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An Example of STEM Education in Turkey and Distance Education for Sustainable STEM Learning

Türkiye'de bir STEM Eğitimi Örneği ve Sürdürülebilir STEM Eğitimi için Uzaktan Eğitim

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Abstract. Global competition, which affects the future of all living things on earth, relies on the economic powers of countries. Education, on the other hand, is the most sensible investment that countries can make for their future. Having emerged from these considerations, STEM education aims to raise the knowledge and skills acquired by students to the synthesis and evaluation stages in Bloom's taxonomy with an interdisciplinary perspective. The first aim of this two-stage multiple case study was to explore STEM education project in Kayseri, Turkey, and evaluate on site by determining the opinions of all the stakeholders. The results from the first stage were related to readiness, practices, problems, and suggestions regarding STEM education. Considering the pivotal role of technology among other STEM education disciplines, the fact that this new generation of learners, also called digital natives, take this education only face-to-face in schools is an element that will affect its sustainability. Based on this premise, the second aim of this study was to explore the feasibility, sustainability, and extensibility of distance STEM education based on distance education's expert opinions. The results from the second stage had implications for the design and implementation of STEM education. Conducted based on the opinions of almost all relevant stakeholders, this study includes an example of STEM education practice implemented in Turkey and multidimensional evaluations of delivery of STEM education via distance education.

Keywords: STEM education, distance education, distance STEM education case study, exploratory approach.

Öz. Dünya üzerinde yaşayan tüm canlıların geleceğini etkileyen küresel rekabet, ülkelerin ekonomik güçleri üzerine kuruludur. Eğitim ise ülkelerin geleceğine yaptığı en akıllıca yatırımdır. Bu düşünceler üzerine ortaya çıkan STEM eğitimi, öğrencilerin elde ettiği bilgi ve becerileri disiplinlerarası bir bakış açısıyla Bloom'un taksonomisinde yer alan sentez ve değerlendirme basamaklarına yükseltmeyi hedeflemektedir. Bu doğrultuda iki aşamalı olarak yapılandırılan bu çoklu durum çalışmasının ilk aşamasında ülkemizde yürütülen Kayseri ili STEM eğitimi projesi eğitimdeki tüm paydaşların görüşleri dikkate alınarak yerinde incelenmiş ve değerlendirilmiştir. İnceleme sonucunda, bu eğitime ilişkin hazırbulunuşluğa, uygulamalara, sorun ve önerilere yönelik bulgulara ulaşılmıştır. Teknolojinin STEM eğitimi disiplinlerinin başında geldiği göz önünde bulundurulduğunda, dijital yerliler olarak adlandırılan bu son yeni kuşak öğrenenlerin, bu eğitimi sadece yüz yüze okulda alması eğitimin sürdürülebilirliğini etkileyecek bir unsurdur. Bu düşünceden yola çıkılarak çalışmanın ikinci aşaması olan uzaktan STEM eğitiminin yapılabilirliği, sürdürülebilirliği ve yaygınlaştırılabilirliği uzman görüşleriyle araştırılmıştır. Araştırma sonucunda uzaktan STEM eğitimi tasarımı ve uygulamalarına yönelik bulgulara ulaşılmıştır. Konunun hemen hemen ilgili tüm paydaşlarının görüşleri ile yürütülen bu çalışma, ülkemizde uygulanmış bir STEM eğitimi örneği ve bu eğitimin uzaktan yürütülmesine dair çok yönlü değerlendirmeler içermektedir.

Anahtar Sözcükler: STEM eğitimi - Uzaktan eğitim - Uzaktan STEM eğitimi - Durum çalışması - Keşfedici yaklaşım

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Introduction

Throughout history, the effort to keep pace with competition has guided nations' independence, economies, and welfare, or their future, in other words. In the last century, physical power lost its significance and was replaced by economic power that bought the brainpower. Economic power seems to be in parallel with the importance given to education of nations as well as investments and innovations. There is a need for a generation capable of responding to changing and evolving global conditions and having a share in global competition, that is, using innovative means in solving problems rather than knowing the knowledge. In line with this need, STEM (Science, Technology, Engineering and Mathematics) education, which aims to equip individuals with knowledge and skills from an interdisciplinary perspective, is seen as an important tool for economic development and leadership in scientific field (Lacey & Wright, 2009, p. 89).

STEM education, which emerged as a result of the collaborations in the fields of science, mathematics, engineering and technology in the previous years and which now serves as an umbrella term, is an educational movement that embraces the disciplines it contains in an interdisciplinary and interconnected approach. As a relatively young educational movement, it actually flourished during World War II and the Sputnik Program. Finally, in the early 1990s, the National Science Foundation (NSF) first proposed the abbreviation of SMET and then STEM (Sanders, 2009, p. 20). Although no sound consensus has been achieved yet for many issues, common STEM education practices are based on silo approach, embedded approach or integrated approach (Roberts & Cantu, 2012). In this education, the integrated approach is the one with the most acceptance as it creates a single learning area by intertwining all STEM fields. Shaped by the influence of various historical events, economic policies and opinions, STEM education has also been a controversial issue about its name. For example, some suggest using the term STEAM by adding "arts" to STEM while there are others who advocate that there should be STREAM education models with the addition of "reading" to represent literacy area (Feldman, 2015). Although there is still a need for clear definitions regarding the theoretical framework, curriculum and in-class practices of STEM education, the objectives of STEM education have been determined (Wang, Moore, Roehrig, & Park, 2011, p.3).

STEM has a structure that is open to improvement and there is at least a consensus on its primary objective: to raise individuals who can adopt a creative, innovative, questioning and critical attitude towards problems. In fact, the whole world, especially countries such as the United States, China, and Australia, supports the innovations in education with political policies and high budget funds in order to reach these goals. Compared with other countries, Turkey's STEM policy seems to have been a belated initiative without a sufficient budget allocated.

Realizing the implications of this education around the world, the president of Turkish Industry & Business Association, a non-governmental organization composed by people shaping Turkish economy, highlighted the need for STEM education starting from pre-school ages by saying, "In order to raise the quality of education as well as to move our country to the top of global competition, the solution is clear: starting from early ages in education, we do not have any other option but to invest more in science, technology and innovation, in STEM" (Basaran, 2015). There have been discussions in Turkey about how these disciplines can be expanded in educational settings and how children can experience learning by doing-living-feeling, critical thinking, designing and creating new ideas and products starting from the early childhood period, peak years of curiosity and creativity.

The objectives stated by Turkey's Vision 2023 and the Ministry of National Education (MoNE) strategic documents require defining STEM education on a national scale (Corlu, Adiguzel, Ayar, Corlu, & Ozel, 2012). In June 2017, regulations in national education policies announced that STEM education would be applied for the first time in secondary school level in Turkey. This education would be gradually expanded to all grade levels starting from the 5th grade and be covered in the last unit in all grade levels. With the curriculum revised at the beginning of the 2018-2019 academic year, schools started offer STEM education under the name "Science, Engineering and Entrepreneurship Practices" starting from 4th grade. This revised curriculum states that science, engineering and entrepreneurship practices will be embedded in all units within an academic term and students are expected to realize the design and production process of products in connection with the related units in the school environment (MoNE, 2018).

The age of innovation, which we are already in, guides a generation to lead the country in the future. Called as "Generation Z" or "digital natives/digital settlers", these children interact and socialize with mobile communication tools. Unlike the generations preceding them, these digital natives are exposed to information and communication technologies since the moment they are born. Providing this generation, which constitutes 17% of Turkey's overall population, with a well-planned STEM education will make it possible to create a sustainable economy and having a greater say in global competition. While a new generation is expected to lead the changing world, it is unthinkable that education is not affected by this change.

In this respect, STEM education to be delivered through distance education could allow teaching to emerge from the boundaries of traditional schools, to ensure equal opportunities in education and to provide students with the skills of the modern age. However, while research on distance education has been increasing recently, studies on distance STEM education have been limited. In addition, how to ensure the sustainability and feasibility of STEM education is a problem to be discussed. Therefore, distance STEM education can be considered as an alternative education approach that can provide solutions to these problems. As a matter of fact, it should be taken into consideration that this education is an inevitable need for career development of students, teachers and administrators and for the future of countries. Within Turkey context in particular, the status of current STEM education practices and the feasibility of STEM education could be considered as issues that should be investigated in detail. In order to apply STEM education in Turkey, the existing curriculum, infrastructure and teachers' competence for this education should be identified and supported within the framework of an innovative educational policy.

The overall purpose of this study was to investigate over one of the first STEM education practices in Turkey and to discuss the role of distance education on sustainable STEM education. For this purpose, in the first phase of this multiple-case study, which consists of two stages, STEM education which was designed by Kayseri Provincial Directorate of National Education and carried out in certain pilot schools (kindergarten, secondary school and science and art center for gifted students) was investigated through the process and outputs. In the second phase of the study, how to integrate distance education to this system for a sustainable STEM education was examined by expert opinions. The study addressed the following questions:

(i) How was one of the widely implemented STEM education which is conducted in Kayseri, Turkey?

(ii) What is the ideal role of distance education in a sustainable and feasible STEM education?

Research Method

This study adopted a case study approach to explore the factors related to a single or multiple situations with a holistic approach and to elaborately investigate the mutual effects of these factors and the situation(s) on each other (Yıldırım & Simsek, 2006, p.2). In fact, this study utilized an exploratory case study approach because it focused on the opinions, experiences, and practices related to the objectives, functioning, and outcomes of STEM education and how distance STEM education should be. The exploratory approach is used to explore new or emerging situations with limited preliminary research and no clear or single set of outcomes, and it is generally employed as a basis for explanatory case studies (Mills, Durepos, & Wieb, 2010). In addition, since this study involved two cases and each case was examined by dividing them into sub-units, an *embedded multiple-case study* approach was utilized (Yin, 2014). Two separate cases for this embedded multiple case study were examined in two different environments.

Participants

The multiple cases in this study were examined with qualitative data collected in Kayseri and Eskisehir, two cities in Central Anatolia Region in Turkey. In Stage 1, the first case, the state of the STEM education project in Kayseri, one of the first STEM initiative in Turkey, was examined. Stage 2, the feasibility of distance STEM education, was conducted with experts from a higher education institution with over 35-year experience in delivering open and distance education services and STEM experts in Turkey. The study samples were determined using the maximum variation sampling method, a purposive sampling method. The maximum variation sampling method (List, 2004; Patton, 2002) aims to explain a situation by reaching all possible parties in a target audience. For this purpose, in Stage 1, the researchers tried to reach many different stakeholders such as senior administrators of Provincial Directorate of National Education (PDNE) in Kayseri, school administrators, teachers, students, parents and different types of schools. Briefly, while selecting the schools coded with the letter “S”, the researchers tried to select schools in different grade levels to diversify the data. The number of participants was determined based on some factors such as voluntary participation and permission by administrators. Detailed information about these factors is given in Table 1.

Table 1. *Distribution of Participants*

Stage 1

Place	Administrator	Teacher	Student	Parent	Total
S1	1	1	0	1	3
S2	1	2	2	0	5
S3	1	2	1	1	5
S4	1	2	0	0	3
STEM Research & Development (PDNE)	1	*	*	*	1
Total	5	7	3	2	17

Stage 2

	Professor	Associate Professor	Assistant Professor	Graduate Degree	Total
Female	1	2	1	0	4
Male	1	4	1	2	8
Total	2	6	2	2	12

Star (*) symbol indicates that the corresponding participant was not available in that field.

In Stage 2, the feasibility of distance STEM education was investigated through interviews with numerous experts working in different fields and places. A total of 12 participants were interviewed: 7 of them through face-to-face interviews and 5 of them via e-mails. In order to increase the variety of data in this research, the researchers selected individuals with different academic titles and expertise in different fields such as science, technology, engineering, mathematics, assessment in education and distance education. Face-to-face interviews were conducted with field experts working in a distance education institution in Eskisehir that is specialized in open and distance teaching (ODE). In addition, the researchers tried to reach experts working in STEM education or distance education in Turkey or abroad via e-mail. When it was not possible to conduct face-to-face or online interviews with the people who responded to the e-mail, the opinions of these experts were received via e-mail.

Data Collection Tools

In this multiple case embedded study, the researchers developed measurement tools in order to ensure the research validity and reliability and to answer the research questions. In the data collection process, data collection tools were developed in line with previous literature, the research objectives and the participants' characteristics.

For Stage 1, five different interview protocols developed by the researcher and prepared specifically for the participant groups were used. The interview technique was the most suitable technique for this study because interview protocols adopt semi-structured interview techniques and provide a certain level of standard and flexibility. The total interview duration was 40 minutes with STEM R&D, 55 minutes with administrators, 80 minutes with teachers, 30 minutes with students and 15 minutes with parents. Also, another interviewer attended the sessions to ensure that the coherence was not disturbed during the interviews and all of the responses were noted down. According to Karasar (2004), it is useful to have more than one interviewer to take part in interviews as much as possible. This situation allowed the interviewers to make a division of labor between them. Therefore, it was easier to save the notes by recording the data instantly. This also made it possible to recognize the clues and to raise additional questions during the interviews.

The structured and semi-structured interviews designed based on the interview protocols were also conducted for Stage 2. Each participant who is expert in various fields answered the questions in the interview protocol. Like stage 1, there were no time constraints for the participants to respond to the questions in the interview protocol and also in these stages the researchers made additional explanations for the participants when necessary for face-to-face interviews. Those participants included in the data collection part of the study via e-mail responded to the structured interview protocol sent to them. In addition, semi-structured interviews were recorded using a voice recorder with the permission of the participants so that their statements could be recorded and analyzed completely. The face-to-face ones lasted for a total of 66 minutes and the duration of each interview session ranged from 5 to 20 minutes. The researchers transcribed the interviews and prepared them for analysis.

According to Yin (2014), credibility, reliability, verification and data driven determine the value of case study process. Considering these, four types of tests are mentioned: structural validity, internal validity, external validity and reliability. In this study, data triangulation and researcher triangulation contribute to the effect of structural validity. Also, study which has explanatory and causality principle may explain the cases depending or affecting factors (Akar, 2016). That is related with external validity and applied in this paper. Moreover, explaining analytic generalization of findings to various factors is detailed for external validity. All in all, the size of the sample was adequate, the data were collected by more than one researcher, the researchers tried to make use of as many opinions and resources as possible, the data were protected in accordance with the relevant principles and the researchers remained impartial to the study outcomes. In order to ensure validity, this study also used peer examination and multiple data collection tools, too. In general, the validity of this study was based on the researchers' impartial observation and evaluation of the research subject. The reliability of the study, on the other hand, was enhanced by ensuring cross-time stability, independent inter-observer agreement and internal consistency criteria. Consequently, all these contribute to the validity and reliability of the study.

Data Analysis

In this study, the content analysis method was used as a qualitative data analysis method for both of the case studies. According to the process for data analysis presented in Figure 1, as the first step in the qualitative data analysis, the voice recordings in both stages were transcribed. Then, for the content analysis, the researchers elaborated on the data in order to identify the concepts and relations that can explain the collected data. Taylor, Bogdan and DeVault (2016) propose that researchers should read data collected in a content analysis several times, get an overall sense of comments and thoughts, identify themes and interpret the structure. The first stage of this analysis in this study was coding the data.

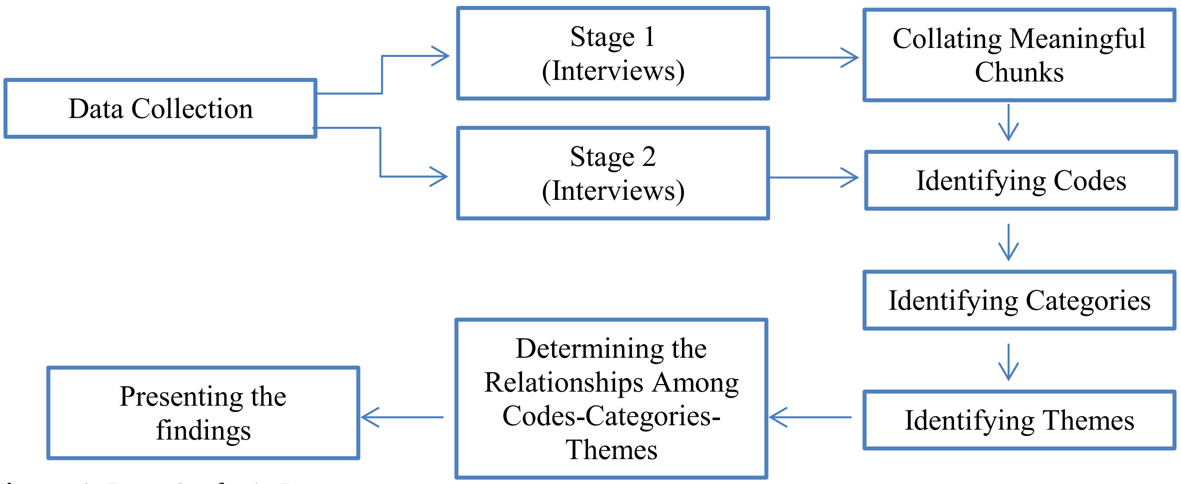

Figure 1. Data Analysis Process

Coding involves categorizing words and sentences, or meaningful chunks of data in other words. After the coding process, categories and themes were created based on the codes of the interviews. Category and theme creation is briefly the classification of codes. In other words, the categories that gave an overall description of the generated codes and the themes that collated the categories were determined. In addition, the researchers developed the categories and themes required for data analysis based on the research questions. In final stage of the analysis, the relationships among the codes, categories and themes were identified and the findings were interpreted.

Results

This study investigated the cases in Stage 1 for the current STEM education in Kayseri and in Stage 2 for the feasibility of distance STEM education. Also, as a secondary outcome of this study, a STEM education model was developed by taking into consideration the results from these two cases. Figure 2 shows the themes and categories that emerged from the data.

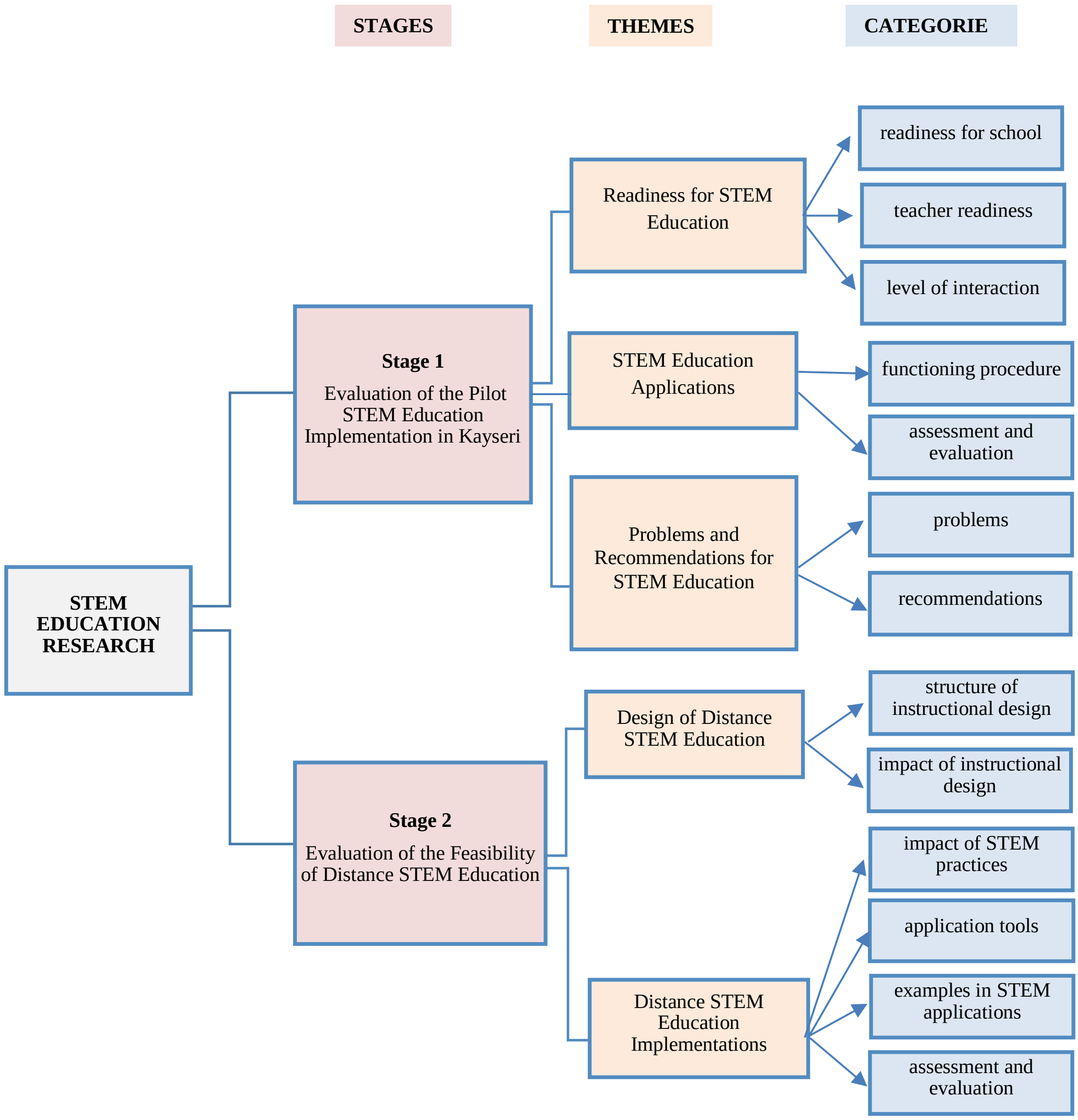

Figure 2. Themes and Categories of the Results

Results and Interpretation – Stage 1

The following three main themes related to the evaluation of the pilot STEM education implementation in Kayseri emerged from the interviews: opinions on readiness for STEM education, opinions on STEM education implementations, and problems about and recommendations for STEM education. Moreover, in this part of study, like school code “O”, participants are also coded with letter such that administrator is “A”, student is “St”, teacher is “T” and parent is “P”.

Readiness for STEM education. Three sub-categories were identified under the theme of readiness for STEM education: readiness of schools, readiness of teachers, and level of interaction.

The sub-category of readiness of schools dealt with the strengths and weaknesses of schools while preparing for and implementing this education. The participants' focus was particularly on the time schedule of this education and the physical conditions of the school. About the time schedule of the education, for example, a participant from the PDNE said,

> Addressing the fields of technology and engineering, out of school activities are conducted through robotics and software. In-class activities scaffold the fields of science and mathematics with science and mathematics courses. In addition, the extracurricular time allocated for STEM education is 6 hours.

However, the school administrators' statements showed that the time schedule for implementations varied in practice. For example, a kindergarten principal mentioned that they adapted the schedule according to the school structure instead of following the standard procedure and said, "STEM education is implemented over five days depending on the activity and conditions of classrooms" (S1-A). A middle school administrator expressed his objection to implementing this education during the time outside of classrooms was a disadvantage by saying "t would be better if they offered STEM education as an elective course" (S3-A). A student at another middle school said, "It would be better if our friends participated more and STEM were covered by other courses" (S2-St) and pointed out that attendance was low when this education was offered during the time outside of classrooms and integrating it with other courses would be more effective. A teacher at O2 school said, "Such activities should be initiated in the scientific practices course and be continued in science courses. It should also be integrated into the existing curriculum", which hints at the problems encountered in placing STEM education in the overall schedule for school subjects. Some of the responses given by the participants addressed the significance of schools' physical conditions (e.g. building design, material, etc.) at the beginning of this education for school readiness. A participant from the PDNE unit, for example, stated, "Particularly, the materials for robotics were insufficient at the beginning" but added that these problems were gradually eliminated. O2 administrator pointed out that schools should be prepared for this education before launching it by saying, "Schools should be made ready for STEM education. Materials must be completed in the laboratory. Materials should be distributed to schools fairly." A teacher at O2 agreed with the opinion that the number of materials between schools should be proportional to the number of students and said, "Our teachers perform the applications with the STEM materials given. However, we do not have sufficient materials for the number of our students. Our need for materials is much more than that." Modifications at schools vary in the process of preparing for this education. For example, when asked if there were any arrangements at their schools for STEM education, an administrator answered, "Yes. We have a special STEM classroom" (S3-A) whereas another school principal said, "There is no change or something new except for the materials given" (S2-A). To the same question, the kindergarten administrator, on the other hand, answered, "We are the first pilot school among kindergartens. After designing the *STEMbus*, we became a leader for other schools" (S1-A). These responses revealed the differences among the pilot schools in terms of their readiness for this education.

The second sub-category of STEM education readiness was readiness of teachers. This sub-category included the status of teachers, the practitioners, in the process of starting STEM education. The primary results that emerged from the interviews were that teachers were not knowledgeable about the content of STEM education and they were not enthusiastic about it. To begin with, the teachers made it clear that they started this education without knowing what it really was when they started it. A middle school teacher said,

> They sent us materials, but they didn't show any interest in us at all afterwards. It was two or three months after we started practicing that they summoned us for in-service training. We had difficulties in this process. First, we tried to find out what STEM was with our own efforts and then we explained it to students. The fact that the resources were in English also made our job difficult. Since there were no schools that could set an example for us, we tried to do something on our own. (S3-T).

Another teacher said, "Generally, STEM should be introduced first and then implemented after that" (S2-T). These statements suggest that such a program should not be initiated without preparing teachers for this education first. Another important result regarding the teachers' readiness was their reluctance or lack of enthusiasm. Not being knowledgeable about the subject, which has already been mentioned above, could have resulted in reluctance or loss of motivation among the teachers. Referring to the lack of interest by the authorities once they sent the materials, a teacher admitted, "No one was willing to open a STEM course because they would not be supported this year, too" (S3-T). It was not only teachers that mentioned teachers' reluctance. A middle school administrator, for instance, addressed the difficulties encountered in administrative processes and mentioned teachers' reluctance by saying, "Teachers' unwillingness to open courses was one of the toughest challenges" (S3-A) The participant from the PDNE added, "Also, when some teachers were told about STEM education, they said that they did this education already and they were indifferent towards it". On the other hand, each school administration followed a different procedure about teachers' participation in this education. A kindergarten administrator said, "All of our teachers were involved in STEM education" (S1-A) while a middle school administrator said, "Teachers who were willing to go were sent to this training" (S2-A). However, one of the teachers protested, "This should not be put only on science teachers' shoulders, but it should be on voluntary basis" (S3-T), which hints about the frustration among those teachers that were sent to the training without asking their opinion.

The third sub-category of STEM education readiness was interaction. The need for a strong interaction between students, teachers, supervisors and the local PDNE lies at the heart of the sustainability of the programs. When asked about the changes anticipated in the long term, one of the administrators answered, "It is no longer applicable due to personal issues" (S3-A). This attitude was caused by the lack of communication between the teachers and the PDNE. In addition, the problems with readiness, which were already mentioned in the preceding sub-categories, had a role in this communication problem. On the other hand, the level of communication between teachers also varied among the schools. For example, as a response to the question about teacher collaborations on this education, a teacher replied "Every Monday before the STEM day, we meet and exchange ideas about what we will do" (S1-T) whereas another one said, "No, we did no such work".

Views on STEM Education implementations. The first sub-category regarding STEM education implementations was the functioning procedure. Analysis of the interviews showed that using Lego sets was a common practice in STEM education among other practices. This situation is directly related to the response, "We were given Lego sets by the PDNE" (S2-A). It was observed that there were different opinions about the limited provision of Lego sets, the frequency of its use in STEM education and different STEM education implementations. One of the teachers stated that she did not merely stick to the materials provided and explained, "STEM materials are generally suitable for physics. Therefore, I usually use STEM materials for robot construction and attracting attention. We produce new materials with materials used in daily life" (S2-T). Another participant teacher stated that they placed Lego use at the center of this education:

> They built the STEM laboratory. There were only Legos. We followed the CD packed in Lego boxes sent by the PDNE. We focused on one branch of STEM. During lessons, materials are normally introduced with Lego pieces. Students are given building instructions booklets in Lego sets. Students then follow these instructions to build products. After that, they produce original works (S3-T).

One of the kindergarten teachers, on the other hand, emphasized that STEM implementations were conducted in a different order in their school by saying, "We perform science, mathematics and material applications respectively in the order specified by the textbook. In the free time, the children work with STEM materials in the science center, I mean STEMbus (S1-T). Expressing the inappropriateness of founding this education solely on Lego use, a middle school teacher said, "Other colleagues of mine often use Lego. But I don't use it too often and I think the novelty wears off at some point. I don't use any resources. I let my students produce materials for science fairs and I use some of them in my lessons" (S2-T). A middle school student stated that STEM education should involve a diverse range of materials and explained, "I would like to see different works and be inspired by them. I would like to work with something else apart from Lego sets" (S2-St).

The second sub-category of the opinions on STEM education practices addressed assessment and evaluation. It was observed that different tools were taken into consideration instead of standardized assessment and evaluation tools in measuring the effect of such education on student achievement. The following responses by some teachers confirm this result: "I can see the impact of STEM education through their commitment to the course. The difference of our students from other students in engineering will be seen in the long term. Our success in science fairs is just an example (S2-T) and "No written or oral examinations were carried out. The students explained the mechanisms in their products (S3-T).

Problems and recommendations for STEM education. The results obtained in this category include two sub-categories: funding and STEM education outside the school. The participant from the PDNE explained why funding was needed to expand STEM education: "A significant economic support is required for the science and technology pillars of STEM. PDNE does not have any financial support for this project. Economic problems have been overcome with the support of benefactors."

For the question about where students who have already learnt about STEM education can improve themselves outside the school, a middle school administrator answered, "No, there are not any practices outside the school that students can benefit from" (S2-A). This problem was also mentioned by two students. One of the students said, "Since there is no Internet and material at home, we are unable to do research or practices on STEM. I wish I had a computer, a tool kit, materials, and a Lego set that I could use outside the school" (S3-St) and the other one said, "I wish there were a STEM truck loaded with materials for everyone. I also wish the materials could be taken home and used at home" (S2-St).

The results obtained in recommendations for STEM education include two sub-categories: student motivation and teachers' STEM education. One of the students stated that permanent learning through fun occurred when students were motivated by saying, “I participated in a STEM competition with my original project. We couldn't win, but it was a lot of fun” (S3-St). Another category that the participants made recommendations for was teachers’ STEM education careers. For example, a teacher said, “Teachers should be provided with more training” (S1-T) and a middle school administrator said, “Exemplary cases abroad can be examined for more successful STEM education” (S3-A).

Results and Interpretation – Stage 2

The following three main themes related to the feasibility of distance STEM education emerged from the interviews: Views on the design of distance STEM education, and problems and opinions on distance STEM education implementations.

Views on the design of distance STEM education. The sub-categories under this theme include the structure and the impact of STEM instructional design.

The interviews with the field experts yielded different views on the design structure. On the structure of system design for a successful distance STEM education, Participant 1 stated that the design structure would play a key role in making the education effective and efficient by saying, “The most important key to instructional design is to develop and design meaningful, effective, attractive, productive learning activities. These can be added to existing courses via design.” Participant 7 emphasized that distance education could contribute this education with its flexible design structure by saying, “Although STEM education tends to involve hands-on activities more, there are more advantages to conducting it or, at least, supporting it with distance education. The case here can be designed for the target audience. For example, the target audience can be teachers or students.”

In addition to the structure of the instructional design, the impact of the design was another sub-category obtained as a result of the interviews. The results showed that, in distance STEM education, the design could have effects on many interrelated components such as students, teachers and system. Regarding the fact that STEM education to be started outside the school by means of distance education design and to be designed according to the target audience would continue in the school and affect students’ learning process completely, Participant 3 said “Students can access a number of materials and contents from media they want before coming to class. They can then discuss the results and processes when they bring these experiences into the classroom.” On the other hand, Participant 6 supported the idea that a well-prepared design can be effective in eliminating deficiencies in formal education:

> When the teacher is not present in the environment or away, the students can take more responsibility and use a little more creativity in their designs. Sometimes, the whole process may be based on giving assignments and checking. Teachers assign whatever they want. Students then do what they are told. Distance education can put an end to this.

Views on distance STEM education applications. There were four subcategories under this theme: impact of STEM practices, application tools, examples in STEM applications, and assessment and evaluation.

Some of the participants stated that the impact of distance STEM education applications would vary depending on the different components within its structure. For example, Participant 1 stated that STEM education could improve the functioning of the education system by saying,

> The existing programs have shown that projects aiming to improve skills such as technology, collaboration, and critical thinking skills have failed. They became burdens on the existing school curricula because they were not transferred outside the school. Distance education component of STEM education can also eliminate such a burden and relieve the school.

Participant 3 agreed that technology, which is one of the pillars of both distance education and STEM education can be used by students in different ways to obtain various benefits by saying, "Nowadays, children should know whatever is providing us with these technologies (…) It is perfectly done with distance training. The theoretical part is taken here and the loss of time is prevented." Participant 8 stated that implementation would not only offer benefits with the use of technology, but it would also serve as a means of reaching a wider audience by saying, "With distance training, STEM will reach large audiences and information about the movement will have positive results. Some people can participate in this program even as a hobby. It seems that science can lead universities to visually reach out to the public."

The second subcategory under the theme of distance STEM education implementations dealt with STEM application tools. The interviews with experts from different fields indicated that different instructional tools could be used in STEM education process. Suggesting that distance education can particularly support teaching science as a subject in different aspects, Participant 12 said, "Today we have virtual labs, laboratories with distance access. Instead of dissecting a frog, you can perform dissection multiple times with virtual applications and collect comparative data. You can combine children from different geographies on a single platform, and you can transform a monologue (one-way) education model into a social network."

In the same way, Participant 4 stated that educational tools could be adapted for use with contemporary technology by saying,

> … Especially in simulations in science course, it can be used in very dangerous experiments that cannot be safely done otherwise. Therefore, it may be possible to combine STEM education with augmented reality. In addition, flipped classrooms, use of wearable technology in education, and adaptive learning technologies can be integrated into STEM education.

The third subcategory was implementation examples. The participants mentioned different implementation examples, most of which were experienced abroad by them. Participant 6 stated that STEM education could be expanded through the use of distance education by saying,

> We tried to increase the interaction between teachers with Moodle or social networks like LinkedIn. There is a closed area where teachers communicate with each other. There is also a web page of the project. Products from the closed area usually reach the wide audience through the web page, increasing the effect. They implement shared experiences there. They usually have activities such as learning based on adventure. For example, 3-4 teachers go to a mountain to solve a problem for environmental education. As all teachers have no possibility to go there, they synchronously communicate with other teachers. Then teachers share findings their classes. They share the experience of 3-4 people in a synchronous way with millions of people.

Participant 10 stated that the target audience of distance STEM education could be teachers as well rather than students by saying, " ….teach integrated online STEM education courses, but these courses are for teachers. In my online courses, they learn what integrated STEM education is, they prepare lesson plans and then they teach them in their classes." The last category under this theme addressed opinions about assessment and evaluation in distance STEM education. Assessment and evaluation is the basis of the determination, dissemination and sustainability of the improvement, effectiveness and efficiency of any educational activity. For example, Participant 2 said, "Flexibility and variety are inherent in this education, so these should also characterize the assessment and evaluation activities in this field." In the same way, Participant 1 mentioned a previous experience of hers and emphasized that appropriate assessment and evaluation techniques should be chosen among a wide range of tools by saying, "It required different assessment and evaluation tools. Unfortunately, teachers had to measure these applications with conventional assessment evaluation methods because they introduced them during extra hours due to the curriculum they had to follow. So it didn't make any sense."

Discussion and Recommendations

STEM education has been a popular research topic around the world. On the other hand, in Turkey, the number of implementations and publications in this subject started to increase significantly in 2017. Nevertheless, there is still limited research conducted on distance STEM education in Turkey also in the world. Nowadays, when information and communication technologies advance at a pace difficult to keep up with, conducting studies with relevant technologies and innovative distance education models in order to support STEM education will be an important contribution. Such implementations and studies can carry STEM education to a different level not only in national but also international level. For these reasons, this study aims to contribute to the field by examining the operation of the first nationwide implementation on STEM in Turkey and by examining the feasibility of distance STEM education, which is seen as a way and method in the sustainability of this initiative based on experiences and expert opinions in our country. At the same time, it aims to guide the researchers interested in the subject and future research.

This study was conducted by the researchers in the field of distance education and also science education. Therefore, this study could be an important contribution towards the need in the literature because of the researchers' characteristics and since the study was designed to be implemented at a national scale, it involved culture-specific cases and it brought a new perspective for the integration of STEM education with distance learning.

Based on two separate cases, this study was conducted in different environments and with the contributions of different stakeholder groups (e.g., students, teachers, parents, administrators, and distance education and STEM field experts). The fact that this study was conducted over a relatively long period of time (January 2016-December 2017) made it possible for the authors to observe different implementations. For example, although STEM education was implemented in Kayseri at the beginning of this study, it is no longer implemented today due to various reasons.

The results also showed that readiness is one of the most important criteria for the proper functioning of any project. Education is a multi-faceted field with many components and variables. To ensure that formal or distance STEM education can be sustainable and disseminated, it is first necessary to ensure that appropriate environments are provided for the appropriate conditions. Otherwise, different problems arise on different components. Some of these cannot be compensated in the process.

When starting STEM education, it is also important to understand the nature of the subject in order to act primarily in accordance with the purpose in the process management. As shown by the results from the interviews, teachers, who we can call the backbone of education, should first understand what this training is and be convinced that this training will be useful for students.

Increasing quality in-service training, setting up partnerships and training prospective teachers according to the integrated structure of STEM education could help improve this education (Oner & Capraro, 2016, p.14; Corlu, Capraro, & Capraro, 2014). In addition to properly planned in-service trainings, continuous academic, technical and social support should be provided to prevent the loss of motivation in the process. For example, considering the STEM education experience in Kayseri, effective introduction of this education to teachers at the beginning of the process could have resulted in more effective implementations of this education. In addition, these trainings and support could have been delivered with distance education. Thus, continuity and flexibility in education, which is one of the most important advantages of distance education, could have been employed. In fact, training on STEM education to be given to teachers, administrators, or all parties through distance education would be beneficial in terms of both time and cost. Besides the problems of budget and hardware, there are problems such as the workload of teachers, guidance and counseling teachers and coordinator teachers (Bumen, Ates, Ural, & Acar, 2012, p. 33). Instead of bringing teachers together in so-called seminars in crowded environments when they do not feel ready physically and psychologically, presenting flexible working and implementation activities through distance learning environments could positively affect motivation and willingness (Taslibeyaz, Karaman & Goktas, 2014, p. 156). Apart from being unfamiliar with the topic, teachers may also have different reasons for their reluctance. According to our results, these include expectations of economic support, expectations of social status, concerns about meeting the deadlines in the curriculum, concerns about the need to prepare students for central exams, and heavy workload (e.g. intensive course hours, paperwork, social studies, training courses etc.). Many of these problems can be solved directly or indirectly by distance education (Erturk & Aydin, 2017, p. 600).

As shown by the results, although STEM education includes various disciplines, it is mostly associated with science teachers. Science teachers normally study science education, which is one of the STEM education disciplines, at undergraduate level, but interdisciplinary approach requires that teachers of other STEM areas be included in trainings as well. For STEM education, environments with multiple perspectives can be created that bring together teachers different subject areas. Moreover, through distance education, STEM education can be open to not only teachers, students or administrators but also to anyone interested in it. The activities to be delivered with open and distance education would be accessible by different groups ranging from experts in the fields of science, technology, mathematics and engineering, to families or other individuals who are willing to learn or who cannot go to school because of their limitations of any kind.

In every attempt related to education, whether physical and time planning of schools is appropriate for this new situation is one of the problems encountered. As a matter of fact, the problem of lack of sufficient materials in schools was mentioned repeatedly during the study. First of all, materials can be diversified according to the nature of STEM education. In other words, this education should not include only robotic or coding materials. However, the number of teachers who stated that they thought or were informed in this way was quite high. This is because STEM education is constantly being announced in association with Lego sets or with robotic and coding activities. This perception must be changed as the first step. The 3R rule (Reduce-Reuse-Recycle), which students are reminded of continuously, can be used in STEM education by means of creative activities. According to Karahan, Canbazoglu Bilici and Unal (2015), students can build a strong student voice on the use of technology and social and environmental problems, and they can strengthen the link between society and schools (p. 234).

In addition, in cases where materials or time at school are not available or limited, students who want to improve themselves at home in addition to a limited number of STEM activities can be supported by distance STEM education. The results also showed that this education requires a serious budget at the national level when it is desired to be multi-faceted. Distance education can reduce the required budget. For example, materials that are disposable or costly can spread through shared experiences. Current education policies provide political support to STEM education (Corlu, 2014, p. 6). Therefore, with this support, the smart board, internet connections and EBA, which are distributed to schools within the scope of a national project, could provide opportunities and infrastructure for distance STEM education initiatives.

One of the problems encountered in this study was the timeframe specified for STEM education implementation sessions. The fact that this education was offered in hours outside the school led to some problems and disruptions. At the end 2016-2017 school period, the ministry announced that all middle school grades (Grades 5-8) would cover STEM education with the upcoming curriculum. However, both this announcement and the results from previous studies showed that kindergarten students and teachers are the most neglected group in terms of the support and studies for STEM education (Kumtepe & Genc Kumtepe, 2014). The revisions projected for 2018-2019 school period could improve the STEM education in Turkey. However, there are limited research findings on how teachers will adapt the activities in order to provide the students with the desired knowledge and skills (Hacioglu, 2018, p.132; Stohlmann, Moore, McClelland, & Roehrig, 2011). It would be useful to include real-life examples of local and global issues in textbooks to improve and guide teachers and students' perceptions of these disciplines. The active process to be undertaken by students in finding solutions to these problems could support STEM education. Otherwise, science festivals to be held at the end of the term may include products that do not go beyond the classical modeling tasks carried out in units instead of original studies. With the help of distance education support for this problem, students can prepare for the applications they will do in the school or they can experience the activities that cannot be done at school.

Another problem encountered in the case of formal STEM education was the lack of assessment and evaluation. As the distance education experts in this study emphasized in STEM education program and evaluation can be done in the process by getting continuous feedback from students and teachers with a good design for purpose. In fact, as a science teacher, the primary author observed that students tend to show more interest in the assignments or course works given in virtual environments like EBA. Therefore, distance education would provide convenience in measurement and evaluation process and contribute to the development and improvement of STEM education (Conrad & Openo, 2018).

In changing world conditions, every sector, including education, has to embrace innovations and make improvements. However, they need to be based on detailed needs analysis, planning processes, periodical assessments and experience. In Turkey, the primary obstacle for STEM education is the lack of expert human resources. This situation negatively affects the quality of education, student performance and motivation. The difference in achievement in our country is not only between western and eastern schools. Considering İstanbul as a major city, achievement and opportunities vary according to the income level of the districts. Today, open learning and open education resources, which utilize various materials and platforms in accessing the right information systems, are considered as important alternatives in raising the human resources and eliminating inequality in education (Downes, 2007, p. 32).

Like the case for all initiatives, the policy to be followed in STEM education should be specified in detail because if the main objective, related strategies and indicators are not carefully planned at the beginning of the process, then these initiatives are either abandoned or considered to be impractical. For example, open and distance learning systems, which have been used for many years in Turkey and around the world today, are accepted as important initiatives in the dissemination, sustainability and delivery of education to different groups. In addition to utilizing similar technologies, these education models provide the expected efficiency because they are designed to respond to local needs during planning. Therefore, both STEM education and existing education can be supported with distance education by determining the policies required for the needs.

In examples of STEM education abroad, various studies are being carried out in order to increase the participation of underrepresented groups such as girls in STEM areas. According to the Council of Higher Education, In 2016-2017 school period, out of approximately 14 million students registered in higher education institutions, 7.7 million were male students, while the number of female students was 6.6 million. The difference between these rates is even greater in student placement for college degrees in STEM (Akgunduz et al., 2015). The reasons for this situation are evident in traditional misconceptions such as “there is no point in sending girls to school” and “girls cannot be engineers” (Gok, 2010). In this regard, open and distance learning systems play an important role in terms of ensuring equal opportunities for women’s access to education especially in eastern Turkey. The results from a 35-year longitudinal data analysis showed that open and distance education helps bring a nationwide balance between the number of female and male students in Turkey (Aktaş et al., 2019). If supported by distance education, STEM education will be accessible to not only women but also to other disadvantageous groups of learners. Many different groups such as those who cannot attend school due to various reasons (e.g., disabilities, illness, convictions, geographical restrictions etc.) will have access to this education by means of distance education.

In summary, training activities for prospective teachers, STEM workshops, competitions for original STEM works, abroad holiday awards for original designs and taking part in international catalogs for original designs are promising developments for the promotion of STEM education. However, launching and terminating such efforts and initiatives without detailed planning due to different policies do not allow long-term measurements and cost-benefit analyzes. Although teachers are mostly considered to be the most important actors in education, it is decision makers that lead reform movements. Since 2015, YOK has limited student quotas in basic science departments such as physics, chemistry and biology. However, these areas are the basis of STEM areas as much as engineering and technology. Supporting this idea, the Dean of METU Faculty of Arts and Sciences said:

> One can do nothing without basic science education. First of all, medicine, engineering, health, and most importantly, economy are directly affected. The success of economically developed countries such as South Korea and China is hidden in their investment in basic sciences. Basic sciences are the focus of science. The way to correct the mistakes should not be locking the doors of these programs (Kolcu, 2015).

Failing to train sufficient specialists in these areas will probably result in Turkey becoming a country that depends heavily on foreign resources in information transfer and production for such important disciplines. Unfortunately, the situation of vocational high schools is not much different. It is essential to anticipate today that there will be no local labor force with expertise in these majors and to take measures to prevent this.

The perception of education and science is one of the most important indicators of a country's development level. Therefore, system design, operation and evaluation are not structures that will be designed and modified by quick decisions. As a subject that concerns all educational levels, STEM education is an integrated model that requires the right design and infrastructure in addition to enthusiastic, qualified and expert practitioners. For the expansion and sustainability of STEM education, it would be beneficial to increase initiatives such as STEM*bus* mobile laboratories, science and arts centers, university units such as METU BILTEMM (Science, Technology, Engineering and Mathematics Education Practice and Research Center), overseas project partnerships, Nesin Math Village, children's university and Aziz Sancar GIS project.

One of the problems encountered in education today is the fact that actors of different generations are the parties of the process. Recognizing and understanding generations enables us to see our areas of struggle in the organizational system (Kuran, 2018). It is essential that decision-makers and teachers consider the technologies into which children are born and accept them as effective tools of education process. Children's interest in games and the use of technology can be transformed into enjoyable learning with games specially designed for STEM education. Children who seek solutions to problems from everyday life during games can collaborate with their peers and experts, learn, interact and thus socialize.

In addition to working in a collective understanding and dialogue in STEM education planning, implementation and evaluation processes, the role of schools' infrastructure and professional development training and support in the success of these innovations is indisputable. It is important for all parties to express their ideas clearly and the practices they adopt to be effective in the effectiveness and continuity of education. It is important to support the dialogue between stakeholders from different contexts and professional roles to ensure that various perspectives on STEM education and curriculum can be developed and discussed (Holmlund, Lesseig, & Slavit, 2018). Therefore, policy makers working on a common platform with managers, teachers, students and STEM field experts could benefit from different experiences and solutions to educational and social problems. In addition, the contribution of distance education technologies to the local STEM education activities and STEM training programs to be carried out on a large scale should not be forgotten. These applications, which will be designed to support face-to-face trainings, are also effective tools in expanding and understanding STEM education. In this process, it is possible to understand the opinions of all parties about STEM education by listening to and exploring their individual stories. Therefore, further research is needed to develop a national and global vision for STEM education.

References

Akar, H. (2016). Durum calismasi. In A. Saban & A. Ersoy (Eds.), *Egitimde nitel arastirma desenleri* (pp.130-149). Ankara: Ani Yayincilik.

Akgunduz, D., Aydeniz, M., Çakmakçı, G., Cavas, B., Corlu, M., Oner, T., & Ozdemir, S. (2015). STEM egitimi Turkiye raporu: "Gunumuz modasi mi yoksa gereksinim mi?" İstanbul: İstanbul Aydin Üniversitesi STEM Merkezi.

Aktas, S. G., Genc Kumtepe, E., Kantar, Y. M., Ulukan, I. C., Aydın, S., Aksoy, T., & Er, F. (2019). Improving gender equality in higher education in Turkey. *Applied Spatial Analysis and Policy, 12*(1), 167–189.

Basaran, C. S. (2015). Eğitimde yeni trendler: STEM konferansı. Retrieved from http://www.tusiad.org.tr/__rsc/shared/file/2015-05-29-Cansen-Basaran-Symes---STEM-konferansi.pdf.

Bumen, N.T., Ates, A., Ural, G. & Acar, V. (2012). Turkiye baglaminda ogretmenlerin mesleki gelisimleri: Sorun ve oneriler. *Egitim ve Sosyal Bilimler Dergisi, 41*(194), 33.

Conrad, D., & Openo, J. (2018). *Assessment strategies for online learning: engagement and authenticity.* Athabasca University, AU Press.

Corlu, M. (2014). FeTeMM egitimi makale cagri mektubu. *Turkish Journal of Education, 3*(1), 4-10.

Corlu, M.A., Adiguzel, T., Ayar, M.C., Corlu, M.S. & Ozel, S. (2012). *Bilim, teknoloji, mühendislik ve matematik (BTMM) egitimi: disiplinler arası calısmalar ve etkilesimler.* X. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi'nde sunulmuş bildiri, Niğde.

Corlu, M. S. Capraro, R.M., & Capraro, M. M. (2014). Introducing STEM Education: Implications for Educating Our Teachers For the Age of Innovation. *Education and Science. 39*(171), 74-85.

Downes, S. (2007). Models for sustainable open educational resources. *Interdiciplinary Journal of Knowledge and Learning Objects,*3(1), 29-44.

Erturk, R. & Aydin, B. (2017). Öğretmenlerin iş motivasyonunu arttıran ve olumsuz etkileyen durumların incelenmesi. *The Journal of Academic Social Science*, 5 (58), 582-603.

Feldman, A. (2015). STEAM rising. *Slate.* Retrieved from http://www.slate.com/news-and-politics/2018/06/donald-trump-returns-to-race-baiting-as-republicans-stumble-toward-themidterms.html.

Holmlund, T.D. , Lesseig, K. & Slavit, D. (2018). Making sense of "STEM education" in K-12 contexts. *International Journal of STEM Education, 5* (32), 3-18.

Gok, F. (2010). Türkiye'de eğitim ve kadınlar. Şirin Tekeli (Ed.), 1980'ler Türkiye'sinde Kadın Bakış Açısından Kadınlar. İstanbul: İletişim Yayınları, 161-176.

Hacioglu, Y. (2018). *5. sınıf fen bilimleri ders kitabındaki etkinliklerin STEM eğitimi acısından incelenmesi.* Ders Kitapları Uluslararası Sempozyumu'nda sunulan bildiri, Yıldız Teknik Üniversitesi, İstanbul.

Karahan, E., Canbazoglu, B.S., & Unal, A. (2015). Integration of media design processes in science, technology, engineering, and mathematics (STEM) education. *Eurasian Journal of Educational Research*, 60, 221-240

Karasar, N. (2004). *Bilimsel araştırma yöntemi.* Ankara: Nobel yayıncılık.

Kolcu, G. (2015). YOK: Kapatıp güçlendireceğiz Akademisyenler: Bilim biter. *Hürriyet.* Retrieved from http://www.hurriyet.com.tr/egitim/yok-kapatip-guclendirecegiz-akademisyenler-bilim-biter-28865916.

Kumtepe, A.T. & Genc Kumtepe, E. (2014). STEM in early childhood education: We talk the talk, but do we walk the walk? In H.Y. Yang, Z. Yang, D. Wu & S. Liu (Eds.), *Transforming K-12 Classrooms with Digital Technology*. (pp. 140-163). New York, NY: IGI Global.

Kuran, E. (2018). Telgraftan tablete. Destek Yayınları.

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

List, D. (2004). Maximum variation sampling for surveys and consensus groups. Adelaide: Audience Dialogue.

MEB (2018). *Fen bilimleri dersi öğretim programı*. Ankara. Retrieved from http://mufredat.meb.gov.tr/ProgramDetay.aspx?PİD=325.

Mills, A.J., Durepos, G., & Wieb, E. (2010). *Encyclopedia of case study research*. California: SAGE Publications.

National Science Foundation. (2016). *Science & engineering indicators 2016 Digest.* Virginia: NFS.

Oner, A.T. & Capraro, R.M. (2016). FeTeMM okulu olmak iyi öğrenci olmak anlamına mı gelir?. *Education and Science Journal, 41(185),* 1-17.

Patton, M. Q. (2002). *Qualitative research and evaluation methods*. Thosand Oaks: CA, Sage.

Roberts, A. & Cantu, D. (2012). Applying STEM instructional strategies to design and technology curriculum. *PATT 26 Conference, Technology education in the 21st century*. *26-30 Haziran 2012 in* (pp. 91-93). Stockholm, Sweden.

Sanders, M. (2009). STEM, STEM education, STEMmania. *The Technology Teacher*, 68(4), 20-26.

Taslibeyaz, E., Selcuk K. & Goktas, Y. (2014). Öğretmenlerin uzaktan hizmetiçi eğitim deneyimlerinin incelenmesi. *Ege Eğitim Dergisi.* 15(1), 139-160.

Taylor, S.J., Bogdan, R., & DeVault, M.L. (2016). *Introduction to qualitative research methods.* New Jersey: Wiley.

Wang, H.H., Moore, T.J., Roehrig, G.H., & Park, M.S. (2011). STEM integration: teacher perceptions and practice, *Journal of Pre-College Engineering Education Research*. 1(2). 3-13.

Yıldırım, A. & Simsek, H. (2006). *Sosyal bilimlerde nitel araştırma yöntemleri* (6. baskı). Ankara: Seçkin Yayıncılık.

Yin, R.K. (2014). *Case study research. Design and methods*. 3rd. ed. Thousand Oaks, California: Sage.

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