the difficulties experienced in STEM activities in online and face-to-face education

Codes	Online education					Face to face education				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
Inability to communicate with the student				X	X					
Limited time to practice STEM		X			X					
Lack of material/wrong material selection		X		X		X			X	
Difficulty in group work				X	X					
Inadequate selection of resources	X									
Lack of technical infrastructure		X								
Absence from classes		X								
No original products	X									
Inability to achieve class dominance						X				X
Inadequate physical conditions of the classroom						X	X	X		X
Curriculum/subject raising anxiety							X		X	
Inability to adapt to STEM activities	X						X			
Difficulty in providing interdisciplinary integration								X		
Lack of psychomotor skills								X		
Inadequate tools for evaluation									X	
Lack of interest/motivation in students								X		

When the views of the teachers in Table 6 are examined, it can be said that one of the biggest problems in online education is to communicating with students and receiving feedback from them during the lesson.

Some students may experience communication breakdowns due to lack of technical infrastructure, problems with internet speed and connection, and absenteeism from classes. Another difficulty experienced in the online education process is that STEM is a time-limited situation in the application process. The opinions of the teachers about the difficulties experienced in the online education process are as follows:

> *T5: "We see that the child has difficulty in expressing himself in the process. At this point, distance education is not very efficient, and we have a problem in the conclusion part. After all, you have to get some feedback on things. How will the student show what he/she has done in distance education? Will he show it either with the picture he took or the video he took? He can do this as much as he can fit into the frame. I can't see it in three dimensions."*
>
> *T4: "We do not know whether the student is doing activities in the distance education process or not."*
>
> *T2: "The main problem in distance education is that the other person does not have the technical infrastructure. There are problems such as not enough computers or internet.*
>
> *T5: "STEM is not a one-day process. STEM practice crammed into a single lesson is also not right."*

It is seen that the most common difficulty faced by teachers in the face-to-face education process is the physical conditions of the classroom. Some teachers, on the other hand, stated that the large number of students during group work made it difficult to achieve classroom dominance. A few of the teachers stated that it is sometimes not possible to both train the curriculum of the course and allocate time for STEM activities. A teacher, on the other hand, is the scale used to evaluate the process and product in STEM activities, etc. states that the number of vehicles is few and insufficient. Teachers' views on the difficulties that occur in STEM practices in the face-to-face education process are as follows:

> *T1: "It is very difficult to do group work, especially in crowded classes.*
>
> *T3: "Because our classes are small, there is chaos in the classroom.*
>
> *T2: "The fact that there are crowded classes is always difficult and there is a concern about educating the curriculum, you know, when there are too many subjects, this can sometimes be effective."*
>
> *T4 "How we measure and evaluate activities, I think this is the most important problem. Because I don't know much about it. There are not many scales or rubrics for assessment.*

3.7.6. *Theme: Advantages of STEM Activities in Online and Face-to-Face Education*

Table 7

Opinions on the advantages of STEM activities in online and face-to-face education

Codes	Online education					Face to face education				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
Cooperation with family	X		X							
Providing interdisciplinary integration	X		X		X					
Applying different teaching methods and techniques					X					
Increasing persistence/development of positive attitude	X									
Increasing course success	X		X							
Students proving themselves	X		X							
Developing inquiry skills					X					
Learning by doing						X	X	X	X	
Students take responsibility for learning						X		X	X	
Dexterity development								X		

As can be seen from Table 7, when STEM is used in online education, it creates different advantages for teachers and students. These advantages for teachers can be listed as providing interdisciplinary integration, applying different teaching methods and techniques, and being in cooperation with the family. In terms of students, the advantages can be stated as increasing course success, improving questioning skills, increasing permanence and developing a positive attitude. Opinions on the advantages of STEM-based activities can be listed as follows:

> *T5: "As long as I make STEM, I need to add science, technology and engineering. I must add math. Sometimes I have to question the layer of philosophy as well."*
>
> *T3: "In distance education, instead of teaching only science to students, you teach science and integrate mathematics, for example, you integrate technology with augmented reality application at the discovery stage. Then the engineering design process comes into play with product design.*
>
> *T1: "The student realizes that he can do something and his self-confidence increases, and a positive attitude towards the lesson is formed. The student is excited for the next science lesson."*

Considering the advantages of STEM in face-to-face education, it is seen that more teachers express their views on learning by doing. Likewise, in face-to-face education, it is seen that students are better at taking responsibility for learning with the support of teachers. In addition to these, one teacher stated that face-to-face education supports the development of hand skills as it allows group work. The advantages of STEM-based activities in classroom environments where face-to-face education is provided are as follows:

> *T3: "The student learns by doing, living by doing, questioning and designing at the same time, and his dexterity develops."*
>
> *T1: "One of my students was very fond of technology. he was opening the broken tools; the student did not know at first what was good. He finally managed to design something on his own and brought the motor of one of the tools to class, and then built a device that generates electrical energy from wind energy."*
>
> *T4: "If you are designing activities suitable for the STEM approach, you have to activate the student. So the student has to design something. I think these are all great advantages. It is important that students work both individually and as a team."*

T1: "The student realizes that the teacher supports him. we cooperate with teacher and student

3.7.7. Theme: Disadvantages of STEM Activities in Online and Face-to-Face Education

Table 8

Opinions on the disadvantages of STEM activities in online and face-to-face education

Codes	Online education					Face to face education				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
Physical conditions of the classroom						X				
Crowded classrooms and time issues						X				
Inability to achieve class dominance						X				
Psychological/Physical exhaust in teachers						X				
Lack of motivation in students		X								
Physical conditions of the house			X							
Project tasks done by parents			X							

Looking at Table 8, there are different disadvantages for teachers and students in online education and face-to-face education processes. Disadvantages in face-to-face education for teachers can be stated as crowded classrooms, time problems, difficulty in maintaining classroom dominance, psychological effects, and physical exhaust. For students, the disadvantages of online education are seen as not being able to obtain materials, not wanting to be involved in activities, and lack of motivation. In terms of the disadvantages of online education for students, when digital tools come into play, students do not want to open the camera if the physical conditions of the house are not suitable, it is difficult to carry out applied activities, and it is not possible for the child to do the experiments that require expertise in the home environment, or sometimes the parents do the project tasks. The views on the disadvantages of STEM-based activities in terms of online education and face-to-face education are as follows:

T1: "Time is a disadvantage for crowded classes in terms of face-to-face education. Class domination is difficult for large classes. In addition, the conditions in the village school are not favorable. Conditions affect people psychologically.

T4: "There is no advantage in distance education. Because you can't structure the lesson as you want

T3: "In face-to-face education, for example, in phase change experiments, if students were at school, they would see a gas cloud. We cannot do that sight in online education. There is technological software, there are simulations. We can use them. We would also integrate technology, but I think the student should touch and do it himself in the experiment. If there is distance education, this will be a disadvantage.

T3: "Maybe the child will not do the activity at home, he does not turn on his camera anyway, which can be a disadvantage in this respect."

4. Conclusion, Discussion and Suggestions

The training systems of the Covid-19 are affected by this situation and the training systems were introduced online or hybrid training (Hsaj, 2021). At this point, there is important to STEM-based activities in the face-to-face and online education process of STEM education, which is a popular approach recently. This study, it is aimed to compare the opinions of science teachers to face and online stem-based activities. In this context, the results of the study are presented in categories.

Disciplines / Learning Areas that STEM is related: As a result of the study, it is seen that the teachers associate the STEM approach with science, technology, engineering, and mathematics disciplines. As a

result of a similar study, teachers have been found to associate stem with at least two or three fields of science, technology, mathematics, and engineering (El Deghaidy VD, 2017). In this study, the responses to which of the learning areas of STEM is more suitable for the question of "Physical Events" has come to the forefront. As the reason for this situation, students can be expressed as the most physics with the STEM's science field lessons. However, two participants expressed that STEM can be adapted to all learning areas. Considering the findings of the study and the studies in the fields, it is observed that Stem can be applied to many areas and that stem practitioners should be sufficient. As a matter of fact, in many studies, teachers have not sufficient knowledge of Stem (Asghar et al., 2012; Becker and Park, 2011; Agile and Özgünay, 2018) and not to receive adequate training on Stem (Milara et al., 2020) are expressed.

Application of STEM events in online and face-to-face education: Under this theme, the majority of teachers in the online education process are evaluated in advance of the teacher in advance, the idea that they are prepared in advance of the process positively affects the process in advance. Most of the teachers who do STEM activities in online education think that being prepared for the lesson has a positive effect on the education process. The research in the field of field supports this result (Eroğlu and Bektas, 2018; Siew et al., 2015). Teachers stated that the students are not as adequate in their face-to-face training while the activities are implemented in the online education process. In this context, it is clear that the student is used to using digital tools for the student to take their learning responsibility. This process is in schools' live lessons, subject expression videos, exercises, tests, etc. is carried out through applications. Under the contact of STEM application size theme, it is understood that the teachers in the activities in the face-to-face training process are also important to group work and cooperation. The necessity of group work and cooperation is highlighted in many studies to succeed in stem learning (Al-deghaidy et al. 2017; Guzey and Dig., 2014; Herro and Quigley 2017; Nadelson and Seifert, 2017). However, as a result of the study, one of the teachers stated that experiment- type activities can be made in face-to-face education.

There are concerns in the related literature that distance education may not be suitable for STEM courses that require hands-on experiments in laboratory environments (Wladis et al., 2015). In line with the findings obtained in the research, it is seen that both application forms have different advantages. It is seen that in face-to-face STEM applications, teachers support students more, activities that offer the opportunity to learn by doing, such as experimenting, can be done more easily, technological opportunities can be used better, and it is easier for students to work in cooperation in face-to-face education. On the other hand, in online STEM applications, it is revealed that students and teachers are more prepared for the activities and the student's tendency to take responsibility is more. Similarly, in the Baptista et al., 2020 study, students demonstrated a great responsibility for their own learning, how to manage their time, and to make decisions without the help of teachers.

The usefulness' situations of STEM Applications: In online education and STEM applications, teachers mentioned the necessity of providing interdisciplinary integration and choosing the problem situation well. This situation brings to mind the idea that they carry out studies in accordance with the nature of STEM. Regarding productivity, one of the participants stated that a problem situation from daily life is more interesting for students. In various studies, it is emphasized that the importance of carrying out different applications by transferring the concept of "Daily Life" to the learning environment and designing an encouraging learning environment for students with real-life examples will help STEM education (El Deghaidy et al., 2017; Fan et al., 2020). In STEM applications in face-to-face education, teachers emphasized the importance of providing interdisciplinary integration of STEM, as in online education. There are also opinions that teachers who apply STEM should have content knowledge and pedagogical content knowledge. In the literature, it is stated that teachers must have pedagogical content knowledge in order to carry out a good STEM activity (El Deghaidy et al., 2017; Metin et al.; 2023a; Stinson et al., 2009; Wang et al., 2011). In both face-to-face and online STEM activities, the importance of interdisciplinary integration, identifying problem situations suitable for daily life, and pedagogical field and content knowledge adequacy are emphasized. As a matter of fact, in many studies in the literature, the problem

situation determined in STEM applications is applicable, education is provided to students by associating them with daily life for the realization of more permanent learning (El Deghaidy et al., 2017; Fan et al., 2020), and teachers who practice STEM provide the necessary theoretical and professional skills. It is stated that their experience (Baptista et al., 2020) plays an important role in conducting STEM applications more effectively.

Preparation for STEM Activities in Online and Face-to-Face Education: Many teachers state that preparation is important in the implementation of both face-to-face and online STEM-based activities. It is understood that the stage of preparing the lesson plan for STEM is very important in the preliminary preparation process by the teachers. In particular, for an application to be made; It is extremely important to make a plan, which is a preliminary preparation, about determining the purpose of the application, which methods and techniques are appropriate, which tools and equipment will be needed, in which order the application will be carried out, in which environment and how the application will be carried out, and how the application will be evaluated (Margot & Kettler, 2019). In this respect, the fact that teachers care about preparing the plan for STEM activities shows how conscious they are. In addition, while preparing the lesson plan, teachers consider many details such as integrating the fields, the materials being available at home, and being suitable for the level of the student (Metin & Özcan, 2015).

However, the majority of teachers use students' Web 2.0 tools. It also emphasizes the necessity of using tools effectively. In the preliminary stage of face-to-face education, while teachers prepare a STEM lesson plan, want to reach materials from close quarters, and try to adapt to the physical conditions of the classroom environment, students are encouraged to use the opportunities offered by Web 2.0 technological tools in online education. Similar results are seen in the literature (Bolatli and Korucu, 2018; Bozkurt Altan and Ercan, 2016; Çalış 2020; Sias et al, 2017; In this situation, it is seen that teachers try to make STEM applications based on the learning environment, students, and their own experiences in both forms of application.

Difficulties Experienced in STEM Activities in Online and Face-to-face Education: Looking at the difficulties experienced in STEM-based activities in terms of online education, it is seen that the most stated difficulties by teachers are communicating with students, limited time, incomplete/wrong selection of materials, and difficulty in exchanging ideas while doing group work. Similarly, there are studies stating that teachers complain about the lack of sufficient material, technical support, student interest/motivation, and time to carry out their online teaching activities (Baptista et al., 2020; Bell, 2016; Hysaj, 2021; Stone & Springer, 2019; Niemi & Kousa, 2020; Nuere & de Miguel, 2020; Metin et al.; 2021a; Özdemir, 2021). However, due to the limited interaction between teachers and students in distance education, limited communication is also considered a problem in many studies (Bond, 2020; Evagorou and Nsıforou 2020; Jeong and González-Gómez, 2021; Kim, 2020; Niemi and Kousa, 2020; Metin et al.; 2021b). Kim (2020) states that online learning may fall short in involving young children who need more interaction and hands-on work. However, the fact that students do not have sufficient technological equipment and internet connection is shown as the reason for the difficulties in communicating with students in the literature (Baptista et al., 2020; Hall et al., 2020). When we approach the difficulties experienced in STEM-based activities in terms of face-to-face education, the difficulties can be shown as the inadequacy of the physical conditions of the classroom, the anxiety of raising the curriculum, the underdeveloped psycho-motor skills of the students, and the inability to adapt to new methods and techniques. In the literature, the problems experienced with STEM activities in face-to-face education are expressed as the fact that the activities take too much time, the lack of materials and the problem of training the program (Can and Uluçınar Sağır, 2018; El Deghaidy et al, 2017; Eroğlu and Bektaş 2018). As a result of the research, it is seen that the problems encountered while performing STEM applications in face-to-face education and online education are parallel, but in addition to these problems in online education, the difficulties brought by distance education are added.

The Advantage of STEM Activities in Online and Face-to-face Education: There are different advantages for teachers and students in the process of STEM applications in online education and face-to-face education. He states that STEM-based activities in online education have advantages such as being able to cooperate with families, using different teaching methods and strategies, and making inter-field integration easier. As a matter of fact, it is emphasized that family incentives play an important role in fulfilling the responsibilities of students in online education (Bond, 2020; Iivari, 2020; Özdemir, 2021). The advantages of STEM applications in online education for students are; It can be stated as increasing course success, learning by doing, improving questioning skills, increasing permanence, and developing a positive attitude. Provides permanent learning of STEM application in related literature (Becker and Park, 2011), students developed the questioning research skills (et Baptiste., 2020), and learning opportunities recognized through experiences (Madden et al., 2016) it is highlighted.

In this respect, the results of the study show parallelism with the results of other studies in the literature. However, it is also stated that students do not have the opportunity to learn by doing online education, active participation is not enough, and feedback is not provided (Baptista et al., 2020; Bond, 2020; Foti, 2020; Hsaj, 2021). However, there are various studies emphasizing the importance of feedback on students' learning in online education (Guasch et al., 2013; Simons et al., 2020). It is seen that STEM-based activities in face-to-face education contribute to the creation of products by doing/designing, and students' ability to realize their own learning and improve their hand skills. Similarly, various study results emphasize that STEM supports learning by doing (Madden et al., 2016).

Disadvantages of STEM Activities in Online and Face-to-face Education: There are different disadvantages for teachers and students in the process of STEM applications in online education and face-to-face education. Disadvantages of STEM applications in face-to-face education for teachers; It is stated that it is difficult to apply in crowded classrooms, it takes excessive time, it becomes difficult to dominate the classroom, negative psychological effects, and physical exhaust. Similar results regarding the disadvantages of STEM applications in face-to-face education, such as psychological and physical exhaust, the unwillingness of students, difficulty in adapting to the process, crowded classrooms, and unsuitable physical conditions of the classroom, have been found in the relevant literature (El Deghaidy et al, 2017; Eroğlu & Bektaş, 2018). When we look at the disadvantages of online education in this process from the point of view of teachers, it can be found that the process is not structured properly and is not suitable for material supply. For students, one of the disadvantages of online education is seen as the students' unwillingness to participate in activities and lack of motivation. In terms of the disadvantages of online education for students, when digital tools come into play, students do not want to open the camera if the physical conditions of the house are not suitable, it is difficult to carry out applied activities, and it is not possible for the child to do the experiments that require expertise in the home environment, or sometimes the parents do the project tasks. As a matter of fact, it is stated in the literature that students do not open cabins in online education, parents do the homework given to the students, and parents attend the classes with online education beyond what is expected from them (Metin & Korkman, 2021; Metin et al., 2023b).

As a result of the study, these two methods (online and face-to-face stem activities) were compared and the following results were obtained: It has been determined that technological opportunities can be used more easily in face-to-face STEM applications. Development of hand skills of the students while performing the stem activities as a positive aspect and the inadequacy of the physical conditions of the class as the negative aspect of stem education in face-to-face stem applications. It has been determined as a negative aspect that students take more responsibility in online STEM applications, the teacher should choose the problem situation well, and there is more difficulty in communicating with students compared to face-to-face education. Collaboration with the family in the implementation of the STEM activities has been identified as a positive aspect.

Based on the results of the study, the following are recommended: As a result of the research, it is seen that teachers generally prefer STEM applications for physics subjects. Guidance materials can be developed for teachers on how to make applications for all areas in STEM components can be developed. Discussion platforms can be created to share information between teachers on how to make more efficient practices in both online and face-to-face STEM applications. In the study, it is seen that teachers do not feel sufficient in STEM activities in online and face-to-face applications and their field and pedagogical content knowledge about STEM applications is not sufficient. In this respect, in-service training activities can be organized to make the training of teachers about the STEM approach more qualified and they can be encouraged to participate. Conducting another study involving different stakeholders (students, teacher candidates, parents, etc.) affected by the Covid 19 epidemic may allow access to different data on STEM and the distance education process. Qualitative research methods can be used to monitor teachers' course processes in distance education and face-to-face education more closely and to obtain in-depth and detailed information.

References

Ahonen, A. K., & Kinnunen, P. (2015). How do students value the importance of twenty-first-century skills? *Scandinavian Journal of Educational Research, 59*(4),395-412.

Asghar, A., Ellington, R., Rice, E., Johnson, F., & Prime, G. M. (2012). Supporting STEM education in secondary science contexts. *The Interdisciplinary Journal of Problem-based Learning, 6*(2), 85–125.

Baptista, M., Costa, E., & Martins, I. (2020). STEM education during the covıd-19: teachers' perspectives about strategies, challenges, and effects on students' learning. *Journal of Baltic Science Education, 19*(n6A), 1043-1054.

Becker, K., & Park, K. (2011). Effects of integrative approaches among science, technology, engineering, and mathematics (STEM) subjects on students' learning: A preliminary meta-analysis. Journal of STEM education: *Innovations and research, 12*(5/6), 23-37.

Bell, D. (2016). The reality of STEM education, design, and technology teachers' perceptions: A phenomenographic study. *International Journal of Technology and Design Education, 26*(1): 61-79.

Blackley, S., & Howell, J. (2015). A STEM narrative: 15 years in the making. *Australian Journal of Teacher Education, 40*(7), 101-112.

Bolatli, Z., & Korucu, A. T. (2018). Secondary school students' feedback on course processing and collaborative learning with web 2.0 tools-supported STEM activities. Bartın University Journal of Faculty of Education, 7(2), 456-478.

Bond, M. (2020). Schools and emergency remote education during the COVID-19 pandemic: A living rapid systematic review. *Asian Journal of Distance Education, 15*(2), 191-247.

Bozkurt Altan, E., & Ercan, S. (2016). STEM education program for science teachers: perceptions and competencies. Journal of Turkish science education, 13(special), 103-117.

Bybee, R. W. (2010). Advancing STEM education: A 2020 vision. *Technology and Engineering Teacher, 70(*1), 30-35.

Can, K., & Uluçınar-Sağır, Ş. (2018). Sınıf öğretmenlerinin fen, teknoloji, matematik ve mühendislik (FeTeMM) uygulamalarına ilişkin görüşleri [Classroom teachers' views on science, technology, mathematics and engineering (STEM) practices]. *Uluslararası Türk Eğitim Bilimleri Dergisi, 6*(11), 62-83.

Creswell, J. W. (2007). Qualitative inquiry and research design: Choosing among five approaches (2nd ed.). United States of America: Sage Publications, Inc.

Çalış, S. (2020). Physics-chemistry preservice teachers' opinions about preparing and implementation of STEM lesson plan. JOTSE, 10(2), 296-305.

Çevik, M., & Özgünay, E. (2018). STEM Education through the Perspectives of Secondary Schools Teachers and School Administrators in Turkey. *Asian Journal of Education and Training, 4*(2), 91-101.

Çorlu, M. S., Capraro, R. M., & Capraro, M. M. (2014). Introducing STEM education: Implications for educating our teachers in the age of innovation. *Education and Science, 39(*171), 74-85.

Denson, C. (2011). Building a framework for engineering design experiences in STEM: A synthesis. *National Center for Engineering and Technology Education, 169*, 1–6.

Dhurumraj, T., Ramaila, S., Raban, F., & Ashruf, A. (2020). Broadening educational pathways to STEM education through online teaching and learning during COVID-19: *Teachers' perspectives. Journal of Baltic Science Education, 19(*6A), 1055-1067.

El-Deghaidy, H., Mansour, N., Alzaghibi, M. & Alhammad, K. (2017). Context of STEM integration in schools: views from in-service science teachers. *EURASIA Journal of Mathematics, Science, and Technology Education, 13*(6), 2459–2484.

Eroğlu, S. & & Bektaş, O. (2016). STEM eğitimi almış fen bilimleri öğretmenlerinin STEM temelli ders etkinlikleri hakkındaki görüşleri [Views of STEM-trained science teachers about STEM-based lesson activities]. *Journal of Qualitative Research in Education, 4*(3), 43-67.

Evagorou, M., & Nisiforou, E. F. I. (2020). Engaging pre-service teachers in an online STEM fair during COVID-19. *Journal of Technology and Teacher Education, 28*(2), 179-186.

Fan, S. C., Yu, K. C., & Lin, K. Y. (2020). A framework for implementing an engineering-focused STEM curriculum. *International Journal of Science and Mathematics Education, 25*(1), 24-39.

Foti, P. (2020). Research in distance learning in Greek kindergarten schools during the pandemic of COVID-19: Possibilities, dilemmas, limitations. *European Journal of Open Education and E-learning Studies, 5*(1), 19-40.

Guasch, T., Espasa, A., Alvarez, I. M., & Kirschner, P. A. (2013). Effects of feedback on collaborative writing in an online learning environment. *Distance Education, 34*(3), 324-338.

Guzey, S. S., Tank, K., Wang, H. H., Roehrig, G., & Moore, T. (2014). A high-quality professional development for teachers of grades 3–6 for implementing engineering into classrooms. *School science and mathematics, 114(*3), 139-149.

Günbatar, M. S., & Bakırcı, H. (2019). STEM teaching intention and computational thinking skills of pre-service teachers. *Education and Information Technologies, 24*(2), 1615-1629.

Hall, J., Roman, C., Jovel-Arias, C., & Young, C. (2020). Pre-service teachers examine digital equity amidst schools' COVID-19 responses. *Journal of Technology and Teacher Education, 28*(2), 435-442.

Herro, D. & Quigley, C. (2017). Exploring teachers' perceptions of STEAM teaching through professional development: implications for teacher educators. *Professional Development in Education, 43,* 416–438.

Hrastinski, S. (2008). Asynchronous and synchronous e-learning. *Educause quarterly, 31*(4), 51-55.

Hysaj, A. (2021). *COVID-19 pandemic and Online Teaching from the Lenses of K-12 STEM Teachers in Albania.* In 2021 IEEE International Conference on Engineering, Technology & Education (TALE) (pp. 01-07). IEEE.

Iivari, N., Sharma, S., & Ventä-Olkkonen, L. (2020). Digital transformation of everyday life–How COVID-19 pandemic transformed the basic education of the young generation and why information management research should care? *International Journal of Information Management, 55*, 1-6.

Jeong, J. S., & González-Gómez, D. (2021). A STEM course analysis during COVID-19: A comparison study in performance and affective domain of PSTs between F2F and F2S flipped classroom. *Frontiers in Psychology, 12*,1-13.

Kennedy, T. J., & Odell, M. R. (2014). Engaging students in STEM education. *Science Education International, 25*(3), 246-258.

Kim, J. (2020). Learning and teaching online during Covid-19: Experiences of student teachers in an early childhood education practicum. *International Journal of Early Childhood, 52*(2), 145-158.

Kuo, Y.C., Walker, A. E., Belland, B. R., & Schroder, K. E. E. (2013). A predictive study of student satisfaction in online education programs. *The International Review of Research in Open and Distributed Learning, 14(*1), 16-39.

Lacey, T. A., & Wright, B. (2009). Occupational employment projections to 2018. *Monthly Labor Review, November,* 82-109.

Madden, M. E., Baxter, M., Beauchamp, H., Bouchard, K., Habermas, D., Huff, M., Ladd, B.& Plague, G. (2013). Rethinking STEM education: An interdisciplinary STEAM curriculum. *Procedia Computer Science, 20*, 541-546.

Madden, L., Beyers, J., & O'Brien, S. (2016). The importance of STEM education in the elementary grades: Learning from pre-service and novice teachers' perspectives. *The Electronic Journal for Research in Science & Mathematics Education, 20*(5), 1-18.

McDonald, C. V. (2016). STEM Education: A review of the contribution of the disciplines of science, technology, engineering, and mathematics. *Science Education International, 27*(4), 530-569.

Merriam, S.B. (2013) Qualitative Research: A Guide to Design and Implementation. John Wiley & Sons Inc., New York

Metin M., Emlik H., Gürlek E. H., Demirbaş S. (2021b). The investigating of teachers' views about distance education applications in terms of different variables, *Studies in Educational Research and Development, 5*(1), 19-47

Metin, M., Güler, M. M., & Çevik, A. (2023a). Views of STEM-trained science teachers about 21st century skills. *Studies in Educational Research and Development, 7*(1), 1-29.

Metin, M., Gürbey, S. & Çevik, A. (2021a). Teacher opinions on distance education in Covid-19 pandemic process. *Maarif Mektepleri International Journal of Educational Sciences, 5*(1). 66-89.

Metin M. & Korkman N. (2021) A valid and reliable scale development study to determine the problems encountered by teachers in the distance education process, *Journal of Educational Technology & Online Learning, 4*(2), 215-235,

Metin, M., Korkman, N., & Kolomuç, A. (2023b). Teachers' encountered problems in the distance learning. Maarif Mektepleri *International Journal of Educational Sciences, 7*(1), 116-141.

Metin, M. & Özcan, A. (2015). Basic concepts of education, In Metin, M. & Aytaç T. (Eds.), Introduction to educational science. Pegem-A Publishing, Ankara

Ministry of National Education (MoNE) (2005). İlköğretim fen ve teknoloji dersi (6., 7., 8. sınıflar) öğretim programı [Science curriculum (Elementary and middle school 3, 4, 5, 6, 7, and 8th grades)].Talim Terbiye Kurulu Başkanlığı. Ministry of National Education General Directorate of Assessment,Evaluation and Examination Services Support Material.

Ministry of National Education (MoNE) (2013). İlköğretim fen ve teknoloji dersi (6., 7., 8. sınıflar) öğretim programı [Science curriculum (Elementary and middle school 3, 4, 5, 6, 7, and 8th grades)].Talim Terbiye Kurulu Başkanlığı. Ministry of National Education General Directorate of Assessment, Evaluation and Examination Services Support Material.

Ministry of National Education (MoNE) (2017). İlköğretim fen ve teknoloji dersi (6., 7., 8. sınıflar) öğretim programı [Science curriculum (Elementary and middle school 3, 4, 5, 6, 7, and 8th grades)].Talim Terbiye Kurulu Başkanlığı. Ministry of National Education General Directorate of Assessment, Evaluation and Examination Services Support Material.

Ministry of National Education (MoNE) (2018). İlköğretim fen ve teknoloji dersi (6., 7., 8. sınıflar) öğretim programı [Science curriculum (Elementary and middle school 3, 4, 5, 6, 7, and 8th grades)].Talim Terbiye Kurulu Başkanlığı. Ministry of National Education General Directorate of Assessment, Evaluation and Examination Services Support Material.

Milara, I.S., Kl'itkanen, J. Lam, M. Iwata, M.C. Orduftaand, J. Riekki (2020). STEAM in Oulu: Scaffolding the development of a Community of Practice for local educators around STEAM and digital fabrication. *International Journal of Child-Computer Interaction, 26*, 1-14.

Moore M.G. (2007). *Hand of distance education*. Lawrance Erlbaum Associates.

Nadelson L.S & SeifertA.L (2017) Integrated STEM defined: Contexts, challenges, and the future. *The Journal of Educational Research, 110*(3), 221-223.

National Science Foundation (NSF). (2014). National Science Board National Science Foundation Science & Engineering Indicators https://www.nsf.gov/statistics/seind/

Niemi, H. M., & Kousa, P. (2020). A case study of students' and teachers' perceptions in a Finnish high school during the COVID pandemic. *International Journal of Technology in Education and Science (IJTES), 4*(4), 352-369.

NRC (National Research Council) (2010*). Exploring the intersection of science education and 2lst century skills: A workshop summary*. Washington, DC: National Academies Press.

Nuere, S., & de Miguel, L. (2021). The digital/technological connection with Covid-19: An unprecedented challenge in university teaching. *Technology, Knowledge and Learning, 26*(4), 931-943.

Özdemir, E. B. (2021). Views of science teachers about online STEM practices during the COVID-19 period. *International Journal of Curriculum and Instruction, 13*(1), 854-869.

Schlosser, C., & Anderson, M. (1994). *Distance education: Review of the literature*. Ames, IA: Iowa Distance Education Alliance.

Sias, C. M., Nadelson, L. S., Juth, S. M., & Seifert, A. L. (2017). The best laid plans: educational innovation in elementary teacher generated integrated STEM lesson plans. The Journal of Educational Research, 110(3), 227-238.

Siew, N. M., Amir, N. ve Chong, C. L. (2015). *The perceptions of pre-service and in-service teachers regarding a project-based STEM approach to teaching science*. SpringerPlus, 4(8), 1-20.

Simons, J., Leverett, S., & Beaumont, K. (2020). Success of distance learning graduates and the role of intrinsic motivation. *Open Learning: The Journal of Open, Distance and e-Learning, 35*(3), 277-293.

Stinson, K., Harkness, S., Meyer, H., & Stallworth, J. (2009). Mathematics and science integration: models and characterizations. *School Science and Mathematics, 109*(3), 153–161.

Stone, C., & Springer, M. (2019). Interactivity, connectedness and teacher presence: Engaging and retaining students online. *Australian Journal of Adult Learning, 59*(2), 146-169.

Stohlmann, M., Moore, T. J., & Roehrig, G. H. (2012). Considerations for teaching integrated STEM education. *Journal of Pre-College Engineering Education Research (J-PEER), 2*(1), 28-34.

Wang, S. K. (2008). The effects of a synchronous communication tool (yahoo messenger) on online learners' sense of community and their multimedia authoring skills. *Journal of Interactive Online Learning, 7*(1), 59-74

Wang, H. (2012). *A new era of science education: Science teachers' perceptions and classroom practices of science, technology, engineering, and mathematics (STEM) integration*. Unpublished doctoral dissertation, Minnesota University.

Wang, H. H., Moore, T. J., Roehrig, G. H., & Park, M. S. (2011). STEM integration: Teacher perceptions and practice. *Journal of Pre-College Engineering Education Research (J-PEER), 1*(2), 1-13.

White, D. W. (2014). What is STEM education and why is it important? *Florida Association of Teacher Educators Journal, 1*(14), 1-9.

Wladis, C., Conway, K. M., & Hachey, A. C. (2015). The online STEM classroom—Who succeeds? An exploration of the impact of ethnicity, gender, and non-traditional student characteristics in the community college context. *Community College Review, 43*(2), 142-164.

Appendix: INTERVIEW QUESTIONS

1. Which of the learning areas in the Science Curriculum (Earth and Universe, Living Things and Life, Physical Events, Matter and Nature, Science, Engineering and Entrepreneurship) are more appropriate for STEM-based activities? a) Does the application dimension of STEM-based activities vary in distance education and face-to-face education processes? Can you explain why you think this way?

2. What needs to be done to ensure efficiency while performing STEM applications?

a) What is the importance of the distance education process while making these applications?

b) What are the important aspects of the face-to-face education process while making these applications?

3. Do you make preliminary preparations before performing STEM-based activities? a) Do you make preliminary preparations before performing STEM-based activities in the distance education process? If you are preparing; Could you tell us about these preliminary preparations?

b) Would you make preliminary preparations before performing STEM-based activities during the face-to-face education process? If you are preparing; Could you tell us about these preliminary preparations?

4. What are the difficulties you experience while performing STEM-based activities?

a) What kind of difficulties did you encounter in the distance education process while performing STEM-based activities?

b) What kind of difficulties did you encounter in the face-to-face education process while performing STEM-based activities?

5. What are the advantages of using STEM Based activities?

a) What are the advantages of using STEM-based activities in science lessons in the distance education process?

b) What are the disadvantages of using STEM-based activities in science lessons in the distance education process?

c) What are the advantages of using STEM-based activities in science lessons during face-to-face education?

d) What are the disadvantages of using STEM-based activities in science lessons in the face-to-face education process?