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Views of Science teachers about online STEM practices during the COVID-19 period

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Abstract

The study aimed at obtaining and analyzing the opinions of Science teachers who practiced online STEM activities in the Science course during the transition process to distance education due to the COVID-19 pandemic. The research was carried out with six (n = 6) Science teachers of the 7th grades in six different public schools in Ankara in the Spring term 2019-2020 school year based on criterion sampling method and on voluntary basis. Teachers' opinions about online STEM implementation were obtained via a semi-structured interview form comprising five open ended questions. The data obtained were analyzed using content analysis. The results showed that teachers had difficulty in conducting and coordinating online STEM activities through correcting feedback. Teachers were able to provide corrective feedback only at a minimum level. It was understood that they needed family support in most cases, and student participation was too low. Participant teachers also stated that during the online STEM activities, students and teachers could easily and quickly access resources via the internet, and online STEM implementation contributed to developing students' 21st century skills, such as problem solving, accessing and analyzing data, and critical thinking.

Keywords: COVID-19 period, Science classes, STEM activities, distance education

1. Introduction

"Education", a concept that can be defined as the process of creating a permanent change in the individual, is a process that is affected by the developments of our age

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(Akpınar, 2003). In order not to remain behind the developing and changing world, it is necessary to adapt to these conditions with education.

Coronavirus cases, also known as Covid-19, started to be seen for the first time in the world on December 1, 2019 and gradually turned into a pandemic. Named as a global pandemic by the World Health Organization, Covid-19 has required the cessation of activities in many areas, suspension and change of functioning (WHO, 2020). Education process is at the top of these areas. According to the data shared by UNESCO as of April 17, 2020, a total of 1,724,657,870 students in 191 countries around the world were affected by the pandemic process. In this pandemic process that suddenly surrounded the world, various measures have been taken in order to minimize the negative effects on education and training activities. "Distance education" comes first among these measures. As in the whole world, distance education has been introduced in all levels of education in our country. Following the first coronavirus case in our country on March 11, 2020, the Ministry of National Education made a statement regarding the measures taken against coronavirus (MEB, 2020). According to the statement, it has been announced that education will be continued through "distance education" at all levels of education. Since this date, distance education has been a method that we encountered during the pandemic process and started to be applied intensively. Students' perceptions and opinions about the distance education process are the main factors affecting the efficiency of distance education (Başar et al., 2019). Distance education has been an important practice that is preferred at certain levels from time to time all over the world. In the relevant literature, there are studies regarding the positive and negative aspects of distance education, the opinions of the practitioners, and the comparison with face-to-face education (Aydın, 2002; Demir Kaymak, & Horzum, 2013; Gaytan, 2007; Horzum, 2007, 2011; Karakaya, Arık, Çimen & Yılmaz, 2020; Moore & Kearsley, 1996; Saba, 2000; Şimşek, 2002; Verduin, & Clark, 1994). Revealing the positive and negative aspects of distance education, as well as the opinions of students, teachers, administrators, and parents, has a critical role in this process that the world faces for the first time in the 21st century. When the relevant literature is examined, the fact that the studies conducted in the Covid-19 process are very few and insufficient make the subject important.

For this reason, the research is important in terms of providing the opportunity to determine the views of teachers who practice STEM online and have an important role in the process of transition to distance education due to the COVID-19 pandemic. STEM is a radical change movement realized in the field of education in the 21st century (Land, 2013). STEM is an approach, which is a new approach in education, which is called STEM in the Turkish education system, consisting of the initials of the English equivalents of Science, Technology, Engineering and Mathematics (Bybee, 2010; Çorlu, 2014; Gonzalez, & Kuenzi, 2012; Gülen, 2016; Moomaw, 2013). It is seen that most STEM implementations are carried out in face-to-face education (Arık, 2019; Arık & Benli

Özdemir, 2019; Özcan, & Koca, 2019; Gazibeyoğlu, 2018; Karcı, 2018; Dedetürk, 2018; Aygen, 2018; Doğanay, 2018; Yıldırım, & Selvi, 2017; Ceylan, & Özdilek, 2015; Barcelona, 2014). STEM implementations, which have started to be used widely in face-to-face education, are also desired to be used by teachers in the distance education process.

In this context, it is aimed to determine the opinions of teachers who apply STEM online in the Science course in the process of transition to distance education during the COVID-19 pandemic. In line with the main purpose of the study, the research question sought in the research is: ***"What are the viewpoints of Science teachers who conduct STEM online activities in the Science course?"***

Based on this main research question, the sub-research questions of the research are as follows:

In the view of participant teachers;

1. What are online STEM practices like?
2. Are there any advantages of online STEM implementation? If so, what are they?
3. Are there any disadvantages of online STEM implementation? If so, what are they?
4. What are the similarities between online and face to face STEM implementations?
5. What are the differences between online and face to face STEM implementations?

2. Method

2.1. Research model

In this study, descriptive scanning model, which is a quantitative research model, was used in the collection, analysis, and interpretation of the data to reveal the opinions of teachers who apply online STEM in the Science course in the process of transition to distance education due to the COVID-19 pandemic. Descriptive survey model is a quantitative research technique used in studies aiming to collect data to determine certain characteristics of a group (Büyüköztürk et al., 2008).

2.2. Study group

While determining the study group in the research; criterion sampling method, one of the purposeful sampling methods, was used. In the purposeful sampling method, information-rich situations that are the most suitable for the researcher's purpose are

selected as a sample (Tanrıöğen, 2009; Patton, 2002). In this context, the Spring Semester of the 2019-2020 Academic Year was carried out with volunteer 7th grade Science teachers (n = 6) in 6 different public schools in Ankara. The demographic information of the teachers participating in the study is given in Table 1. Provided that the identities of the teachers are kept confidential, they are coded as "T1, T2, T3…".

Table 1. Demographic information of the study group

Features	**N**	**%**
Gender		
Female	4	66,6
Male	2	33,4
Total	6	100
Professional Seniority		
0-5 years	1	16,7
5-10 years	4	66,6
10-15 years	1	16,7
Total	6	
Education level		
License	3	79,9
Post Graduate	2	33,4
Doctorate	1	16,7
Total	6	100

When Table 1 is examined, 66.6% of the teachers participating in the study are female, 33.4% are male, 16.7% have 0-5 years and 10-15 years of professional seniority, 66.6% It is seen that he has 15 years of professional seniority, 79.9% of them are at the undergraduate level, 33.4% are at the master's level and 16.7% are at the doctoral level in terms of education level.

2.3. Data Collection Tools

Semi-structured interview forms were developed using the relevant literature in order to make interviews with teachers about online STEM implementations. While preparing the interview forms, care was taken to ensure that it was suitable for the purpose of the study, that the questions were clear, easy to understand and open-ended, and that they did not guide the participants. The forms were presented to the opinions of 2 teachers and 2 lecturers who have expertise and experience on the subject, and the validity of the scope and appearance was examined. Based on the feedback, the questionnaires were finalized before the pre-application. While collecting research data; The researcher

conducted semi-structured interviews with teachers online. Each interview lasted approximately 50 minutes. The interviews were recorded with a voice recorder within the knowledge of the participants. Then, the data on the voice recorder were transferred to the computer environment in writing and to each teacher's interview file separately.

2.4. Data collection process

The study was carried out with 7th grade Science course teachers (n = 6) working in 6 different schools in the central districts of Ankara province as of March 2019-2020 Academic Year Spring Semester. In the study, the working group was determined by using the appropriate sampling method, one of the non-probabilistic sampling methods. Three different STEM activities in accordance with the 7th grade Science lesson plan prepared by the researcher were simultaneously applied in the 7th grade under the guidance of the teachers. Information on the implementation process is given in Table 2.

Table 2. Implementation process

GROUPS	***PRE-STUDY***	***LEARNING PROCESS***	***TIME***	***POST-STUDY***	***LAST INTERVIEW***
Study Groups 1,2,3,4,5,6	Student information and preparations	Online STEM Supported Science Teaching Activities: • My Hubble Telescope • My Grass Man • Brightest, Most Beautiful and Cheapest Lighting System	3+3+3 Class Hours	Determination of the most successful work by the group's own teacher according to the rubric prepared.	Semi-structured interview

Before the learning process, the students were informed by their teachers about the activities they will do in the next lesson and the materials they will prepare. Then, STEM activities prepared by the researcher in accordance with the Science lesson plan were conducted with the students under the guidance of the course teachers. After the learning process, according to the rubric prepared by the researcher, each group's own lesson teacher chose the most successful study. After the learning process is completed; The researcher conducted semi-structured interviews with 6 teachers with online.

2.5. Data analysis

The data obtained from semi-structured interviews with teachers at the end of the implementations were analyzed with content analysis. Content analysis is the coding and quantification of what people say and write. The goal in content analysis is to collect similar data systematically and subject it to an understandable interpretation. According to Yıldırım and Şimşek, qualitative data are analyzed in four stages in content analysis: Coding of data, finding themes and sub-themes, organizing the data according to codes and themes, interpreting the findings (Yıldırım & Şimşek, 2012).

The data were coded separately by the researcher and an expert. "Consensus" and "Disagreement" between the researcher and the expert were determined by marking. To determine whether there is consistency among the researchers, the formula introduced by Miles and Huberman (2015) was applied, which is Reliability = Consensus / All views. (Arık & Yılmaz, 2017). Reliability of two encoders was calculated as = .87. As a result of the calculation, the reliability of the research was found over .80 for each interview question. To ensure reliability in a qualitative research, the harmony between the researcher and the expert should be at least .80 (Creswell, 2013).

3. Results

In this section, the findings of the research are presented respectively within the scope of the research questions. In the presentation of the findings, the answers received within the framework of the questions directed to the teachers to answer the research question and direct quotations were included.

3.1. Findings about teachers' feelings about online STEM implementations:

According to the answers given by teachers about their feelings about online STEM implementations; The obtained themes, sub-themes and their frequencies and percentages are given in Table 3.

Table 3. Theme and sub-themes created for teachers' feelings about online STEM implementations

Theme	***f***	***%***	***Sub-theme***	***f***	***%***
Together positive and negative	6	100	Enjoyable	5	12,5
			Interesting	6	15
			Creative	3	7,5
			Persistent information	3	7,5
			Beneficial	6	15
			Hard	6	15
			Mixed	5	12,5
			Uncontrolled	6	15
TOTAL	***6***	***100***		***40***	***100***

When Table 3 is examined, teachers' feelings about online STEM implementations are positive and negative. While all teachers (n = 6) found it interesting and useful, on the other hand, they stated that the process was difficult and the students progressed uncontrolled during the application process.

Some of the statements of the teachers are as follows:

T5: *STEM implementations attract students' attention to the lesson. Sometimes we see that a student who is not interested in the lesson attends the lesson very well during the STEM activity and offers different, creative information…*

T6: *It is already difficult to control students online, and it becomes even more difficult when STEM is involved. Because you must do it together with the students, by experimenting and breaking it. But unfortunately, the online environment does not allow this ...*

3.2. Findings regarding the advantages of online STEM implementations:

According to the answers given by the teachers about the advantages of online STEM implementations; The acquired themes, sub-themes and their frequencies and percentages are given in Table 4.

Table 4. Theme and sub-themes created regarding the advantages of teachers' online STEM implementations

Theme	***f***	***%***	***Sub-theme***	***f***	***%***
Yes, it has an advantage.	2	33,4	Internet convenience	2	33,3
			Access to resources	1	16,7
			Easy material supply	1	16,7
			Physical ambience	2	33,3
No, it has no advantage.	4	66,6	-	-	-
TOTAL	6	100		6	100

When Table 4 is examined, 66.6 % of the teachers think that online STEM implementations do not have an advantage. Other teachers (n = 2) stated that students and teachers could easily and quickly access related resources on the internet during the application process, students were physically more comfortable because they were at home and they could easily supply from their homes in case of lack of materials.

Some of the statements of the teachers are as follows:

T2: *I do not think that online STEM implementations have an advantage for students or teachers, on the contrary, it is disadvantageous. I do not think that teachers and students are together in this way ...*

T3: *Since the students are at home, their working environment is much more comfortable. For example, a student who forgets his glue or cardboard while at school can easily obtain it at home…*

3.3. Findings regarding the disadvantages of online STEM implementations:

According to the answers given by the teachers about the disadvantages of online STEM implementations; The acquired themes, sub-themes and their frequencies and percentages are given in Table 5.

Table 5. Themes and sub-themes created regarding the disadvantages of teachers' online STEM implementations

Theme	***f***	***%***	***Sub-theme***	***f***	***%***
Yes, there are disadvantages.	4	66,6	Loneliness	3	15
			Inability to share	4	20
			Lack of participation	3	15
			Indifference	3	15
			Time management	4	20
			Inequality of opportunity	3	15
No, there aren't disadvantages.	2	33,4	-	-	-
TOTAL	6	100		20	100

When Table 5 is analyzed, it is seen that most of the teachers (66.6%) are disadvantageous, students cannot share with their classmates (f = 4), some students are alone because they do not have family support (f = 3), and this is the inequality of opportunity (f = 3) stated that it created. In addition, they stated that the disadvantage of the online ambience, the result of indifference to online lessons reflected in the activities.

Some of the statements of the teachers are as follows:

T1: *When we were doing face-to-face STEM activities, we were dividing them into groups of 3-5 people. This was not possible online. Because they need to draw, measure, stick. When we asked for family support, our responsible parents did it very well. But in the opposite case, my student was left alone ...*

T6: *As with face-to-face STEM activities, I do not see any disadvantages in online STEM activities. The working student is still working, doing, concerned, careful. But the student who does not work and who is forced to participate in the event in face-to-face education is the same…*

3.4. Findings regarding the similar aspects of online STEM implementations to STEM implementations in face-to-face education:

According to the answers given by the teachers regarding the similar aspects of STEM implementations in face-to-face education process; The acquired themes, sub-themes and their frequencies and percentages are given in Table 6.

Table 6 Themes and sub-themes created regarding the similar aspects of teachers' online STEM implementations to STEM implementations in the face-to-face education process

Theme	***f***	***%***	***Sub-theme***	***f***	***%***
Yes, it has similar aspects.	6		Enjoyable	6	22,2
			21st century skills	6	22,2
			Interesting	5	18,6
			Persistent information	4	14,8
			Interdisciplinary	6	22,2
No, it hasn't any similar aspects.	0		-	-	-
TOTAL	6	100		27	100

When Table 6 is examined, all of the teachers (n = 6) stated that there is a similarity between the STEM activities performed face-to-face and online. They stated that both implementations included activities that are fun (f = 6), interesting (f = 5), provide interdisciplinary studies (f = 6) and ensure the permanence of information (f = 4). They thought that it contributed to 21st century skills such as problem solving, accessing and analyzing data, creativity and critical thinking (f = 6).

Some of the statements of the teachers are as follows:

T5: *Both implementations ensure permanent information on the subject. This situation is valid not only for the Science course, but also for other courses as there are interdisciplinary studies…*

T6: *For example, while making the "brightest, most beautiful and cheapest lighting system", students set out from the enlightenment problem. They sought a solution to this problem ...*

3.5. Findings regarding the different aspects of online STEM implementations from STEM implementations in face-to-face education:

According to the answers given by teachers about the different aspects of online STEM implementations from STEM implementations in face-to-face education; The acquired themes, sub-themes and their frequencies and percentages are given in Table 7.

Table 7. Themes and sub-themes created regarding the different aspects of teachers' online STEM implementations from STEM implementations in the face-to-face education process

Theme	***f***	***%***	***Sub-theme***	***f***	***%***
Yes, it has different aspects.	6	100	Distance Learning	5	31,25
			Lack of interaction	5	31,25
			More preparation	5	31,25
			Frivolity	1	6,25
No, it hasn't different aspects.	0	0	-	-	-
TOTAL	6	100		16	100

When Table 7 is examined, all teachers (n = 6) think that there are different aspects of face-to-face and online STEM implementations. They stated that there is a lack of interaction between the teacher and the students since it is done through distance education. As a difference, 31.25% of the teachers stated that pre-preparation required much more. They pointed out that the presence of frivolous students also stems from outside the school ambience. Some of the statements of the teachers are as follows:

T2: *It is definitely different. Once you are far away. You have no sense of touch together ...*

T3: *It requires more preparation than STEM implementations in face-to-face education. Because you must use your time well. Both the reduction of the lessons to 30 minutes and the distressing consequences of distance education, perhaps, for the teacher…*

4. Discussion and Conclusion

With this study, the opinions of teachers who practice online STEM in the Science course during the period of transition to distance education due to the COVID-19 pandemic were revealed. The findings obtained as a result of the interviews show that online STEM implementations bring some problems and difficulties.

In this study, the following results have been reached on the basis of the stated purpose:

It has been revealed that teachers have positive and negative feelings about online STEM implementations. In this process, it was stated that STEM implementations are fun and interesting, and they are beneficial for students to maintain the knowledge. However, they thought that the applicability of online STEM implementations was difficult and the process was complicated. It was noteworthy that the students explained that it is very difficult to control during the application. In the study conducted by Gök (2011), it was revealed that the distance education perception levels of the lecturers are medium. As in this study, the instructors also have positive and negative feelings and thoughts. Similarly, in the studies conducted by Ateş, & Altun (2008), Brinkerhoff, & Koroghlanian (2005) and Kışla (2005), pre-service teachers' attitudes towards distance education were found to be close to an unstable level. In another study, Case, Burns, & Dick (2001) revealed that undergraduate and graduate students' attitudes towards distance education are at a level that can be called unstable and they attach more importance to traditional education than distance education. It is considered that this situation may be due to the teachers' lack of knowledge and experience about distance education and its implementations. In studies conducted by Çınar, Leek, & Palic Sadoğlu (2016), Marulcu, & Sungur (2012), Gülhan, & Şahin (2016) on STEM implementations, STEM implementations have been shown to increase student success and develop a positive attitude towards the lesson. They stated that it provides the opportunity to cause, influence the socialization process, increase creativity, and contribute to the development of mental development and psychomotor skills.

Most of the teachers think that online STEM implementations have no advantage. On the other hand, teachers who stated that they have advantages explained that they have this idea because students and teachers can easily and quickly access relevant resources on the internet during the application process, students are physically more comfortable because they are at home, and they can easily obtain them from their homes in case of lack of materials. In a study by Gümüş, & Fırat (2016), distance education provides physical environment flexibility. This situation is seen among the advantages of distance education and supports this study.

Most of the teachers pointed out that online STEM implementations are disadvantageous. They saw that they had difficulties especially in time management. In particular, they saw it as a natural consequence of the reduction of lesson times to 30 minutes and the distance education process. In addition, they stated that the disadvantage of the online environment, the result of indifference to online lessons reflected in the activities. They stated that students who could not be together with their classmates could not share and some students were left alone because they could not get family support. Similarly, Özgöl et al. (2017) found that students do not take distance education courses seriously, attendance is not sufficient, and connectivity and infrastructure problems have a negative impact on the course.

Another result is that all of the teachers stated that there is a similarity between the STEM activities done face to face and online. In both implementations, they observed that STEM activities made the lessons fun and interesting. In addition, they observed that STEM activities, which offer an interdisciplinary approach in both cases, not only provided the permanence of information, but also contributed to 21st century skills such as problem solving, accessing and analyzing data, creativity, and critical thinking. All of the teachers saw similarities between face-to-face and online STEM activities in this study, which is similar to the results of some studies in the literature. Stack (2015), Werhner (2010) and Summers et al. (2005) showed in their studies that there is no significant difference between distance education students and face-to-face education students in terms of academic achievement. In the studies carried out by Özçakır, Sümen, & Çalışıcı (2016) and Wang (2012) on STEM implementations, teachers stated that STEM implementations improved on students' 21st century skills.

Similarly, all teachers think that there are different aspects of face-to-face and online STEM implementations. They stated that pre-preparation especially for online STEM implementations require much more, which makes the process more tiring and difficult. The teachers, who saw the lack of interaction with the students in the distance education process, pointed out that they sometimes faced with seriousness in students due to the outside of school ambience. In addition, Summers et al. (2005) showed that the students who received distance education were less satisfied with the course than the students who received face-to-face education.

5. Suggestions

- Considering the results obtained in the study to determine the opinions of teachers who apply STEM online in the Science course during the transition to distance education due to the COVID-19 pandemic, the following suggestions can be made:
- Online courses should be supported by multiple learning environments where students and practitioners can improve their STEM skills and appeal to more skills. STEM implementations, which especially provide studies for interdisciplinary gains, should ensure that the subject is taught for each course. This research was carried out with 7th grade Science course teachers and students who are in the distance education process. In this context, it can be suggested to create different learning environments at various grade levels, with different units, considering that it will contribute to the literature on online STEM implementations.

References

Akpınar, Y. (2003). Öğretmenlerin yeni bilgi teknolojileri kullanımında yükseköğretimin etkisi: İstanbul okulları örneği. *The Turkish Online Journal of Education Technology-TOJET, 2*(2), 79-96.

Arık, S. (2019). *Acid-base rocket: argumentation based inquiry stem activity.* 2. Uluslararası 19 Mayıs Yenilikçi Bilimsel Yaklaşımlar Kongresi Uygulamalı Bilimler, 27 - 29 Aralık 2019, Samsun.

Arık, S. & Benli Özdemir, E. (2019). *En güçlü, en uzun ve en güzel iskelet benim iskeletim: Bir STEAM etkinliği.* ILTER Congress, 5-7 Eylül, Amasya.

Arık, S. & Yılmaz, M. (2017). Fen bilimleri öğretmen adaylarının çevre sorunlarına yönelik tutumları ve çevre kirliliğine yönelik metaforik algıları. *Kastamonu Eğitim Dergisi, 25*(3), 1147-1164.

Ates̨, A., & Altun, E. (2008). Bilgisayar öğretmeni adaylarının uzaktan eğitime yönelik tutumlarının çeşitli değişkenler açısından incelenmesi. *Gazi Üniversitesi Eğitim Fakültesi Dergisi, 28(*3), 125-145.

Aydın, C. H. (2002). *Uzaktan eğitimin geleceğine ilişkin eğilimler.* Açık ve uzaktan eğitim sempozyumu. 23–25 Mayıs 2002.

Aygen, M., B. (2018). *Fen bilgisi öğretmen adaylarının bütünleşik öğretmenlik bilgilerinin desteklenmesine yönelik Stem uygulamaları.* Fırat Üniversitesi: Yayınlanmamış yüksek lisans tezi.

Barcelona, K. (2014). 21st century curriculum change initiative: A focus on STEM education as an ıntegrated approach to teaching and learning. *American Journal of Educational Research, 2* (10), 862-875.

Başar, M., Arslan, S., Günsel, E., & Akpınar, M. (2019). Öğretmen adaylarının uzaktan eğitim algısı. *Journal of Multidisciplinary Studies in Education, 3*(2), 14-22.

Brinkerhoff, J., & Koroghlanian, C. M. (2005). Student computer skills and attitudes toward Internet-delivered instruction. *Journal of Educational Computing Research, 32* (1), 27-56.

Büyüköztürk, Ş. (2011). Deneysel desenler (3. baskı). Ankara: Pegem Akademi.

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

Case, T., Burns, O. M., & Dick, G. N. (2001). *Drivers of on-line purchasing among U.S. university students.* Proceedings of the 7th Americas Conference on Information Systems, 873-878

Ceylan, S., & Özdilek, Z. (2015). Improving a sample lesson plan forsecondary science courses within the STEM Education. *Procedia-Social and Behavioral Sciences, 177*, 223-228.

Creswell, J. W. (2013). *Research design: Qualitative, quantitative, and mixed methods approaches* (4nd ed.). Thousand Oaks, CA: Sage.

Çınar, S., Pırasa, N., & Palic Sadoğlu, G. (2016). Views of science and mathematics pre-service teachers regarding STEM. *Universal Journal of Educational Research, 4*(6), 1479-1487.

Çorlu, M. S. (2014). FeTeMM eğitimi makale çağrı mektubu. *Turkish Journal of Education, 3*(1), 4-10

Demir Kaymak, Z., & Horzum, M. B. (2013). Çevrimiçi öğrenme öğrencilerinin çevrimiçi öğrenmeye hazır bulunuşluk düzeyleri, algıladıkları yapı ve etkileşim arasındaki ilişki. *Kuram ve Uygulamada Eğitim Bilimleri Dergisi.* Doi: 10.12738/estp.2013.3.1580

Dedetürk, A. (2018). 6. *sınıf ses konusunda FeTeMM yaklaşımı ile öğretim etkinliklerinin geliştirilmesi, uygulanması ve başarıya etkisinin araştırılması.* Erciyes Üniversitesi: Yayımlanmamış yüksek lisans tezi.

Doğanay, K. (2018). *Probleme dayalı STEM etkinlikleriyle gerçekleştirilen bilim fuarının ortaokul öğrencilerinin fen bilimleri dersi akademik başarılarına ve fen tutumlarına etkisi.* Kastamonu Üniversitesi: Yayımlanmamış yüksek lisans tezi.

Gazibeyoğlu, T. (2018). *STEM uygulamalarının 7. sınıf öğrencilerinin kuvvet ve enerji ünitesindeki başarılarına ve fen bilimleri dersine karşı tutumlarına etkisinin incelenmesi.* Kastamonu Üniversitesi: Yayımlanmamış yüksek lisans tezi.

Gaytan, J. (2007). Vision shaping the future of online education: Understanding its historical evolution, implications, and assumptions. *Online Journal of Distance Learning Administration, 10*(2). http://www.westga.edu/~distance/ojdla/summer102/ gaytan102.htm adresinden 14.11.2011 tarihinde erişilmiştir.

Gonzalez, H. B., & Kuenzi, J. J. (2012, August). *Science, technology, engineering, and mathematics (STEM) education: A primer.* Congressional Research Service, Library of Congress.

Gök, B. (2011). *Uzaktan eğitimde görev alan öğretim elemanlarının uzaktan eğitim algısı.* Yüksek Lisans Tezi. Gazi Üniversitesi Bilişim Enstitüsü: Ankara.

Gülen, S. (2016). *Fen-teknoloji-mühendislik ve matematik disiplinlerine dayalı argümantasyon destekli fen öğrenme yaklaşımının öğrencilerin öğrenme ürünlerine etkisi*. Yayınlanmamış Doktora Tezi, Ondokuz Mayıs Üniversitesi Eğitim Bilimleri Enstitüsü, Samsun.

Gülhan, F., & Şahin, F. (2016). Fen-teknoloji-mühendislik-matematik entegrasyonunun (STEM) 5. sınıf öğrencilerinin bu alanlarla ilgili algı ve tutumlarına etkisi. *International Journal of Human Sciences, 13*(1), 602-620.

Gümüş, M., & Fırat, M. (2016). Açık ve uzaktan öğrenmenin tercih edilme nedenlerinin belirlenmesi. *AUAd, 2*(4), 158-168.

Horzum, M. B. (2007). *İnternet tabanlı eğitimde etkileşimsel uzaklığın öğrenci başarısı, doyumu ve öz-yeterlik algısına etkisi.* Doktora tezi. Ankara Üniversitesi Eğitim Bilimleri Enstitüsü, Ankara

Karcı, M. (2018). *STEM etkinliklerine dayalı senaryo tabanlı öğrenme yaklaşımının (STÖY) öğrencilerin akademik başarıları, meslek seçimleri ve motivasyonları üzerine etkisinin incelenmesi.* Çukurova Üniversitesi: Yayımlanmamış yüksek lisans tezi.

Land, M. H. (2013). Full STEAM ahead: The benefits of integrating the arts into STEM. *Procedia Computer Science, 20,* 547-552.

Marulcu, İ., & Sungur, K. (2012). Fen bilgisi öğretmen adaylarının mühendis ve mühendislik algılarının ve yöntem olarak mühendislik-dizayna bakış açılarının incelenmesi. Afyon Kocatepe Üniversitesi *Fen ve Mühendislik Bilimleri Dergisi, 12*(1), 13-23.

MEB. (12 Mart 2020). Bakan Selçuk, koronavirüs'e karşı eğitim alanında alınan tedbirleri açıkladı. [http://www.meb.gov.tr/bakan-selcuk-koronaviruse-karsi-egitim-alaninda-alinan-tedbirleri-acikladi/haber/20497/tr adresinden 06.05.2020 tarihinde erişilmiştir.]

Miles, M. B., & Huberman, A. M. (1994). *An expanded sourcebook qualitative data analysis.* Thousand Oaks, California: Sage Publications.

Moomaw, S. (2013). *Teaching STEM in the early years: Activities for integrating science, technology, engineering, and mathematics.* Redleaf Press.

Moore, M. G. & Kearsley, I. G. (1996). Distance education: A systems view. Wadsworth Publishing Company.

Moore, T. J., & Tank, K. M., Glancy, A. W., & Kersten, J. A. (2015). NGSS and the landscape of engineering in K-12 state science standards. *Journal of Research in Science Teaching, 52*(3), 296-318.

Özcan, H. & Koca, E. (2019). STEM Yaklaşımı ile Basınç Konusu Öğretiminin Ortaokul 7. Sınıf Öğrencilerinin Akademik Başarılarına ve STEM'e Yönelik Tutumlarına Etkisi. *Eğitim ve Bilim, 198* (44), 201-227.

Patton, M. Q. (2002). *Qualitative research & Evaluation methods.* Çeviri. F. I. Bilican, & Y. Dede. Thousand Oaks, California: Sage.

Saba, F. (2000). Research in distance education: A status report. *International Review of Research in Open and Distance Learning, 1*(1), 1-9.

Tanrıöğen, A. (2009). *Bilimsel araştırma yöntemleri*, Ankara: Anı Yayıncılık.

Yıldırım, A., & Şimşek, H. (2011). Sosyal bilimlerde nitel araştırma yöntemleri. Ankara: Seçkin Yayıncılık.

Yıldırım, B., & Selvi, M. (2017). STEM uygulamaları ve tam öğrenmenin etkileri üzerine deneysel bir çalışma. *Eğitimde Kuram ve Uygulama, 13*(2), 183-210.

Verduin J. R., & Clark, T. A. (1994). *Uzaktan eğitim: Etkin uygulama esasları.* Çev: İlknur Maviş, Anadolu Üniversitesi Basımevi, Eskişehir.

WHO. (2020). Coronavirus disease (COVID-19) Pandemic. (https://www.who.int/emergencies/diseases/novel-coronavirus-2019 adresinden 02.05.2020 tarihinde erişilmiştir.)