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Evaluation Of Design-Based STEM Activities Developed by Science Teachers During Distance Education

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ABSTRACT

This study aimed to examine science teachers' opinions on distance STEM education and how they evaluate design-based STEM activities they designed and implemented themselves in accordance with the engineering design process. Conducted using qualitative research methods, this study employed a case study design. The participants of the study consisted of 6 science teachers who were doing the Master's in science education at a public university in the Western Black Sea region, Türkiye, in the 2020/21 academic year. The courses were conducted online for one semester. An open-ended interview form, observation notes, and worksheets were used as data collection tools. The data were analysed using descriptive analysis method. Despite the fact that the participants appeared to have found some situations positive, including saving time and space, having the chance to watch the lesson again, easy access to documents, and avoiding health risks, they also found some other aspects negative such as inability of doing group work and having low interaction.

Keywords: distance STEM education; engineering design process; science teachers

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INTRODUCTION

Distance education is a learning process in which individuals in different environments and times can reach each other and relevant resources through distance communication systems. Today, many universities conduct courses through distance education and there is distance education research and application centers in 120 universities (Council of Higher Education [CoHE], 2020). Despite this, the history of distance education in Türkiye is not very long. Distance education has many benefits, such as ensuring the sustainability of education (Akinbadewa & Sofowora, 2020; Omiles et al., 2019; Seage & Türegün, 2020) and reducing educational costs (Al-Husban, 2020; Hall & Knox, 2009) although students and teachers are in different locations. Moreover, barriers such as lack of infrastructure, economic reasons, technical problems, lack of public awareness and regional differences are considered as disadvantages of distance education (Gökdaş & Kayri, 2005).

During the pandemic that emerged all over the world in 2019, universities had to make a very rapid transition to distance education. Every educator with or without sufficient experience in distance education suddenly started to teach through distance education technologies. For this reason, educators sought to find out how distance education could be more effective (Karip, 2020). Since the pandemic, a new system in education has been emerging. With this new understanding of education, the importance of being able to continue uninterrupted learning has been emphasized again, and it is considered that the quality of this education depends on digital access and technological progress (Can, 2020). In order to achieve quality and progress in education, education systems are aimed to raise individuals with 21st century skills. With these skills, there is a need for individuals who can follow the technological developments required by the age, as well as being capable of thinking, researching, questioning and inventing in this connection. It is precisely at this point that STEM [Science, Technology, Engineering and Mathematics] education appears. Integrating disciplines in STEM education is an opportunity to acquire 21st century skills such as responsibility, creativity, collaboration, critical thinking and problem solving (Partnership for 21st Century Skills, 2009). STEM education is also seen as the type of education that enhances life skills, ensures quality learning and the use of existing knowledge in daily life (Yıldırım & Altun, 2015).

Distance STEM Education

Due to the pandemic, the interest in distance education and the increasing importance given to STEM education in recent years and the applicability of STEM education through the distance education approach have come to the forefront, as an issue that is of great importance. As a result of relevant developments, the concept of distance STEM education has emerged to be used (Uyanık, 2021). Despite the use of different expressions (digital STEM, online STEM) in relation to distance STEM education, all of them are believed to serve the same purpose, but vary according to the content of the process (Uyanık, 2021). Distance STEM education means providing STEM education online. It can be defined as education that can be carried out synchronously and asynchronously, assisted by various technological materials, and in a process

in which the disciplines of science, technology, engineering and mathematics are handled in an integrated manner, with the active participation of the student. Considering that teachers are the ones who will train students in STEM skills through distance education, it is important to first ensure that teachers participate in the distance STEM education process. For this reason, distance STEM education was carried out synchronously with the teachers in the study.

Studies on STEM education are widely carried out in our country and in the world (Partnership for 21st Century Skills, 2009). However, there are very few studies in the literature on distance STEM education, especially nationwide (Artsın & Deligöz, 2019; Aykan & Yıldırım, 2022; Özkaya, et al., 2022; Tekin-Poyraz & Genç Kumtepe, 2019). While studies on distance education have gained momentum with the pandemic, the number of related studies is still limited in the literature (Artsın & Deligöz, 2019; Chiang, et al., 2022; Gattullo et al., 2022; Jones, et al., 2021; Tekin-Poyraz & Genç-Kumtepe, 2019; Skliarova et al., 2022).

Rationale of the Research and Research Questions

In an era where information and communication technologies are developing day by day, it has once again been seen, owing to the pandemic, that education for new generations cannot be limited to school walls. Nevertheless, there are few studies examining the acceptance of the use of online learning systems, which have rapidly become widespread since the pandemic (Akın et al., 2022). In this ever-changing and developing world, it is necessary to keep up with innovations and to organize our education systems according to new educational trends and to make new reforms in education in this regard. STEM education is an opportunity for us to realize these. It seems necessary to offer STEM education with science teachers via distance education, which became part of our lives with the pandemic as it is obvious that the education systems in the world will no longer be the same as before, and it is highly likely that distance education will not be completely abandoned. In this connection, both the necessary studies on STEM education should gain momentum in our country and new breakthroughs should be achieved on this platform by minimizing the problems encountered in distance education, which is an approach switched to unprepared due to beginning of the pandemic crisis. For these reasons, this study is believed to be important both on account of the lack of sufficient number of studies on distance STEM education and as an example of providing an important approach such as STEM through distance education. The present study is also thought to contribute to the field and set an example indicating that the activities to be implemented within the scope of STEM education can be continued with distance education. At the same time, it is important to study distance STEM education with teachers in the research. Because teachers are primarily responsible for providing students with STEM knowledge and skills. Although face-to-face education is now in place, the necessity of distance education cannot be denied. For this reason, it is important that distance STEM education takes place in the study.

Having taken all these situations into consideration, this study aimed to examine the opinions of science teachers about distance STEM education and the activities carried out in this process in addition to how they evaluated the distance STEM activities they had designed and

implemented according to the engineering design process. In order to achieve this goal, 14 weeks of distance STEM education was conducted with the participating science teachers. The problem statement guiding the study can be expressed as: "How do science teachers evaluate distance STEM education and the design-based STEM activities developed in this context?" Within the scope of this problem statement, the sub-problems of the study can be presented as follows:

- How do science teachers evaluate distance STEM education, the activities implemented, and the distance STEM activities they design and implement themselves?
- How can the efficacy of distance STEM education be increased according to science teachers?

METHOD

This study employed the case study design from among qualitative research methods. Case studies are methods in which one or more phenomena, environments, programs, social groups or other interconnected systems are examined in depth (McMillan, 2000). Moreover, the factors related to one or more situations are investigated with a holistic approach. Based on "how" and "why", a case study allows an in-depth examination of an event (Yıldırım & Şimşek 2011). The case examined in this study is science teachers' evaluations of distance STEM education and design-based STEM activities developed in this context.

Participants

The study was conducted as distance education in the fall semester of the 2020/21 academic year with 6 science teachers who were doing their Master's degree at the time in the Department of Mathematics and Science Education at the Faculty of Education of a public university in the Western Black Sea region of Türkiye and taking the elective course "STEM Education Practices". Participants were selected using purposive sampling method. Purposive sampling allows in-depth examination of information-rich situations depending on the purpose of the study (Patton, 2002). The science teachers were between the ages of 24-38, 2 of whom were male and 4 of whom were female; each was assigned pseudo names, such as Teacher Serap, Teacher Ahmet, Teacher Derya, by the researcher.

Implementation process

This study was conducted in the "STEM Education Practices" course taught as an elective course in the Master of Science Curriculum. It was a 14-week course with three class hours per week. The implementation took place synchronously with distance education due to the pandemic.

The first 5 weeks included the instruction of concepts related to STEM education, its history, the relationship between the related curricula and STEM, as well as STEM-based

teachinglearning models such as 5E Learning Model, Project-Based and Problem-Based Learning. In the 6th, 7th and 8th weeks, design-based STEM activities were carried out through distance education within the scope of STEM education practices. After the 8th week, each science teacher executed their own design-based STEM activities. Both the activities carried out by the researcher and the activities designed by the participants were prepared according to the STEM education cycle (Ministry of National Education, 2016), which can be seen in Figure 1.

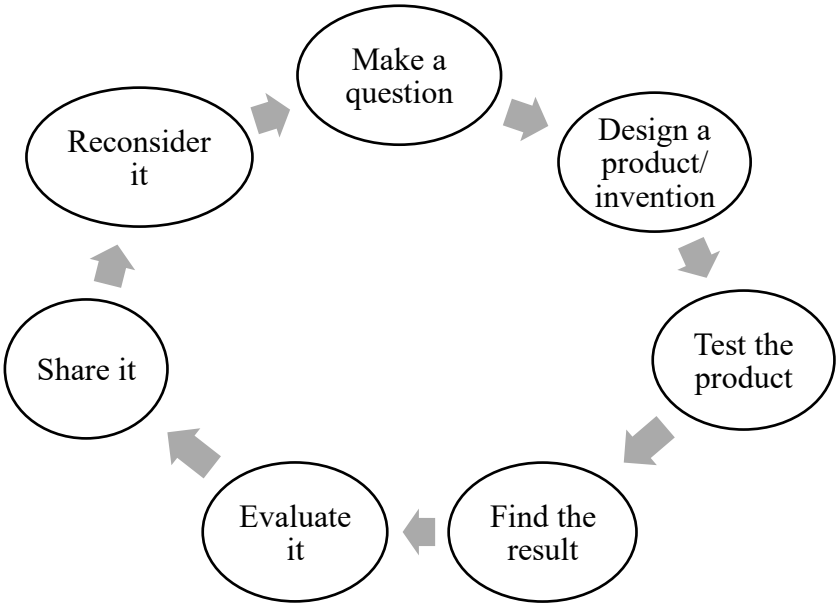

Figure 1. STEM education cycle (MoNE 2016)

The material list of the activities used throughout the lessons was sent to the science teachers via e-mail a few days in advance. The reason why the material list is determined in advance and the same materials are given to teachers is that there are some limitations in the product to be created. Considering the teachers' inability to obtain some materials, alternative materials were also included in the list. Prior to the activities, the worksheet of the relevant activity was shared online on the screen at the beginning of the lesson. Science teachers were given one class hour to construct their designs. In the activities where the given time was not enough, one more class hour was spent online. They sent photos of the products they designed to the researchers at the end of the activity. After the sample activities, the participants individually designed their own activities so that the other participants could be administered the related activities according to the STEM education cycle.

Data collection tools

Data were collected through an interview form, observation notes, and worksheets.

Semi-structured interview form

With the use of predetermined questions in the semi-structured interview form, the data can be presented in a more systematic and comparable way. This provides a great deal of convenience to the researcher (Yıldırım & Şimşek, 2011). The semi-structured open-ended interview form prepared for the purpose of the present study consists of a total of 14 questions to determine the participants' opinions on distance STEM education practices. The participants were asked to express their views on distance STEM education practices, the points they saw as advantages and disadvantages in the STEM activities they had designed and implemented, and as to how the effectiveness of distance STEM education could be increased. In this context, some of the questions asked to teachers are as follows:

1. Did this course help you? If so, how did STEM education contribute to you?

2. If we retconned this course, what would you change and why?

3. At what points did you have difficulty in the activities implemented by the instructor within the scope of the course?

The interviews were conducted online, in an environment where the participants felt comfortable due to the pandemic conditions. The interviews lasted approximately 30-45 minutes. Before the interview, permission was obtained from the teachers to record the interviews. The recorded interviews were transcribed for analysis.

Observation notes

Throughout the process, the researcher observed the teachers during the activity and took field notes. The researcher plays the role of participant observer. As the participant observer, the researcher spent time with the participants at the research process and interview processes (Sönmez & Alacapınar, 2013). The data obtained through observation as a supportive data source for the main data in the semi-structured interview form were used to answer the subproblem of the research that reads, "How do science teachers evaluate distance STEM education, the activities implemented, and the distance STEM activities they design and implement themselves?"

Worksheets

Worksheets were used both in the activities implemented by the researcher and in the activities in which the participants used their own designs. The worksheets were prepared according to the STEM education cycle by using different sources. The prepared worksheets were sent to two experts in the STEM field. Experts were asked to evaluate the worksheets according to the STEM education cycle. Each worksheet included a section where teachers were asked to write down their thoughts about the activity so that the worksheets could be used to support the

interview and observation data. A worksheet as an example of the activities implemented within the scope of the study is given in Annex-1.

Data Analysis

The data were analysed using descriptive analysis. In descriptive analysis, the data obtained are summarized and interpreted according to predetermined themes (Yıldırım & Şimşek, 2011). Moreover, direct quotations are used to present the findings to the reader in an interpreted way. While analysing the data, a literature review was first conducted and themes were identified in line with the theoretical framework. The themes determined for the first sub-problem are as follows: "Positive Opinions about Distance STEM Education" and "Negative Opinions about Distance STEM Education". The theme determined for the second sub-problem has been set as the "Suggestions Related to the Course".

RESULTS

The results obtained from the interviews with science teachers, lesson observations, and worksheets are presented according to the sub-problems.

Results related to the first sub-problem

For the first sub-problem, i.e., "How do science teachers evaluate distance STEM education, the activities implemented and the distance STEM activities they design and implement themselves?", the following themes have been determined: "Positive Opinions about Distance STEM Education" and "Negative Opinions about Distance STEM Education".

Positive opinions about distance STEM education

In relation to the theme of "Positive Opinions about Distance STEM Education", two subthemes were identified, namely, "favourable aspects of the process" and "contribution of the process". While analysing the opinions of science teachers in the STEM education process that took place through distance education due to the pandemic, the findings belonging to the subtheme of "favourable aspects of the process" were presented in the form of codes such as saving time and space, having the chance to watch the lesson again, having easy access to information and documents, avoiding health risks, ensuring continuity in education and having fun lessons.

The participants stated that, thanks to the introduction of STEM training course through distance education due to the pandemic, they saved time for students participating from different locations and that they considered it as an advantage to participate in the lessons from home environment. Ahmet, one of the teachers, expressed his thoughts as follows: *"...During distance education, it was a great advantage that participants could access the learning environment from home. In this course, I had classmates from different cities. I think it is advantageous in terms of not having to travel and saving time."* Another teacher, Derya, supported Ahmet's

opinion with the following statement: *"I think having remote classes made it easier for the students who attended the lesson. Otherwise, some of my classmates from out of town may not have been able to attend the lessons most of the time, but as it was remote, they could learn about STEM activities without missing the classes".* This study also revealed from the lesson observations that the participants considered themselves advantageous in participating in the process online. As emphasized by the teachers Serap, Melike, and Derya, time was used more efficiently that way, owing to distance STEM education, and they had the chance to watch the lessons again at times when they missed any lesson. Another teacher, Ceyda said: *"One of the advantages of distance education is that it eliminates distances. In addition, we can go back to the parts of the lesson we missed whenever we want, which is not possible in formal education"*, emphasizing the opportunity to watch the lessons again.

Some of the participants stated that the distance education provided them with the opportunity to access information and documents more quickly in a shorter time. To this end, Murat, one of the teachers, said, *"It allows us to access information, documents, records, etc. related to the subject in a shorter and faster way."* Another teacher, Melike stated that it was very fast to access the lecturer's notifications and presentations about the course thanks to the digital environment, adding that *"...It was very fast to access the lecturer's notifications and presentations about the course thanks to the digital environment."* In addition, Melike's statement in the worksheet that reads, "*We have instant access to worksheets*" supports this view. With STEM education being conducted remotely, the participating science teachers stated that the continuity of education was ensured and that it was suitable in terms of not posing a health risk. In the same connection, Teacher Ahmet said, *"I think the most important positive aspect of distance education is that it does not pose a health risk. I can say that distance education, which is a result of the COVID-19 pandemic in the world, has solved a big problem by ensuring the continuity of education and training activities at all levels in our country despite its limitations."* According to another participant, Gözde, *"The positive aspects of distance STEM education are that continuity can be ensured without the need for classrooms or laboratories alike and that raising awareness by indicating that STEM approach can be applied anywhere. Continuity in education is essential"*, emphasizing that distance STEM learning ensures continuity in education. Some of the participants stated that they enjoyed and had fun during the distance STEM learning process. One of the participants Teacher Murat, for example, said: *"...It is also a really fun course and I really enjoyed every stage of it".* Similarly, Teacher Serap stated that she enjoyed the theoretical part of the course very much and that she would like to listen to it again, saying that *"I would like to listen to the theoretical part of this course again from the lecturer as it was very enjoyable"*. Course observation data confirm the outcome that the participants had fun during the lesson. In addition, when the activity worksheets of the teachers were analysed, the teachers personally stated that they enjoyed each activity.

Furthermore, the participants stated that the distance STEM education process made a positive contribution in many aspects, such as learning and applying the STEM approach, generating solutions to problems, adapting science and mathematics outcomes to STEM, preparing lesson

plans and facilitating the applicability of the STEM approach in lessons. They also pointed out that, through the distance STEM education course, they made better sense of STEM education, whose popularity they had heard of, and that it started to attract their interest. In a similar context, Teacher Serap said, *"STEM is a popular concept that I have heard a lot about, but I had never received any training on it before. That's why I took this course, and as the course progressed, I read more about it, so the STEM approach started to interest me more"*, and stated that her interest in STEM education increased. On the other hand, some participants stated that they misidentified STEM education before taking this course and believed that its applicability was quite low; however, after taking the course, they seemed to realize that they learned STEM education more accurately, saw that its applicability in lessons was higher, and learned to come up with solutions to problems. As another example, Teacher Derya mentioned about the contributions of the lesson as follows: *"I think it contributed a lot because I realized that I had misunderstood STEM education at first. Now I know that activities should be done with the materials at hand. I thought that more complicated and flawless projects should be produced; however, after this course, I learned that we can come up with a solution to a problem with any material we have at home and that the solution produced is rooted in the STEM education itself."* In addition to his previous comments, Teacher Ahmet also said *"Before taking the course, as a teacher, I thought that the applicability of this approach was lower. Since taking the course, however, my opinion about its applicability has changed positively. I believe that STEM-based educational practices should be used in lessons. I chose the course because I have been interested in STEM education, and now I am happy to have more information about this approach"*, and emphasized the contribution of the process to the teachers. During the lesson observations, the participants appeared to have misconceptions about STEM education in the first week, yet changed over time.

Some of the participants stated that they came up with solutions to the question: "How can I adapt the subjects and intended learning outcomes to STEM education?" thanks to distance STEM education and related activities. In this direction, Teacher Murat said, *"It definitely contributed. Now, for every lesson I will teach, I have started to think about how I can make use of STEM education for the benefit of my students."* Similarly, Teacher Serap said, *"...the emphasis on the use of the STEM approach in science learning outcomes attracts my attention. When teaching a subject, I first think about how the STEM approach can be used for that particular subject matter".* In addition, some participants also stated that their STEM education contributed to preparing lesson plans according to different learning styles (e.g., Teacher Ceyda). Likewise, Teacher Melike stated the contributions of STEM education and said: *"It definitely made a very clear contribution. I think it is really useful in terms of preparing lesson plans according to different learning styles and gaining a general understanding"*.

Negative opinions about distance STEM education

The two sub-themes belonging to the theme of "negative opinions about distance STEM education" are: "undesirable aspects of the process" and "difficulties experienced in the

process". The codes belonging to the first sub-theme are: inability of doing group work and low interaction. The participants stated that communication skills were unlikely to improve since group work could not be conducted during the distance STEM education. In this context, one of the participants, Teacher Ceyda, said: *"The lack of group work means that students cannot gain communication skills properly. In group consciousness, a higher sense of responsibility can be achieved"*, in order to emphasize the aspects, she did not like in the process. Similarly, Teacher Serap supported Ceyda's words when she said: *"I would prefer to have done the activities in groups, interactively. We could not do it this way in remote learning."*

As for the undesirable aspect of the process, two of the participants- Derya and Ceyda- stated that it would not be possible to advance STEM education, which is oriented towards practice, just by looking at the screen during distance education since some information remained in theory. In this connection, Derya shared her views and said: *"...Some subjects remain in theory and there are problems in practice."* Teacher Murat, likewise, said: *"I liken distance STEM education to a barber teaching his apprentice how to shave remotely. I mean, STEM education, which is completely application-oriented, is not as useful when it is done remotely. I believe that being able to put into practice the knowledge and training received through distance education is also directly related to the ability of the apprentice"*, by exemplifying his views in an effort to express the aspect of distance STEM education that he found undesirable.
Under the sub-theme of difficulties in the process are the codes such as the difficulty of communicating through a camera, going through the product design stages, providing necessary materials, having insufficient time, building an internet infrastructure and having technical problems. It was clear that science teachers had difficulties in the stages of designing their products during the lesson within the scope of STEM activities. In this connection, Teacher Melike said that she had difficulties while testing and sharing the product she designed within the scope of the activity in the distance education environment, and Teacher Ahmet said: *"I had a lot of difficulty when I was asked to show the design I made in front of the camera to other participants and to test this design at the same time. I couldn't do it and then I had to send the video of it later"*, in line with Melike's words. Similar to the other participants, Teacher Murat stated that he had difficulty in showing and explaining the products he made through the camera and that he had difficulty in the drawing phase of the design stages. Teacher Derya also stated that it was both difficult and time-consuming to think about the problem and create a prototype for its solution. Both observation data and worksheets support what the teachers stated. Lesson observations also show that teachers had difficulties especially at the product design stage. Derya also added that one of the difficulties of the participants in the distance STEM education process is the difficulty in providing materials for the activities to be implemented within the scope of STEM education. In the same context, Teacher Ceyda clearly stated that she had difficulty in finding materials due to the pandemic, but other than that, she mentioned no other challenges, but a lot of fun: *"Sometimes I had difficulty finding materials due to the pandemic, but other than that, I had no difficulty at all. We had a lot of fun."* Some participants stated that they had difficulties in terms of material supply due to the late receipt of the material list (the participants namely, Serap and Melike). In this context, Teacher Melike expressed the difficulty

she experienced in providing materials with her following words: *"It should have been much easier and earlier for us to receive the activity material lists".* Some participants also indicated that the problems arising from the internet infrastructure in the process created communication problems and made it difficult to understand some issues. At this point, Teacher Ahmet expressed the difficulty he experienced as follows: *"Internet infrastructure and other softwarerelated problems in distance education make effective communication difficult and may prevent some subjects from being understood sufficiently or examined in more detail."* Furthermore, Ceyda also stated that she could not see the designed products clearly when they were presented because of the poor screen quality from time to time and that she experienced some problems due to the internet: *"...We cannot see the product clearly during its presentation. The screen quality is poor and there are sometimes problems on the Internet.*"

Results related to the second sub-problem

As for the second sub-problem: "How can the efficacy of distance STEM education be increased according to science teachers?", a theme was determined as "Suggestions related to the course".

Results related to the "Suggestions for the Course"

The codes under the theme, "Suggestions for the course", comprise the aspects indicating that the course and activities should be conducted face-to-face, the design and materials should be told in advance, the duration of the course should be increased, coding should be added and different resources related to STEM should be included. Most of the participants stated that STEM activities would be more efficient and effective if the distance STEM education was provided through face-to-face education. Teacher Derya stated: *"...it would have been more productive if we had carried out STEM activities face-to-face"*. In one of his suggestions about the course, teacher Murat stated that he would like to change the way the course is offered and since it is based on practice, thus it needed to be provided face-to-face. Teacher Ahmet stated that although distance training was conducted with some shortcomings, he would prefer to have taken the course face-to-face and that even the most successful distance learning remains incomplete compared to face-to-face education. Unlike the suggestions of the participants indicating that the course should be offered face-to-face, Teacher Melike did not make any suggestion about the course as distance learning with her statement: *"I would not want it to be changed because I think there would not be a big difference between face-to-face and distance training courses"*.

Some of the participants suggested that the activity to be designed should be assigned as homework before the lesson and the design should be described in advance so that it would be easier to obtain materials (Melike). In the same context, Teacher Serap stated her opinion as follows: *"...I thought it would have been better if the design was assigned as homework before the lesson, so we could provide the materials we wanted to make the design with."*, and in another statement of her, she added: *"There is nothing I want to change in the way the lesson is*

taught. It is effective and efficient. I would like to listen to the theoretical part of this course again from the lecturer, it was very enjoyable", yet she gave no suggestions. One of the participants, Murat, suggested that the lesson be extended in terms of its duration so that more creative ideas would emerge, and he added: *"...I would also like to extend the duration of the lesson because if there was a little more time, more creative ideas and products could emerge"*. In order to make the lesson more effective, Melike, stated that: *"Maybe it would be better if we added some coding. Another drawback I saw was that various STEM resources (digital or printed) were not included. For example, an article based on a sample STEM activity could have been included.*" Some of these participants indicated that everything was very good and that they did not want to change anything about the course (i.e., teachers Ceyda and Ahmet).

Conclusion and Discussion

According to the results of the study, the science teachers found certain aspects, i.e., saving time and space, having the chance to watch the lesson again, and providing easy access to information and documents as positive with respect to distance STEM education. Some other research results exist in the literature supporting the data obtained in this study (Aykan & Yıldırım 2022). Kazanidis, et al. (2015), and evaluate how university students participating in a distance STEM course benefited from the process and the adequacy of this process in terms of STEM learning; the results revealed that the students reported positive opinions about the teaching capacity of the distance STEM training course. Similarly, Burke and Dempsey (2020) identified the issues that teachers found advantageous regarding the education during the pandemic; their participants emphasized that they had the opportunity to get acquainted with digital education platforms and that such a training would save time and practicality in terms of accessing some resources and materials.

The fact that distance education does not pose a health risk, ensuring continuity in training and the course being fun are among the other results of the study, which were emphasized by science teachers as the popular aspects of the process. Moreover, it was revealed that distance education raised the awareness of teachers that STEM education can be applied anywhere. Tekin-Poyraz and Genç-Kumtepe (2019) reported that if STEM learning is supported by distance education, it can reach disadvantaged groups who cannot go to school for various reasons (e.g., due to disabilities, illnesses, or living in rural areas, etc.) and they can have access to STEM education. Yusuf, et al. (2021) mentioned the necessity of distance education, especially during the pandemic, and the science teachers as the participants of that study stated that the STEM education offered through distance education had many contributions, indicating that the process contributed to learning the STEM approach and being able to apply it. Similarly, Artsın and Deligöz (2019) conducted a conceptual evaluation study on science, technology, engineering and mathematics education in massive open online courses. According to the study, if STEM education is provided through massive open online courses, STEM-based activities will be visible to a wider audience, thereby raising social awareness, and making contributions to developing countries and individuals alike. Moreover, the opinions of science teachers in that study indicated that being able to adapt the intended learning outcomes in science and

mathematics to the STEM approach and to prepare lesson plans in line with this are also among the contributions of the distance STEM education process.

The results of the present study also show that despite the positive opinions teachers reported about distance STEM education, the activities implemented as well as the ones they designed and implemented themselves, they still had negative opinions. They stated that the lack of being able to do group work, low interaction and the course remaining in theory were the negative aspects of the process while learning about the STEM approach through distance education. In another study, Hebebci, et al. (2020) reported that some teachers had positive opinions about distance education, while others stated that high levels of interaction and social communication could not be easily achieved in distance education as in face-to-face education. Moreover, Başaran et al. (2020) aimed to obtain information about the efficiency of the distance education process by examining the views of teachers, students and parents on distance education during the pandemic process. Similar to the results of the present study, the authors demonstrated that the participants mentioned positive aspects of distance education, in addition to the negative aspects related to the limited interaction. Additionally, the fact that teachers found it very difficult to communicate via computer while testing, sharing and presenting the products they designed within the scope of STEM activities appeared as another problematic situation they experienced in the process. There are studies in the literature that show similar results with the teachers' negative opinions about the distance STEM education (Aykan & Yıldırım, 2022; Bulut et al., 2022; Skliarova et al., 2022; Özkaya et al., 2022).

Most of the science teachers who made suggestions about the course stated that the activities related to the STEM learning provided through distance education due to the pandemic should actually be performed face-to-face. Niemi and Kousa (2020), for example, aimed to reveal the views of teachers and students in a secondary school in Finland during the pandemic about the process and activities. The authors demonstrated that teachers had negative opinions indicating that distance education cannot provide the naturalness achieved in face-to-face education, that a quality learning process cannot be experienced and that the quality of interaction remains low. In the current study, some of the science teachers stated that it would be better if the design to be made within the scope of the activity was assigned as homework before the lesson and told about in advance, and that, knowing the design in advance would make it easier to obtain materials. Tekin-Poyraz and Genç-Kumtepe (2019) demonstrated that with the help of distance education, students can prepare at home for STEM activities to be done at school, or STEMrelated activities that cannot be done at school can be experienced at home. In this respect, it is in parallel with the suggestions of the participants of this study when they emphasized that the design to be created should be informed in advance. Another issue suggested by the participants was to extend the duration of the course, in which way, as they emphasized, more creative ideas and products could emerge. Some participants also stated that it would be beneficial to add coding to the distance STEM education course and that different resources related to STEM should be included.

The results show that the opinions about distance STEM education are mostly positive. For this reason, it is recommended to conduct more studies on distance STEM education so that its content can be enriched. Since the participants stated that they would implement the designbased STEM activities they designed in their classrooms, seminars on design-based STEM activities can be provided for teachers. This study focuses on distance education, demonstrating that teachers have some negative views about it. It is suggested that future researchers should take these views into account and design future studies accordingly. Combining face-to-face and distance learning, blended learning may also be suggested in this regard.

DECLARATIONS

Ethical Considerations : The study was voluntary and anonymous for all participating science teachers. Necessary permissions were taken from the Ethics Committee of Zonguldak Bulent Ecevit University (Protocol number: 913). In terms of ethical considerations, the participants were provided with information about the purpose of the study, confidentiality of their data, and the voluntary nature of their participation.

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ANNEX-1

A worksheet as an example of the activities Problem

Statement:

Umut'un pandemi sürecinde en yakın arkadaşı minik balığı Turuncu' dur. Umut minik balığı Turuncu' nun oynayabileceği, ona arkadaşlık edebileceği bir denizaltı balık tasarlamayı düşünmektedir. Tasarlamayı düşündüğü denizaltı balık; bir balık gibi su üstünde yüzebilmeli ve su altına batabilmeli, ayrıca su içinde askıda kalabilmelidir.
Pekiyi arkadaşlar "Hem su üzerinde hem dipte yüzebilen hem de su içerisinde askıda kalan bir denizaltı balık modeli nasıl yapılabilir?"

Material List:

Etkinlik için gerekli malzemeler şunlardır:

- 500 ml'lik iki adet pet şişe,
- 15 adet bilye,
- 15 adet pipet,
- Selobant (yapıştırma amaçlı),
- Tornavida ya da delici başka bir cisim,
- Makas,
- 3 adet balon,
- 1 kutu oyun hamuru,
- Geniş plastik kutu (yüzdürme havuzu),
- Su

(Verilen malzemelerin hepsini kullanmak zorunda değilsiniz. Malzeme kullanımı konusunda özgürsünüz.)

Rules:

Kurallar:

- ✓ Tasarladığınız denizaltı balık modeli su üzerinde yüzebilmeli,
- ✓ Su altında yüzebilmeli (batabilmeli),
- ✓ Su içinde askıda kalabilmelidir.

Make a Question:

PROBLEME YÖNELİK SORU OLUŞTUR (BİREY/GRUP ARAŞTIRMASI VE TARTIŞMASI):
(Aşağıdaki sorular yapacak olduğunuz denizaltı balık modelinize yol gösterecektir.)

1. Canlılar suda nasıl yüzmektedir?
2. Denizde veya havuzda olduğunuzu düşündüğünüzde suyun üzerinde hareketsiz kalmayı nasıl sağlayabilirsiniz?
3. Dalgıçlar suyun içerisinde nasıl kalabilmektedir?

Design a Product:

ÜRÜN/BULUŞ TASARLA
(Hayal Etme, Planlama ve İnşa etme)

- Tasarlamayı düşündüğünüz denizaltı balık modelini çizelim.
- Tasarımınızda hangi malzemeyi, ne için kullanmayı düşünüyorsunuz?
- Modelinizi inşa edin. Aşağıdaki boşluğa tasarımınızı inşa ederken neler yaptığınızı **sebepleri** ile birlikte yazın.

Test the Product:

ÜRÜNÜ TEST ETME
Ekranda herkesin görebileceği bir şekilde,

- Verilen malzemelerle denizaltı balık modelinizin tasarımını yaparak yüzebilir, askıda kalabilir ve batabilir hale getiriniz ve test ediniz.
- Test etme süreci bireysel/gruplarla birlikte gerçekleşecektir.
- Bu süreçte tüm yaptığınız modelin tasarımı anlatınız.

Find, Evaluate and Share the Result:

SONUÇ ÇIKAR/DEĞERLENDİR VE PAYLAŞ
(Yapılan tasarımlar ile ilgili sonuçları ve değerlendirmeleri paylaşına)

- Model istenilen 3 özelliği de gösterebildi mi? (yüzme, batma, askıda kalma)
- Modeli tasarlarken hangi bilimsel bilgileri kullandınız?
- Etkinlik sırasında ne tür sorunlar ile karşılaştınız ve bunları nasıl çözdünüz?
- Sizin yaptığınız modeldeki kısımlar balıklarda hangi kısımları veya organları temsil etmektedir?
- Denizde daha derinlerde yüzmek istiyorsan ne yapmalısın?
- En çok hangi grubun/öğrencinin modelini beğendiniz neden?
- Bu etkinliği yapmak size neler kazandırdı? Bu etkinliği yapmak sizce neden önemlidir?

Reconsider:

YENİDEN DÜŞÜN
Değiştirme/Geliştirme

- Tasarladığınız denizaltı balık modelinizde ne iyi çalıştı ve ne iyi çalışmadı?
- Tasarladığınız denizaltı balık modelinizi değiştirmek/geliştirmek için neye ihtiyacınız var?
- Değiştirdiğiniz/geliştirdiğiniz denizaltı balık modelinizin taslağını çiziniz