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The Effects of Out-of-School Learning Environments on STEM Education: Teachers' STEM Awareness and 21st-Century Skills*

Okul Dışı Ortamlarda STEM Eğitiminin Öğretmenlerin STEM Farkındalıklarına ve 21. Yüzyıl Becerilerine Etkisi

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ABSTRACT: This study was carried out within the scope of a nature education and science camp project. It aimed to investigate the effects of STEM activities conducted in out-of-school environments on teachers' STEM awareness and 21st-century skills. The research was designed according to the explanatory sequential pattern of the mixed method, and the quantitative and qualitative methods are the continuation of each other. Twenty-three science, elementary math, technology, and design teachers who worked at public middle schools participated in a six-day program that integrated STEM subjects with out-of-school learning. Seven different STEM-integrated out-of-school activities were implemented for six days in one of the central Anatolian regions in Turkey. STEM awareness and 21st-century skills scales were implemented in the study for data collection. A semi-structured interview was also conducted with teachers. The aim was for the teachers who participated in the project to integrate out-of-school and STEM education and then transfer this newly gained knowledge to their students. Both quantitative and qualitative findings support that teacher's acquisition of knowledge and skills throughout the science camp would support their students' craft, analytical thinking, motivation, problem-solving skills, and self-esteem. As such, out-of-learning environments should be used more in both STEM and 21st-century skills education.

Keywords: Out-of-school learning, middle school teacher training, STEM education, 21st century skills.

ÖZ: Bu çalışmanın amacı okul dışı ortamlarda gerçekleştirilen STEM etkinliklerinin öğretmenlerin STEM farkındalıklarına ve 21. yüzyıl becerilerine etkisini incelemektir. Araştırmada karma yöntemin açıklayıcı sıralı deseni benimsenmiştir. Devlet ortaokullarında çalışan 23 fen, matematik, bilişim, teknoloji ve tasarım öğretmeni, STEM konularını okul dışı ortamlarla bütünleştiren altı günlük bir programa katılmışlardır. Yedi farklı okul dışı ortamda kurgulanan STEM etkinlikleri, Türkiye'nin Orta Anadolu bölgesindeki bir ilde bir hafta boyunca yürütülmüştür. Araştırmada veri toplama amacıyla STEM farkındalık ve 21. yüzyıl becerileri ölçekleri kullanılmıştır. Ayrıca öğretmenlerle yarı-yapılandırılmış görüşmeler yapılmıştır. Araştırmaya katılan öğretmenlerin okul dışı ortamlara entegre edilen STEM eğitimleriyle edindikleri bilgileri öğrencilerine aktarmaları hedeflenmiştir. Çalışmanın bulguları, öğretmenlerin bilim kampı boyunca edindikleri bilgi ve becerileri, öğrencilerinin analitik düşünmelerini, motivasyonlarını, problem çözme becerilerini ve özgüvenlerini desteklemede kullanacaklarına işaret etmektedir. Bu nedenle hem STEM hem de 21. yüzyıl becerileri eğitiminde okul dışı ortamların daha fazla kullanılması önerilmektedir.

Anahtar kelimeler: okul dışı öğrenme ortamları, ortaokul öğretmen eğitimi, STEM eğitimi, 21. yüzyıl becerileri.

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Formal education refers to structured, systematic, certificated, and generally state-supported learning that follows an organized curriculum (Ngaka et al., 2012). On the one hand, non-formal learning environments would be "real OSLE (OSLE)" such as museums, science centres, industrial institutions, zoos, and national parks. There may also be "digital/virtual OSLE" such as social media, educational websites, and web 2.0 tools (Karademir, 2018). There has been increasing attention on non-formal learning environments in formal education. Out-of-school education is not only effective for developing leisure-time interests and tuning in with the immediate environment, but it also helps students bring what they learn in the classroom into real life through direct observation, implementation, and experience. The out-of-school environment could be considered a laboratory in physical and social sciences, arts and crafts, health, and physical education (Smith, 2017).

Learning that takes place in non-formal learning environments is not completely independent of the formal teaching offered in the classroom. Rather, a link could easily be established, as most institutions propose learning goals and employ educated staff. However, these easily accessible learning environments are often visited in an unstructured, recreational way. When detailed aims, concepts, or competencies are explicated, such informal settings may offer crucial benefits (Randler et al., 2012). In OSLE, the education curriculum and methodology are flexible. Still, learning takes place in an intentional and organized way, not just by chance. This flexibility empowers students to place their needs and interests at the centre of education. While formal education pays little attention to skill development, out-of-school education emphasizes skills and the development of attitudes such as tolerance. Students' needs are better met in OSLE, which allows them to know themselves and the world more deeply (Grajcevci & Shala, 2016).

According to the STEM Education Turkey Report, STEM education should not be limited to in-class activities; rather, it should be supported with OSLE (Akgündüz & Ertepınar, 2015). There are several studies on the learning outcomes of STEM activities performed in OSLE (Bakioğlu & Çevik, 2021; Baran et al., 2016) and attitudes toward STEM (Cooper & Heaverlo, 2013; Timur et al., 2020; Young et al., 2017). Yet, to the best of our knowledge, there are no known studies focusing on the effects of STEM activities carried out in out-of-school environments on teachers' STEM awareness and 21st-century skills. This research is expected to contribute to the literature on the effects of STEM activities in OSLE. It is a well-known fact that science, technology, engineering, and math took their actual origin from nature; therefore, it is preferable for them to be taught in natural settings. All materials, phenomena, procedures, and problems to be solved could easily be found in nature. Similar to nature, additional out-of-school environments offer enriched educational opportunities for both STEM awareness and 21st-century skills.

This research was carried out for one week with 23 teachers from four different branches in seven different out-of-school environments within the scope of the project called "STEM is All Around," supported by the TÜBİTAK 4004 project. The main aim was to find and describe useful teaching methods in STEM education (SE), including out-of-school education, for promoting 21st-century skills of middle school teachers. This study is guided by the following research main question and sub-question:

1. How did the STEM activities implemented within the project contribute to the teachers?

1.1. Does STEM education conducted in out-of-school learning environments influence teachers’ STEM awareness?

1.2. Does STEM education conducted in out-of-school learning environments influence teachers’ 21st-century skills?

1.3. What are the participants’ opinions on how STEM education contributes to them in out-of-school learning environments?

Theoretical Framework and Literature Review

It has been revealed that out-of-school learning environments increase the social skills of individuals (Panizzon & Gordon, 2003), and such environments enable teachers to learn new ideas and information from each other and increase and improve their teaching strategies and skills (Chin, 2004). STEM education, whose starting point is the philosophy of holism (Simmons, 2021). The multidisciplinary nature of it can be attributed to the influence of Gestalt theory. The Gestalt Approach helps create new ways of discovering, experimenting, or creating educational content, where the whole is more than the parts that make it up and helps capture the development of learning environments that are more connected to the students’ universe, values subjectivity, uniqueness, responsibility and experience (Greenwood, 2020). This philosophical doctrine focuses on the perception of existence in the face of a holistic environment; It coincides with the transdisciplinary logic of the STEM approach. From this point of view, STEM is more than just an approach applied in the classroom. STEM education, which has been popular in recent years, can also be applied in out-of-school learning environments such as summer camps, museum education, and so on. One of the most important reasons for this is that STEM education takes place in out-of-school learning environments is that it offers better foundation for the curriculum content in the USA (Özçelik & Akgündüz, 2018). The goals of STEM education include increasing the knowledge, skills, attitudes, and career awareness of individuals towards STEM as well as the development of 21st-century skills. Out-of-school learning environments contribute to the development of these goals (Bozkurt et al., 2009). It is important that teachers who are expected to transfer STEM goals to their students have high STEM awareness, as teachers with high STEM awareness will provide STEM education more effectively.

Today’s world is changing at an increasing speed, requiring new and shifting knowledge and skills. The 21st-century skills include traditional curricular content such as reading, writing, mathematics, history, and science, as well as writing, interpretation, and synthesis. The Organization for Economic Co-operation and Development (OECD) defines 21st-century skills as cognitive skills, intrapersonal skills, and technical skills (OECD, 2019). Cognitive skills combine thinking, learning, remembering, and reasoning to transform problem-solving and critical thinking. Intrapersonal skills encompass a group of self-communication skills to manage emotions and reach executive functioning. Technical skills involve performing practical tasks that naturally require information fluency in using certain tools and technologies (Ananiadou & Claro, 2009).

The American National Science Teachers Association (NSTA) emphasizes that 21st-century skills have a natural and strong relationship with science education. It is reported that science applications that specifically address the nature of science can provide a rich context for the development of many 21st-century skills, such as critical thinking, problem-solving, and information literacy (NSTA, 2011). Students can be provided with authentic learning environments to develop 21st-century skills (Larson & Miller, 2011). Besides, allowing students to scrutinize curricular tasks to construct their knowledge triggers the development of 21st-century skills (Bybee, 2009).

Similarly, STEM education is the core focus of many countries around the world. Each nation is converting its educational systems to be competitive in the 21st century. However, the situation is not promising in Turkey, as the majority of Turkish students lack access to STEM experiences that meet international standards in STEM disciplines. One of the most important reasons for this is that there are not enough teachers trained in the STEM field (Çorlu et al., 2014). Consequently, STEM activities carried out in an out-of-school environment will also help teachers to improve themselves, who will then raise qualified individuals (Özbilen, 2018).

OSLE provides students with unique and enriched learning opportunities that are not available during the regular school program. This enrichment increases with relevant course content and STEM practices that are not possible in a traditional classroom setting (Peterson & Fix 2007). STEM education aims to increase students' knowledge, skills, and attitudes towards STEM, as well as improve their 21st-century skills. As such, non-formal learning environments play a crucial role in contributing to STEM education goals (Bozkurt Altan et al., 2019). The STEM education program integrated into non-formal learning environments provides cooperative, practical learning opportunities that enable students to find solutions for their daily life problems (Schnittka et al., 2010). Activities that take place outside of school increase students' interest in the subject matter (Bogner & Wiseman, 2004). Teachers shoulder great responsibility to establish a bridge between STEM education and non-formal learning environments to enhance student development. As such, this study might be useful in filling the mentioned gap in STEM education in out-of-school learning environments.

Method

This research employed a mixed-methods approach to examine the effects of STEM activities conducted in OSLE on teachers' STEM awareness and their development of 21st-century skills. Yıldırım and Şimşek (2013) stated that one of the most important reasons for the use of mixed designs in research is that the world around us is complex and comprehensive. The basic premise for choosing the mixed method is to add depth and breadth to the study as the holistic picture from meanings obtained from interviews or observation to the generalization sample from a population obtained from surveys. A mixed-methods study provides stronger inference than using quantitative and qualitative approaches alone (Wasti et al., 2022). In the current research, explanatory sequential design was preferred among mixed designs as it is effective in explaining qualitatively the quantitative results that may occur unexpectedly or unusually (Morse, 1991; Plano-Clark & Creswell, 2008).

Study Group

The science camp was held in September of the 2021-2022 academic year. The study group was determined using criterion sampling, and the participants were selected according to criteria determined by experts. Their willingness to participate in the project, lack of project experience, and having a master's degree were effective in selecting the participants. Twenty-three science, elementary math, technology, and design teachers who worked at public middle schools were chosen from 154 online applications from eight different cities.

Table 1

Demographic Characteristics of Participating Teachers

		f	%
Gender	Female	17	73.9
	Male	6	26.1
Major	Science	14	60.8
	Elementary Maths	5	21.8
	Information Technology	3	13.1
	Technology & Design	1	4.3
Type of school	Public	22	95.6
	Private	1	4.4
Term of office	1-5	5	21.7
	6-10	7	30.4
	11-15	9	39.2
	16 and over	2	8.7
Project experience	Yes	5	21.7
	No	18	78.3

Table 1 shows that 17 of the teachers in this study are female, and six are male. Fourteen of the teachers are from science, 5 of them are from primary school mathematics, 3 of them are from information technologies, and 1 of them is from the technology design branch. Twenty-two of the teachers work in public schools, and one of them works in a private school. Five of the teachers have 1-5 years, 7 have 6-10 years, 9 have 11-15 years, and 2 of them have 16 years or more years of work experience. Five of the teachers have project experience, and 18 do not have any project experience in the current research.

Data Collection Instruments

"STEM Awareness Scale" (15 items) and "Multidimensional 21st Century Skills Scale" (41 items) were used for quantitative data collection. Reliability analyses of the scales were conducted. The data were analyzed using the SPSS-24 program based on normality tests. In line with the findings obtained from the quantitative data, the qualitative stage was initiated. Participating teachers were interviewed in person using a semi-structured interview form. Then, the audio recordings and transcriptions of the interviews were analyzed using content analysis.

Quantitative Data Collection Instruments

STEM Awareness Scale

The scale developed by Çevik (2017) was used to determine teachers' awareness of STEM. This scale was prepared in a 5-point Likert style and consisted of a total of 15 items and three factors. The first factor measures the effect of teachers' STEM awareness on students, the second sub-dimension measures the effect on the lesson, and the third sub-dimension measures the effect on the teacher. It was confirmed by CFA that the scale consisted of 3 sub-dimensions. The Cronbach's Alpha coefficient for the overall scale is .82., and the reliability coefficients of the factors are .81, .71, and .70. The test-retest method was used to validate the scale. In the first stage of this method, the standard deviation and mean of the scale were determined as 0.52 and 3.95, respectively. In the second stage, they were determined as 0.53 and 3.91, respectively. Pearson Correlation Coefficient was found to be significant at the level of p=.001 and r= .615.

Multidimensional 21st Century Skills Scale

The second scale used in the research was developed by Çevik and Şentürk (2019). The scale is in a 5-point Likert style and consists of 41 items, with five factors: "Information and Technology Literacy Skills," "Critical Thinking and Problem-Solving Skills," "Entrepreneurship and Innovation Skills," "Social Responsibility and Leadership Skills" and "Career Awareness". The alpha reliability coefficient of the scale is .86 for the overall scale, and for the sub-dimensions of the scale, it is .84, .79, .76, .73, and .75, respectively. The agreement results obtained with the DFA analysis regarding the reliability of the scale are (χ^2/sd = 2014.17/774; GFI = .90; AGFI = .85; RMSEA = .050; CFI = .95; NFI = .91 and SRMR = .058), which are acceptable for the application. The Cronbach's Alpha reliability coefficient of the scale was determined as .92 for this study.

Qualitative Data Collection

Semi-structured Interview Protocol

In line with the analysis of quantitative data, a semi-structured interview protocol was used to determine the reasons for the changes identified in the participants. It was developed to reveal the main reasons for the changes in 21st-century skills and a STEM awareness in depth. Validity and reliability concepts are against the quantitative paradigm; credibility and trustworthiness are generally used in qualitative research (Krefting, 1991).

In qualitative research, the researcher should ensure that the findings are drawn from the data, not the interpretation of the researcher. Confirmability helps the researcher to reduce bias originating from the researcher's own perspective. Several strategies have been implemented to ensure the credibility of the study. First of all, researchers developed rapport with participants during the science camp, which led to more objective responses in the interviews. Secondly, an audit trail is an effective way to offer a clear description of the research process (Shenton, 2004). The current study employed an audit trail to increase confirmability. The process and results were reviewed by another STEM field expert besides the researchers. Additional expert was asked to compare the same themes with conceptual categories so that no themes were left outside. Thirdly, intercoder agreement was determined by using the formula of Miles and Huberman (1994) Reliability= consensus/ (agreement+ disagreement) *100. According to Miles and Huberman (1994), agreement among coders is expected to be at least 80%. The intercoder agreement was accepted as satisfactory as it reached 84% (83/83+15). In order to ensure confidentiality, the participating teachers were named T1 to T23 (T stands for the teacher, and the accompanying number stands for the number of participants), and the most representative quotations were selected. Initial findings were presented at international conferences for peer scrutiny. Finally, the sample selection was made for transferability, as the characteristics of the participants and the research field explained (Sharts-Hopko, 2002). The most frequently used sampling methods in qualitative research are purposeful, random, and voluntary sampling. How the participants were selected in the study was stated objectively.

The interview questions were formed as follows.

1. Which activity do you think contributed the most to you during the science camp? Explain with reasons.

2. Which activity do you think contributed the least to you during the science camp? Explain with reasons.

3. In which aspect do you think the science camp and STEM education developed you?

4. Which STEM discipline would you say had the most impact on you in science camp?

5. In which aspects do you think your awareness increased in the science camp?

Activities Procedure

The science camp lasted for a total of 6 days in OSLE. These environments included Değle Ruin, a coding laboratory, a playground, a science centre, a museum, a hospital, and a natural park. Legal permissions and ethical documents were obtained from the relevant authorities. Within the scope of the science camp, STEM activities included research and inquiry-based science activities within the framework of engineering, biomimicry, design, coding, environmental awareness, and renewable energy themes. Measurement and evaluation studies were also organized in order to determine the teachers' level of basic knowledge and skills they will acquire in the science camp. Additionally, warming drama games were held for participants to get to know each other. In this study, all activities are genuine and developed by researchers. First, out-of-school environments were determined. Then, the literature was investigated for appropriate activities. For the following step, activities were sent to prospective trainers, and based on their feedback, necessary adjustments were made to finalize activities.

First Day

The participants arrived at the drama class of Karamanoğlu Mehmetbey University Faculty of Education in the morning. They participated in four different warming drama activities, which were prepared to help them get to know each other and express themselves. After the activities, the participants learned each other's names, fields of study, professional experiences, and the provinces they came from to participate in the project. The session focused on planning STEM education in out-of-school settings, providing examples of how STEM education can be integrated into the curriculum and how teachers can expand their teaching beyond the classroom through collaborative, hands-on, and project-based learning activities. STEM activity worksheets and lesson plans were prepared and presented to show how to integrate STEM disciplines into out-of-school activities. To provide a real-life experience, a visit to an apple orchard was organized.

Second Day

Remodeling of Değle Ruins (Karadağ): Değle Ruins is a settlement from the Ancient Eastern Roman period, located 50 km from Karaman-Center. A local resident welcomed the participants at Değle Ruins and provided information about the ruins. An expert in the field of STEM gave a presentation by projecting onto ancient walls, and then the participants took measurements of ancient buildings with laser meters, using both standard and non-standard units. Finally, the group visited the village's primary school to create virtual and real models in a 1:64 ratio based on their measurements.

Third Day

Smart Lighting System Design in the Coding Laboratory: The coding laboratory at the Youth Centre offers an excellent premise for out-of-school learning. The TÜBİTAK Experimental Laboratory has outstanding technical and technological equipment for coding experiences. In addition to the coding training, the participants also examined the laboratories, materials, and social facilities in the youth centre. They set up a lighting system and coded it using the Tinkercad Program. They also learned how they can benefit from or contribute to Youth Centres in their cities. Designing a Toy using STEM in the Parks: On the third day afternoon, the participants made extensive observations of the Karamanoğlu Mehmetbey University Practice Kindergarten Playground materials. They examined the working principles of the materials in the park. Then, the participants designed a toy consisting of simple machines within the scope of STEM.

Fourth Day

Let's Rebuild the Solar System: Konya Science Centre is one of the largest science centres in Turkey. Science centres are attractive not only because of their content but also because of their architecture, green spaces, and diverse usage purposes. TÜBİTAK aims to spread science culture in our society with the help of the science centre. Thus, they are well-suited to the philosophy of out-of-school environments. A planetarium trip was carried out in the centre, and the participants then created a solar system by reducing the sizes of the planets and the distances between them. After the participants examined each other’s systems and finished their presentations, they examined the materials, devices, and automation systems in interactive laboratories.

Fifth Day

Design a Simple Machine using STEM Education in Museums: The materials were presented chronologically to the participants by an expert in the museum. The participants gained technical knowledge by examining the simple machines and equipment and received information about their working principles. In particular, the relationship between the number of gears and the force applied by coffee and flour grinders was explained. Then, the participants developed their own simple machines within the scope of the STEM approach.

Muscle Measurement Device Design in Muscle Research Laboratory: The second activity of the fifth day was carried out at the Muscle and Athlete Exercise Evaluation Laboratory in Karamanoğlu Mehmetbey University Medical Faculty Hospital. It was explained how to benefit from health institutions as an out-of-school learning environment and how to protect against the risk of infection and transmission. Participants’ ideas on how to benefit from health institutions were taken, and muscle strength was measured in one participant. Then, the participants designed their own muscle-measuring devices, and all designed devices were tested.

Sixth Day

STEM in Nature - Design Transportation Vehicle: Theoretical knowledge about biomimicry was provided to the participants one day in advance. The activity worksheet, which they used during their observations in nature, was distributed to the participants. Information was obtained from the authorities about the nature park and the creatures found in Yer Köprü Waterfall. At the end of their trip, the participants created appropriate drawings for the vehicle they wanted to design by taking advantage of the characteristics of the living things in the nature park. They then designed the transportation vehicles with the materials provided to them. All groups presented the tools they designed, and an evaluation was conducted.

Data Analysis

The data analyses were conducted using the SPSS 24 software package. As the study group comprised less than 50 people, the Shapiro-Wilk test was used (Büyüköztürk et al., 2011). However, the normality test did not indicate a normal distribution. Besides, the skewness and kurtosis values were outside the range of +1.5/-1.5 (Tabachnick & Fidell, 2007). Therefore, changes in the group from the pre-test to the post-experiment were analyzed using the Wilcoxon Signed Rank Test, one of the non-parametric tests (Privitera, 2015; Wilcox, 2012). Qualitative data was analyzed using content analysis, as explained above.

Ethical Procedures

Ethical approval for the research was obtained from the Karamanoğlu Mehmetbey University Ethics Committee with the number 07-2022/187 and date 09.11.2022. After obtaining ethical approval, the participants were asked to sign a consent form indicating that they were voluntarily participating in the study.

Results

In this section, answers to the sub-questions under the main question: "In which direction did the STEM activities realized within the scope of the project contribute to the teachers?"

The following findings are in line with the first research sub-question, "Does STEM education conducted in OSLE influence teachers' STEM awareness?" The differences between the pre-test and post-test scores of the participants on the STEM Awareness Scale, both in general and its sub-dimensions, as a result of non-parametric analyses are given in Table 2.

Table 2

Wilcoxon Signed-Rank Test Results for The Participant Pre-Test and Post-Test STEM Awareness Scale

	Pre-test – Post-test	*n*	Mean Rank	Sum of Ranks	*Z*	*p*
Effect of Student	Negative Ranks	1	2.50	2.50	-3.29	.00*
	Positive Ranks	12	7.38	88.50		
	Ties	10				
Effect of Course	Negative Ranks	11	10.64	117.00	-3.64	.71
	Positive Ranks	11	12.36	136.00		
	Ties	1				
Effect of Teacher	Negative Ranks	7	9.50	66.50	-.107	.24
	Positive Ranks	12	10.29	123.50		
	Ties	4				
General	Negative Ranks	9	8.83	79.50	-1.67	.12
	Positive Ranks	13	13.35	173.50		
	Ties	1				

Table 2 shows that after attending the OSLE STEM activities (museum, science centre, playground, ruins, youth centre, research hospital), participants' STEM awareness increased. A significant increase was observed in favour of the "effect of student" sub-dimension (z=-3.29, p<.05). However, this difference was not significant across the scale and in other sub-dimensions. Participants' 21st-century skills were measured with the Multidimensional 21st Century Skills Scale. Result of non-parametric analyses are given in Table 3.

The following findings are in line with the second research sub-question, "Does STEM education conduct in OSLE influence teachers' 21st-century skills?"

Table 3

Wilcoxon Signed-Rank Test Results for The Participant Pre-Test and Post-Test Multidimensional 21st Century Skills Scale

	Pre-test – Post-test	*n*	Mean Rank	Sum of Ranks	*z*	*p*
Knowledge and technology literacy skills	Negative Ranks	4	11.88	47.50	-2.51	.01*
	Positive Ranks	18	11.42	205.50		
	Ties	1				
Critical thinking and problem-solving skills	Negative Ranks	14	9.75	136.50	-1.12	.23
	Positive Ranks	6	12.25	73.50		
	Ties	3				
Entrepreneurship and innovation skills	Negative Ranks	5	6.60	33.00	-2.69	.00*
	Positive Ranks	15	11.80	177.00		
	Ties	3				
Social responsibility and leadership skills	Negative Ranks	8	12.06	96.50	-.98	.32
	Positive Ranks	14	11.18	156.50		
	Ties	1				
Career consciousness	Negative Ranks	6	10.67	64.00	-.94	.34
	Positive Ranks	12	8.92	107.00		
	Ties	5				

Statistically significant differences were observed on the "Multidimensional 21st Century Skills Scale". The difference was observed in sub-dimensions of "Knowledge and Technology Literacy Skills" (z=-2.51, p<.01) and "Entrepreneurship and Innovation Skills" from the (z=-2.69, p<.05) as shown in Table 3. The difference in scores in favour of positive ranks in these sub-dimensions shows that the activities carried out within the scope of the science camp have a significant effect on the Multidimensional 21st Century skills of teachers, specifically Knowledge and Technology Literacy Skills and Entrepreneurship and Innovation Skills. No statistically significant difference was found in the sub-dimensions of Critical Thinking and Problem-Solving Skills, Social

Responsibility and Leadership Skills, and Career Consciousness In order to investigate the underlying reasons for the quantitative findings, interviews were conducted with the participants to answer the third problem (What are the participants' opinions on how STEM education contributes to them in out-of-school learning environments?) of the research. The interviews were coded openly, and five themes emerged: Most effective and least effective activities, efficacy in teaching practice, creating awareness, and contributing to STEM disciplines. These themes are represented in Table 4, Table 5, Table 6, and Table 7 below.

Table 4

The Activities That the Participants Found the Most and Least Effective to Them in the Research

Main Themes	Answers	Codes
Ruins	It contributed a lot (19)	* Technology use (11) *Exploring different programs (9) *Bringing different disciplines together (5)
	It contributed little (4)	*Insufficient internet (3) * Transport (1)
Coding Workshop	It contributed a lot (15)	*Using technology (10) *Exploring different programs (10)
	It contributed little (8)	*Low readiness (6) *Mixed (4)
Science Centre	It contributed a lot (20)	*Using technology (10) *Using different materials (9) *Creativity development (8) *Dexterity (4)
	It contributed little (2)	* Inadequate in self-education (1)
	No response (1)	
Children play area	It contributed a lot (18)	* Opportunity to develop yourself (10) *Imagination development (10) *Development of dexterity (8) *Ensuring seeing (2) *Using technology (1)
	It contributed little (3)	*STEM was not complete (1) *Materials were insufficient (1)
	No response (2)	

Muscle Lab	It contributed a lot (15)	*Using technology (9) *Development of dexterity (5)
	It contributed little (5)	*Use of simple materials (5) * STEM was not complete (4)
	No response (3)	
Museum	It contributed a lot (20)	*Creativity (12) *The importance of group work (4) *Integrating different disciplines (4) *Craft development (4)
	It contributed little (3)	*The setting was not suitable for STEM (2) * More complex problem could be solved (1)
Nature Park	It contributed a lot (18)	*Creative feature (8) *Dexterity (5) *Imagination (4)
	It contributed little (3)	*Using technology (3)
	No response (2)	*Environment compelling (2)

The activities that teachers find most effective, ruins, science centre, and museum, respectively, are shown in Table 4. Teachers benefited from these activities mostly in terms of using technology (21), exploring different programs (19), creativity (20), integrating different disciplines (9), and developing fine motor skills (8). T20 said, “I learned how to construct simple machines with the STEM activity in the museum, my creativity improved,” while T5 asserted that “STEM education and modelling work in archaeological sites impressed me a lot, I learned a lot of technology” again T8 stated “Of the activities, the science centre impressed me the most and inspired me how the disciplines came together. It has opened up new horizons for the future.” Several ancient civilizations have been founded and collapsed in Anatolia. As such, around 150 ruins can be found all over Turkey, but there is a dearth of studies focusing on using those ruins for educational purposes. Besides, all provinces and surrounding towns have lots of museums. Although museum education has been popular for a couple of decades, it is also rare in Turkey. Teachers mostly expressed that the activities held in ruins and museums improve their creativity and use of technology skills. These findings were also supported by STEM awareness and 21st-century skills scale findings.

Table 5

Opinions of the Participants of the Research on Which Direction They Develop More within the Scope of the Teaching Profession

Main Themes	Answers	Codes
Student training	It was helpful (22)	*Technology use (8)
		* Doing different activities (6)
		* Variety of out of school environments (6)
	No response (1)	* STEM approach (5)
Professional development		*Using technology (10)
	Has a positive contribution (23)	*Exploring different programs (8)
		*Current topics (6)
		*Imagination (4)
		*Crafts (4)
		*Using technology (9)
	It was helpful (21)	*Using different materials (9)
Course		*Content enrichment (6)
		*Different approaches (4)
		*Preparing lesson plan (4)
	No response (2)	

Teachers stated that the science camp contributed to their professional development and teaching as well as beneficial to students (Table 5). They reported that their acquisitions in using technology (8), doing different activities (6), experiencing a variety of out-of-school environments (6), and implementing a STEM approach (5) will contribute to their teaching under the theme of raising students. They further stated that acquisitions such as using technology (10), exploring different programs (8) and current topics (6), imagination (4), and hands-on trainig (4) will improve their professional development. Again, they stated that acquisitions such as using technology (9), using different materials (9), enriching the content (6), different approaches (4), and preparing a lesson plan (4) would positively contribute to their teaching under the course theme. T1 exemplified the issue as "The technological tools and materials we use in the science camp will allow us to use them with our students," T3 said, "We learned that there are different out-of-school environments in the science camp. I will conduct similar activities with my students when I return to my school." Again, T10 stated, "I will use the materials such as the lesson plans and worksheets that we used in the activities in the science camp," and T2 expressed his improvements by reporting, "The products we developed in the science camp increased my hand skills and imagination. I feel like a different teacher." The activities were all practical, and teachers engaged in group work to design a product; they asserted that their learning was efficient, permanent, and transferrable to their teaching. Teachers expressed that their acquisition of knowledge and skills throughout the science camp would support their students' craft, analytical thinking, motivation, problem-solving skills, and self-esteem, which also appeared in STEM awareness scale findings.

Table 6

Opinions of the Participants on Which Discipline that Compose STEM Has More Influence in the Science Camp

Main Themes	Answers	Codes
STEM	Quite effective (23)	Science (7), Technology (20), Engineering (15), Mathematics (5)

Participating teachers stated that the science camp is most effective in STEM disciplines, specifically Technology (20), Engineering (15), Science (7), and Mathematics (5) (Table 6). T7 summarized her gains in STEM disciplines during the science camp, stating, "We used technology and design disciplines more in the science camp, which made me feel its effect more." Similarly, T5 said, "In general, technology and programs affected us more in the science camp," and T1 said, "I think we used science more; it was at the core of all activities."

Table 7

Opinions of the Participants on Which Direction Their Awareness Increased Most with the Science Camp

Main Themes	Answers	Codes
STEM	Increased (22)	What is STEM (12) Gathering disciplines together (7) Designed based approach (6)
	No response (1)	
Out of School	Increased (22)	Out of school (16) Different activity in out of school (10)
	No response (1)	
Team Work	Increased (21)	Importance of working together (14) Group work (9)
	No response (2)	
Imagination	Increased (20)	Creativity (10) Designing by imagination (10) Multidimensional thinking (5)
	No response (3)	

Table 7 represents an increase in teacher awareness in four main areas during the science camp. Teachers stated that they now comprehend STEM better (12), can bring disciplines together (7), learned a design-based approach under the STEM theme (6), and became aware of out-of-school environments (16) and different out-of-class activities (10). Besides, they understood the importance of working together (14) and the significance of doing activities with the group (9). Finally, under the main theme of Imagination, teachers stated that they became more aware of the skills of creativity (10), designing by imagination (10), and multidimensional thinking (5). T4 said, "I realized what STEM is, especially with the science camp." T17 added, "I realized how important it is to have the imagination to make design." T20 said, "I became aware of out-of-school environments during the science camp."

Participating teachers came from all over the country. Although their outdoor environments, facilities, and opportunities in their hometown would be different, they basically experienced and learned how to integrate STEM and 21st-century skills in an out-of-school environment. Out-of-school experiences, especially the mentioned subject, are not common in Turkey. Therefore, teachers emphasized that the knowledge and skills that they gained through the science camp would enrich their students learning.

Discussion

In recent years, it has been accepted that the STEM approach has a positive effect on the development of individuals' scientific process skills in activities such as nature education, science festivals, and science schools. The STEM approach also has a positive effect on students' perspectives on science, the nature of science, and their attitudes towards science and science laboratory courses (Balım et al., 2013; Çelik, 2012; Çevik & Abdioğlu, 2018; Markowitz, 2004). This current study aims to identify the effective use of out-of-school environments for STEM education.

The findings of this study are consistent with previous findings that out-of-school STEM activities increase teachers' STEM awareness. Teachers' STEM awareness is statistically significant in favour of the "effect on students" sub-dimension. Yet, this difference was not significant in the course and teachers' sub-dimensions. Within the scope of the research, it can be concluded that the activities carried out significantly increased teachers' STEM awareness. Quantitative findings were supported by qualitative results that teachers reported that their STEM awareness particularly increased in students, lessons, and teaching content (Aslan-Tutak et al., 2017; Karısan et al., 2019). The effect of STEM activities carried out in OSLE may be higher as OSLE provides enthusiasm for learning, hands-on experiences, richness of stimulus, and a real-world context (Akaygün et al., 2015).

After attending the STEM activities in OSLE, the 21st-century skills of the participating teachers increased, and this was observed more in the Entrepreneurship and Innovation Skills and Critical Thinking and Problem-Solving Skills sub-dimensions. No significant difference was found in Critical Thinking and Problem-Solving Skills, Social Responsibility and Leadership Skills, and Career Consciousness sub-dimensions. These findings are also supported by the findings of the qualitative aspect of study. Teachers reported that they became more enthusiastic about solving problems and interested in developing solutions to make life easier. They also stated that they approached people with different personalities more positively, did not avoid solving the difficult problems they encountered, and did not accept the information they learned as it was but accepted it after evaluating it with a critical approach. These findings support the hypothesis of the study as the STEM approach provides interdisciplinary integration and contributes to the development of individuals' innovative problem-solving skills (Roberts, 2012; Schnittka, et al., 2010; Şahin, et al., 2014). Studies have revealed that STEM education helps teachers improve their 21st-century skills (Cunningham & Kelly, 2017; Sullivan, 2008). This study is also consistent with the literature in this aspect since participating teachers contribute to 21st-century skills as they are involved in hands-on activities in OSLE, which offer more stimulus, materials, and phenomena than they can see inside the classroom. Therefore, teachers also reported that they sometimes faced some difficulties during the STEM activities. They stated that they were limited by factors such as lack of internet and some infrastructure deficiencies. Similarly, Thomas (2010), Koosimile (2004), Oriaon et al. (1997), and Tatar and Bağrıyanık (2012) also reported that teachers face similar challenges in out-of-school settings.

Qualitative findings of the study revealed that participating teachers mostly benefited from the historic site, science centre, and museum. Also, their use of technology, discovery of different programs, creativity, integration of different disciplines, and hand skills improved during science camp. Science centers and museums help individuals understand the nature of science by developing their questioning skills (Kubat, 2018). Science education in science museums provides permanent learning and supports classroom learning (Martin, 2004). Ruins, science centres, and museums offer several interesting stimuli for STEM education; this is why teachers stated that they included these out-of-school environments. They used technology more on these sites as they made several measurements with different tools and applied their measurement to both virtual and hands-on designs.

Teachers asserted that the science camp contributed to the themes of being more beneficial to the students in the context of professional competence, professional development, and teaching. Under the main theme of raising students, teachers believe that their acquisitions, such as using technology, doing different activities, incorporating diversity of out-of-school environments, and using the STEM approach, will contribute to educating their students. Under the theme of professional development, they stated that their use of technology, discovering different programs, current issues, imagination, and hand skills improve professionally. Under the lesson theme, they stated that the acquisitions, such as the use of technology, using different materials, enriching the content, using different approaches, and preparing a lesson plan, will contribute positively to the teaching they give in their schools. The findings support Bakırcı and Kutlu's (2018) findings that the STEM approach will increase students' interest and motivation towards the lesson, enable them to think multi-dimensionally, develop their research-inquiry and creativity skills, design products suitable for the problem situation, learn by embodying the subjects, and develop their scientific process skills.

The teachers reported they were influenced by STEM disciplines in descending order: technology, engineering, science, and mathematics. Teachers are believed to be significantly influenced by technological tools and engineering, as they see technological tools (laser meter, muscle measuring device, wireless projection, etc.) that they have never seen before in these environments and make designs like an engineer inspired by these tools. Moreover, compared to other disciplines, technology, and engineering are more popular in media; thus, teachers might be more focused on these disciplines. Similarly, as stated in the literature (Sungur Gül & Marulcu, 2014; Wang 2012), the use of technological tools and equipment by teachers motivates them more to STEM activities, especially in engineering fields.

Teachers' awareness increased in four main areas during the science camp. Teachers stated that they comprehend STEM better, bring disciplines together, and learn a design-based approach under the STEM themes. They also became aware of the out-of-school environments and different out-of-class activities. Besides, they understood the importance of working together and doing activities with the group. Finally, under the main theme of Imagination, teachers stated that they became more aware of the skills of creativity, designing by imagination, and multidimensional thinking. Teachers comprehend how to do STEM activities in out-of-school environments while they come together to design and create a product as a group. It is emphasized that critical thinking, problem-solving skills, being creative, and working collaboratively are among the 21st century skills (Akgündüz et al. 2015).

STEM education in OSLE enables people to take responsibility through teamwork, experience communication with colleagues, and observe how science works by doing their own experiments (The Parliamentary Office of Science and Technology [POST], 2011). To sum up, both quantitative and qualitative findings of the research revealed that STEM was an ambiguous concept for teachers before they attended the project. With the help of the theoretical and practical activities during the project, teachers gained a thorough understanding of the STEM approach. Consequently, teachers' STEM awareness and 21st-century skills improved.

Conclusion

Participating teachers' knowledge, experiences, and skills in applying STEM and 21st-century skills in out-of-school environments seemed to be limited due to the lack of sufficient pre-service and in-service training regardless of their major. Therefore, such training should be improved in order to provide better experiences for middle school students. One way to improve middle school teachers' out-of-school environment practices concentrated on STEM and 21st Century Skills would be to provide them with hands-on activities, such as those presented in this study. Activity books, online activity pools, and more science camps enable teachers to use out-of-school environments more effectively.

Implications

STEM activities in OSLE increase people's awareness of STEM and 21st-century skills. Therefore, it is recommended that educators organize more STEM activities in these environments. Enriched activities should be planned so that people can benefit more from STEM activities in OSLE. STEM activities that take place in OSLE should be carried out collaboratively as much as possible. It is observed in this study that teachers were not aware of the usefulness of ruins, museums, and youth centres, which are readily available in all the cities in Turkey.

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Büşra Bakioğlu and Zeynep Temiz are responsible for the introduction, discussion and conclusion sections. Mustafa Çevik is responsible for the method, findings and data analysis section. All authors participated in writing and critical review.

Conflicts of Interest

The authors have no competing interests to declare that are relevant to the content of this article.

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