ACTA DIDACTICA NAPOCENSIA
Volume 15, Number 2, 2022 - DOI: 10.24193/adn.15.2.4

PRESERVICE SCIENCE TEACHERS' VIEWS ON DISTANCE STEM EDUCATION AND ITS LESSON-PLANNING PROCESS

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Abstract: This study aimed to investigate preservice science teachers' views of distance STEM education and the related lesson-planning process. The study was designed as a qualitative case study. Study participants comprised 22 senior preservice science teachers from a public university in the Western Black Sea area of Turkey during the 2019–2020 academic years. An open-ended view form was used as a data collection tool in this study to reveal preservice teachers' views on distance STEM education and distance group studies when designing a lesson plan. The data collected by the study were analysed using the descriptive analysis methods. Being instructive, providing feedback to preservice teachers about homework and questions, improving both thinking and professional skills, and learning STEM and 5E lesson plan design were among those advantages of distance STEM education expressed by the preservice teachers. The preservice teachers also reported that the less-efficient nature of distance education and their experience of difficulties in communicating during the distance group studies as disadvantages of distance STEM education. This study is thought to contribute research in the field in both theoretical and practical sense.

Key words: distance STEM education; distance group study; STEM education; preservice teachers; case study

1. Introduction

The whole world is currently experiencing a crisis; a virus has taken hold of all kinds of work. A new type of coronavirus, known as COVID-19, and which first appeared in Wuhan, China in December 2019, has been identified as a contagious infection (Republic of Turkey Ministry of Health, 2020). COVID-19, which spread rapidly across the world within a short time, was subsequently announced as a pandemic by the World Health Organization (WHO, 2020). Globally, the pandemic period has influenced many fields, such as tourism and the economy, all of which are closely related to human life. Following health, education was the second-most affected field across all countries (Telli, Yamamoto, & Altun, 2020). Following its emergence, the COVID-19 virus influenced educational applications in a very short period. As of March 2020, the number of students whose educational actions were limited was 300 million, this number increased to 1.6 billion in April 2020 (UNESCO, 2020). The number of countries in which schools were closed in March 2020 was only six, however, this number increased to 195 just one month later (UNESCO, 2020). These numbers prove that COVID-19 has greatly influenced educational activities.

Accordingly, national governments were forced to take certain radical restrictions, such as implementing social isolation, lockdowns, and limitations to transportation and education (Bourouiba, 2020). Due to COVID-19, which spreads rapidly and leads to different crises, many countries had to entirely suspend educational activities in schools. Consequently, the closure of schools and universities has affected many students (Zhong, 2020), and it is for this reason that many countries were forced to shift from face-to-face education to online education during the pandemic. Turkey, like the other countries, undertook the same restrictions in education. Turkey announced that educational activities in primary, secondary and higher education were to be suspended as of March 13, 2020 (Republic of Turkey Ministry of Health, 2020). Distance education in primary and secondary

Received July 2021.

Cite as: Pekbay, C. (2022). Preservice science teachers' views on distance STEM education and its lesson-planning process. *Acta Didactica Napocensia,* 15(2), 43-54, https://doi.org/10.24193/adn.15.2.4

education was maintained through the internet and via television by the Ministry of National Education. Universities in Turkey also used distance education systems.

Distance education is a learning process whereby individuals, who share the same physical environment and time, are given access to one another and related sources via distance communication systems. Today, many universities in higher education deliver some courses online through distance education, and 120 universities in Turkey incorporate a distance-education research and application center (Council of Higher Education, 2020). Nevertheless, the history of distance education in Turkey is relatively recent. While students and teachers are in different locations in distance education, this method of education nevertheless provides many advantages, such as providing educational sustainability (Akinbadewa & Sofowora, 2020; Omiles, et. al., 2019; Seage & Türegün, 2020), and decreasing educational costs (Al-Husban, 2020; Baggaley, 2008; Hall & Knox, 2009). Insufficient infrastructure, economic reasons, technical problems, unawareness in society, and regional differences are considered to be the main disadvantages of distance education (Gökdaş & Kayri, 2005). Research into this issue supports the feasibility of distance education. In their study, Chen, et. al. (2010) report a positive relationship between internet-based learning and student participation. Bernand et al. (2009) in their study found that asynchronous distance education significantly increases achievement in distance education and enhances attitudes towards distance education; however, this also results in less permanent learning compared with face-to-face learning.

Universities made a very rapid transition to distance education during the pandemic period. Educators with no experience in distance education just started to deliver their courses in distance education. For this reason, they sought reasons as to how distance education can be more effective (Karip, 2020). Evidently, distance education changed irreversibly across the world as a result of the pandemic (Durak, et. al., 2020), and this has accelerated the number of studies conducted on distance education. Despite the increasing number of studies on distance education, there remain a limited number of studies on distance Science-Technology-Engineering-Mathematics (STEM) education (Artsın & Deligöz, 2019; Flowers, et. al., 2012; Jones, et. al, 2020; Marvasi, et. al., 2019; Tekin-Poyraz & Genç-Kumtepe, 2019). Distance STEM education refers to delivering STEM education online. STEM education includes knowledge, skills, and beliefs through the intersection of multiple fields of science, technology, engineering, and mathematics (Çorlu, et. al., 2014). The STEM education approach is based on a multidisciplinary focus and covers a period from preschool to higher education. Since, in the 21st-century, national economies are based on the information economy, a higher number of people working within a country that are working in the fields of science, technology, engineering, and mathematics, thereby becomes significant to that country, especially for developed countries. For this reason, many countries have made changes in their educational systems (Ministry of National Education [MoNE], 2016). Within science education STEM is one of the best-known main reform movements (Gülhan & Şahin, 2016).

Technology and science are continuously changing and developing in the 21st-century. Therefore, the characteristics individuals need to possess must also evolve accordingly. This requires individuals who are able to produce knowledge and who possess a higher level of thinking skills (e.g., problem-solving, and creative and critical thinking) (MoNE, 2018). It is exactly at this point that the importance of STEM education emerges. STEM education creates an opportunity for individuals to attain skills, such as a sense of responsibility, communication, creativity, critical thinking, collaboration, and problem-solving; these are called the 21st-century skills (Partnership for 21st-Century Skills, 2009). While studies on STEM education are common in both national and international literature, a limited number of studies on distance STEM education was encountered in the national literature (Artsın & Deligöz, 2019; Tekin-Poyraz & Genç-Kumtepe, 2019). Furthermore, providing the feasibility and sustainability of STEM education remains controversial (Tekin-Poyraz & Genç-Kumtepe, 2019). Accordingly, distance STEM education can be considered as an alternative approach for solving this problem. Flowers at al. (2012) conducted a study with the primary aim of investigating the participation of African American students in STEM education. These authors found a remarkable difference between the number of online STEM education programs and the number of online programs in other fields between them. Tekin-Poyraz and Genç-Kumtepe (2019) conducted a two-staged study; they evaluated a STEM Project devised in a province of Turkey in the first stage of the

study, and consulted expert opinions about the feasibility and sustainability of distance STEM education in the second stage of the study. By the end of their study, the authors created a model of distance STEM education.

There are a limited number of studies on distance STEM education within the related literature, and it is strongly anticipated that the need for distance education will increase, especially as a result of this pandemic. At this point, distance STEM education conducted in this study is thought to contribute to the field. In line with the aforementioned points, this study investigates preservice science teachers' views regarding distance STEM education and the design lesson-plan process. The research question is:

What are preservice science teachers' views regarding distance STEM education?

The sub-questions that guide this study are as follows:

- What are preservice teachers' positive views regarding distance STEM education?

- What are preservice teachers' negative views regarding distance STEM education?

- What are preservice teachers' positive views regarding distance group-studies during the design process of a lesson plan?

-What are preservice teachers' negative views regarding distance group studies during the design process of a lesson plan?

2. Materials and Methods

This study was designed as a qualitative case study. Case studies are mainly conducted as an in-depth analysis of one or multiple cases (Yıldırım & Şimşek, 2008). When conducting case studies, researchers as comprehensive as possible concerning the situation -called cases- being researched, and these cases are not only an object or living creature that have a certain identity, but they can also include an event, activity, or process (Johnson & Christensen, 2014). The case investigated by this study is preservice science teachers' views regarding the distance STEM education and STEM lesson plan design process.

2. 1. Participants

This study used the purposeful sampling technique, which enables an in-depth investigation of cases that are considered to encompass an enriched body of knowledge (Patton, 2002). The study was made as distance education, and included a total of 22 preservice science teachers, four males and 18 females, who were enrolled in the "Contemporary Approaches in Science and Technology Teaching" course in a public university in the Western Black Sea area of Turkey during the spring term of the 2019–2020 academic years. All participants were aged 20–22 years. All the preservice teachers enrolled in the course had done so for the first time.

2. 2. Implementation

This study was carried out within the scope of the Contemporary Approaches in Science and Technology course, which is taught as an elective course in the Science Education program of the university. The course lasted 14 weeks and two lessons were conducted per week. The first six weeks of the course were conducted through face-to-face education. Following the closure of schools in Turkey as of March 11, 2020, due to the Covid-19 pandemic, education continued online. Distance education was made synchronously and asynchronously via the university's distance-education system. The instructor of the course uploaded each week's topic as a voiced presentation in advance of the lessons. During the lessons, education was conducted online.

During the first six weeks of the course, concepts related to STEM education—the history of STEM education; teaching programs and STEM; STEM teaching–learning models; 5E Learning Model; Project- and Problem-Based learning; and Design-based Learning were addressed in face-to-face

education. The final eight weeks of the course were carried out in the form of distance education, and this process is included in Table 1.

Table 1. *Distance education process*

Week	Implementation
Week 1	Engineering Applications in STEM Education -Engineering Design Process
Week 2	Engineering Applications in STEM Education -Exemplary Activity (Rocket Launching)
Week 3	STEM Applications in Primary and Secondary Science Education -Lesson Planning in STEM Education
Week 4	Assessment Methods in STEM Education
Week 5	Exemplary Activity in STEM Education: Barbie Bungee Jumping
Week 6	Exemplary Activity in STEM Education: Eatable Car Contest
Week 7	Exemplary Activity in STEM Education: Prosthetic Hand
Week 8	Presentations of the lesson plans designed by the preservice teachers and the implementation of the open-ended view form.

Within the scope of this course, the preservice teachers studied in groups of five or six. The first two weeks of the distance education was conducted separately for engineering applications. The instructor provided theoretical information regarding the topic. Subsequently, the preservice teachers made an exemplary activity online under the supervision of the instructor. However, the implementation of the activity was not made obligatory since the preservice teachers may not have access to the materials used in the activity due to the pandemic.

In the third and fourth weeks of distance education, the preservice teachers were taught about designing lesson plans suited to the 5E Learning Model in STEM Education, as well as related assessment methods. In the fifth, sixth, and seventh weeks, those exemplary STEM activities that had been designed in accordance with the 5E Learning Model were then carried out. Before the courses began, the preservice teachers were informed that they needed to prepare a STEM lesson plan, one suited for the 5E Learning Model, addressing at least one objective of the Science Education curriculum. Therefore, in the last week, the preservice teachers, together with their group mates, presented those STEM activities they had designed. Furthermore, an open-ended view form was applied in the last week to reveal the preservice teachers' views regarding distance STEM education and the lesson-planning process. The preservice teachers then received a final grade about the lesson plans they had prepared.

2. 3. Instruments

The data in this study was obtained using an open-ended view form that was distributed and returned by the preservice teachers. This form, which comprises five open-ended questions, was developed by the researcher. Expert opinions were consulted to finalize the form. The form aims to reveal preservice teachers' views regarding distance STEM education and the lesson-planning process. The content validity of the form was ensured with the opinions of two experts. These five open-ended questions were then included in the open-ended view form:

(1) Has distance STEM education made any contribution to you? If yes, in what perspectives have this process contributed to you?

(2) What are the advantages of distance STEM education?

(3) Which aspects of distance STEM education challenged you the most?

(4) What are the advantages of distance group studies?

(5) What are the disadvantages of distance group studies?

The open-ended view form was uploaded to the system at the end of the eighth week and the preservice teachers were asked to fill out the form via the online system of the university.

2. 4. Data analysis

The data in this study were analysed using descriptive statistics in line with those themes regarding STEM that had been specified according to the theoretical framework and evaluation criteria. Descriptive statistics are used to summarize and interpret data obtained according to predetermined themes. The main aim of descriptive statistics is to present the views of individuals who are either interviewed or observed to readers, together with excerpts, in an impressive way (Yıldırım & Şimşek, 2008). Data obtained from the preservice teachers' views through the open-ended form were collected under four themes: "Positive views regarding distance STEM education", "Negative views regarding distance STEM education", "Positive views regarding distance group study", and "Negative views regarding distance group study".

Excerpts of those data obtained in each theme are also included in the results section. A code was then assigned to each preservice teacher (e.g., Preservice Teacher 1=PT1, Preservice Teacher 2=PT2, etc.).

Transcriptions of the data were read and coded by the researcher and an expert separately using the predetermined themes. The inter-coder reliability between the researcher and the expert was also investigated using the formula developed by Miles and Huberman (1994), inter-coder reliability=[agreement / (disagreement + agreement)] x 100%. A value above 70% indicates a reliable coding process for a qualitative study. The inter-coder reliability for this study was found to be 94%, indicating that the coding was reliable.

3. Results

Data obtained from the preservice teachers' views through the open-ended form were collected under four themes: "Positive views regarding distance STEM education", "Negative views regarding distance STEM education", "Positive views regarding distance group study", and "Negative views regarding distance group study". Results obtained according to these themes are presented in this section.

3. 1. Results on the theme of positive views regarding distance STEM education

Information about the preservice teachers' positive views regarding distance STEM education is presented in Table 2.

Table 2. *Codes obtained from the preservice teachers' positive views regarding distance STEM education theme and their frequency values*

Sub-themes	Codes	Frequency (f)
Advantages of the process	• Instructive • Providing feedback • Skill development • Linking science to daily life • Importance of STEM • The best comprehension in distance education	6 3 2 1 1 1
Contribution of the process	• Learning and applying STEM o Designing activities o Assessment o Designing lesson plan o Creating authentic problem situations • Useful to students o Teaching science concepts o Entertaining o Permanent • Designing 5E lesson plans	20 13 4

Preservice teachers' positive views regarding distance STEM education were grouped into two categories: "advantages of the process" and "contribution of the process". Being instructive, providing feedback to preservice teachers about homework and questions, improving both thinking and professional skills, linking science to daily life, underlining the importance of STEM today, and the best comprehension occurred in distance education were among those advantages listed by the preservice teachers. PT9 answered the question "What were the advantages of the activity?" with "It was already an all very fine course in the classroom. When it became online, we did not experience any sort of problem since we were always in touch with the instructor and provided with feedback about our homework". This response highlights receiving feedback from the instructor as an advantage of the distance STEM education process.

Learning STEM and how to design and apply a 5E lesson plan, as well as the potential help provided by this situation to these prospective teachers regarding their teaching efficacy were among the points listed by the preservice teachers as contributions to distance STEM education. Nearly all the preservice teachers stated that they learned and applied STEM due to the contribution of those activities made within the scope of the study. More than half of the preservice teachers added that this process would make a significant contribution to them being more effective when educating their students. PT11 thought that the process contributes to learning STEM stating "I have fully comprehended what STEM education is and believe that I will conduct some studies on STEM education. In this process, designing a lesson plan in STEM education brought novelty to me."

3. 2. Results on the theme of negative views regarding distance STEM education

Information on the preservice teachers' negative views regarding distance STEM education is presented in Table 3.

Table 3. *Codes obtained from the preservice teachers' negative views regarding distance STEM education theme and their frequency values*

Sub-themes	Codes	Frequency (f)
Disadvantages	• Less effective compared to face-to-face education	3
	• Less entertaining compared with face-to-face education	1
	• Decision-making process	1
Aspects challenged	• Designing a STEM activity-Creating a problem situation	2
	• Making a design	1
	• Studying in groups	1

The negative views regarding distance STEM education were categorized into two sub-themes: "disadvantages" and "aspects challenged". According to the preservice teachers' answers to the open-ended view form, the disadvantages of the distance education process were that it was a less effective and entertaining process compared with face-to-face education, as well as the wearisomeness of the decision-making process involved. A vast majority of the preservice teachers did not indicate any negative views regarding the activity; however, a few preservice teachers, despite their small number, indicated that distance education is less effective compared to face-to-face education, as a negative view. PT12 asserted that distance education was less effective and therefore indicated the disadvantage of this process: "If we could make the activities in a face-to-face setting instead of distance education, I think that they would be more effective."

Some of the preservice teachers indicating negative views stated challenging aspects as a disadvantage of distance education. These aspects were designing a STEM activity, making a design, and studying in groups. In this regard, PT21 stated that "It was really hard to design a brand new STEM activity. However, it made it harder to make this within a group."

3. 3. Results on the theme of positive views regarding distance group study

Information about the preservice teachers' positive views regarding the distance group study is presented in Table 4.

Table 4. *Codes obtained from the preservice teachers' positive views regarding distance group studies theme and their frequency values*

Sub-themes	Codes	Frequency (f)
Advantages	• Division of labor	11
	• Continuous communication	9
	• Designing an effective plan	7
	• Sense of responsibility	2
	• Diversity in opinions	2

In their responses to the open-ended view form, the preservice teachers indicated several positive views regarding distance group study: making division of labour, keeping a continuous communication, designing an effective plan, gaining a sense of responsibility, and the emergence of diversified opinions. Half of the preservice teachers indicated that, even online, they encouraged a division of labour with their group mates during the process of designing a lesson plan, and furthermore maintained continuous communication with their group. PT7 answered the questions "What were the advantages of group study?" with the response "Each group member took some responsibilities. During this process, we all kept the communication via our mobile phones and discussed the opinions emerged", which highlights the division of labour and continuous communication as an advantage of the distance STEM education process.

3. 4. Results on the theme of negative views regarding distance group study

Information about the preservice teachers' negative views regarding distance group study is presented in Table 5.

Table 5. *Codes obtained from the preservice teachers' negative views regarding distance group studies theme and their frequency values*

Sub-themes	Codes	Frequency (f)
Aspects challenged	• Distance communication	10
	• Being in rapport with groupmates	2
	• Designing an activity	2
	• Testing	1
	• Division of labor	1
Disadvantages	• Crowded groups	2
	• Inability to fulfill responsibilities	1
	• Covid-19 pandemic	1
	• Diversity in opinions	1

The negative views regarding distance group study were categorized into two sub-themes: "disadvantages" and "aspects challenged". Distance communication, being in rapport with group mates, designing a STEM activity, testing the activity designed, and division of labour were among those difficulties experienced by preservice teachers during distance group studies. The preservice teachers stated communication with group mates as being the most difficult aspect of the distance group studies. In addition, maintaining a rapport with group members from a distance, and designing an activity were also stated—albeit rarely—as being difficult aspects of distance group studies by the preservice teachers. PT5 stated "The most difficult part was testing the mask activity. Being in different locations and communicating through phones led to some disorder", which underlines the difficulties experienced in distance communication.

As part of their negative views, some preservice teachers indicated some points that were not appealing to them. These preservice teachers did not like studying in crowded groups, observing some

group members' inability to fulfil their responsibilities, the recently experienced pandemic period (COVID-19), and the emergence of diversified opinions, as examples of those points. In this regard, PT4 expressed: "The only problem was that our group is crowded, and each group member stated his or her opinion. Therefore, it took a while to discuss each opinion emerged and to complete the assignment."

According to the preservice teachers' responses to the open-ended view form, disadvantages of the distance education process included wearisomeness of the decision-making process, and the process being a less effective and entertaining process compared with that of face-to-face education. A vast majority of the preservice teachers did not indicate any negative views regarding STEM activities; however, a few preservice teachers indicated that distance education is less effective compared with face-to-face education, as a negative view. PT12 asserted that distance education was less effective and therefore indicated a disadvantage of this process: "If we could make the activities in a face-to-face setting instead of distance education, I think that they would be more effective."

Some of the preservice teachers indicating negative views stated those aspects that challenged them as being a disadvantage of distance education. These aspects included designing a STEM activity, making a design, and studying in groups. With PT21 stating: "It was really hard to design a brand new STEM activity. However, it made it harder to make this within a group."

4. Discussion

In line with the results obtained in the current study, the preservice teachers' views regarding distance STEM education were discussed under four main headings: the advantages and disadvantages of distance STEM education, and the advantages and disadvantages of distance group studies.

According to the preservice teachers' responses, distance STEM education is instructive, enables skill development, provides a link between science and daily life, and remains on the educational agenda. As the instructor provided feedback, and because they were always in touch with the preservice teachers during the distance education process, the preservice teachers further stated that the distance STEM education course was the online course that they comprehended most efficiently. No study on distance STEM education was encountered by the researchers when investigating the national literature. Kazanidis, et. al. (2015) conducted a study with 57 university students and investigated how students who participated in a distance STEM education benefited from the process, as well as the competency of this process in terms of STEM education. Their results showed that those students who participated in distance STEM education held positive views on the instructiveness of education (Kazanidis, et. al., 2015). This result is in parallel with those put forward by the current study. Preservice teachers in the current study highlighted that they especially learned STEM through distance STEM education, and that they thought would help them to become better teachers.

Being less effective and entertaining compared with face-to-face education, and the decision-making involved were among the disadvantages of distance STEM education listed by the preservice teachers. The related national and international literature reported students' disadvantages as well as the advantages (Akgün, et. al., 2013; Gillies, 2008; Hebebci, et. al., 2020; Kürtüncü & Kurt, 2020). In their study with nursery students, Kürtüncü and Kurt (2010) reported the problems these students experienced in distance education. Their results show that a vast majority of students are concerned about the effectiveness of distance education. This result is corroborated by those of the current study. In a different study by Hebebci et al. (2020), a vast majority of secondary and high school students expressed negative views regarding distance education; contrarily, most of the teachers indicated positive views regarding distance education. The preservice teachers in the current study indicated that they experienced some problems while designing a STEM activity and studying in groups. Contrary to the results of many studies on STEM education (Özçakır-Sümen & Çalışıcı, 2016; Şahin et al., 2014), that studying in groups is stated as a negative view in the current study is a striking finding. Efforts to establish distance communication within groups may have led preservice teachers to state this negative view, as preservice teachers expressed the same views regarding distance group studies during the lesson-plans design process.

Another result of the current study concerning preservice teachers' positive views regarding distance group studies in the lesson-plan design process. Among these positive views, they mentioned the division of labor, continuous communication, designing an effective plan, equipping with a sense of responsibility, and diversity among their expressed opinions. In their study, Felder and Brent (2001) sought insight into the question "Is a distance group study possible?" They argue that a distance group study is possible, and can even be more effective if the instructor of that course puts in extra effort. In their study on distance group studying, Helbo, et. al. (2001), defined projects carried out through distance group studies and provided several suggestions to the problems that thereby emerged: distance group study should be flexible but the group members should simultaneously possess a sense of responsibility, and the group study should be very well planned. Considering these two suggestions, the positive views regarding distance group studies in the current study included these two suggestions.

As discussed with the advantages of distance group studies previously, preservice teachers reported division of labor, taking responsibility, and diversity in opinions, as the positive aspects of the process. However, the preservice teachers also reported—as the disadvantages of distance group studies—those difficulties experienced due to the division of labor, the inability to fulfill the responsibilities within groups, and diversity in opinions. These two different views seem contradictory. This situation is thought to relate to conflicts that occurred within the groups because the preservice teachers highlighted not being in rapport with groupmates and crowded groups as disadvantages of distance group studies. In their study, Doymuş, et. al. (2004) investigated the effect of a collaborative learning method on secondary school students' academic achievement in and attitudes towards a science course. In their study, these researchers collected students' views regarding group studies, and found that a vast majority of these students expressed positive views regarding group studies. Comparatively, some students reported negative views on studying in groups. Doymuş et al. (2004) reported that negative views might stem from the conflicts that occurred within the study groups. The reason for the conflicts that occurred within the study groups within the current study is thought to stem from the difficulty of establishing effective distance communication. Kear (2004) stated that students experience difficulties in communicating in groups since they cannot come together in a face-to-face setting.

5. Recommendations

As the pandemic period is not yet over, and because the need for technology in the current century rises with each passing day, the importance of distance education increases in parallel with these situations. Conducting further research on distance STEM education is suggested as such research will serve as a model to all educators who will both use and study distance STEM education.

Distance STEM education has made a significant contribution to preservice teachers in many regards. Depending on these results, distance STEM education practices can be included at every educational level from preschool to higher education. Considering the views of the preservice teachers in the current study, only a few preservice teachers indicated negative views regarding distance STEM education, whereby these views mostly focused on distance STEM education, compared with face-to-face education, being less effective. The difficulty in establishing communication within groups was the most repeated negative view regarding distance group studies. Researchers of distance STEM education can better design their studies considering those negative views presented by the preservice teachers in the current study. To make the distance education process more effective, it is suggested that educators maintain continuous communication with students and that they deliver education more in a synchronous way. Forming smaller student groups is another suggestion for increasing the effectiveness of intragroup communication.

In the current study, distance STEM education was carried out with senior preservice science teachers within the scope of the Contemporary Approaches in Science and Technology Teaching elective course. Further research can be made on distance STEM education with different grade levels and courses.

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