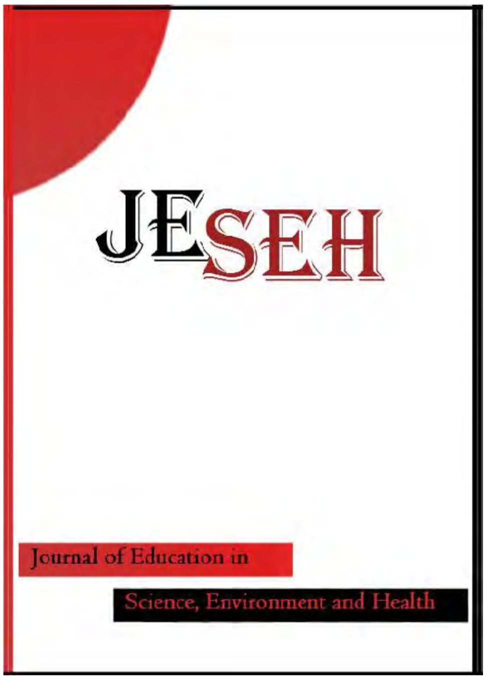

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Effects of STEM Activities in Nature on Students' Environmental Attitudes, STEM Career Interests, and Engineering Perceptions

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Abstract

This study aimed to determine the effects of STEM Activities in Nature on students' environmental attitudes, STEM career interests, and engineering perceptions. In the research, the qualitative method is embedded in the quantitative method in an embedded mixed design. The quantitative dimension of the research was based on a quasi-experimental design with the pretest-posttest control group, and the qualitative dimension was based on a case study. The sample of the study consists of 74 seventh grade students from a moderate socio-economic level secondary school. In the study, STEM activities in the experimental group were carried out 2 hours a week for an 11-week period. In the control group, the activities were carried out in line with the Turkish Ministry of National Education's science applications course curriculum. According to the results of the research, STEM Activities in Nature in the experimental group positively affected students' environmental attitudes and STEM career interests. The activities improved students' engineering perceptions.

Introduction

In the face of the social, economic, cultural, and political problems of the world in global competition, the qualities of qualified individuals appear as the 21st-century skills (National Research Council [NRC], 2009; 2011). Partnership for 21st Century Learning [P21] (2009) classified 21st-century skills as follows: Learning and innovation skills (4C) (creativity, collaboration, critical thinking, and problem-solving); Information, media, and technology skills (information literacy, media literacy, and technology literacy); and, Life and career skills (resilience, assertiveness, adaptability, self-directedness, productivity, responsibility, social and intercultural skills, leadership). The desire to teach these skills has brought about the emergence of different educational approaches. In the 21st century, an education model in which different disciplines are integrated in order to realize well-equipped learning in terms of quality and content has been advocated (Aranda et al., 2019; Bybee, 2013; English, 2015).

STEM education is an education model based on a holistic approach that emerged with the cooperation of multiple disciplines such as science, engineering, technology, and mathematics (Bybee, 2010; Erdogan et al., 2017; Savran Gencer et al., 2019). The concept of STEM was first defined by the US National Science Foundation as an abbreviation of science, technology, engineering, and mathematics disciplines (Breiner et al., 2012). The International Association of Technology and Engineering Educators (ITEEA) defines STEM as a new interdisciplinary course in schools that combines the disciplines of science, technology, engineering, and mathematics in a single field (Mitts, 2016). The purpose of STEM education is to increase the skilled workforce and scientific literacy in STEM fields (NRC, 2011). Such endeavors aim to create a workforce of STEM literate individuals, to make innovations that will create an economic advantage for countries, and to be competent in business fields of the future (Thomas, 2014). For example, the need for STEM-related professions in the USA has doubled in 5 years, and it has been emphasized that students should be encouraged to choose STEM fields in order to meet this need in the field of engineering and science, where the number of people trained in this field can only meet half of the demand (Dave et al., 2010). An individual's level of knowledge about STEM directly affects their attitude towards pursuing a career in STEM fields in the future. It is more probable that a student who does not have sufficient knowledge will not choose a career in the STEM field. If students do not have knowledge about STEM, their interest in making a career in STEM will decrease and this will negatively affect their willingness to participate in activities that serve to increase STEM career knowledge and awareness (Blotnicky et al., 2018).

One of the STEM career fields is engineering. Engineering is defined as the process of designing the man-made world within the framework of science and engineering literacy prepared by the National Assessment of

Educational Progress (NAEP, 2014). For effective STEM education and to increase students' professional awareness, students' perceptions of engineers and engineering should be identified and educational settings should be tailored to the current context in real life. It has been observed that students' engineering perceptions affect their career choices (Chan et al., 2019). Students misconceive engineering as equipment repair and assembly, and engineers as people who work outdoors and do heavy work (English et al, 2011; Fralick et al., 2009; Liu & Chiang, 2019). Many studies have shown that engineering is perceived as men's work (Cunningham et al., 2005; Karataş et al, 2011; Koyunlu Ünlü & Dökme, 2017). Applied interdisciplinary education improves students' engineering perceptions (Hammack et al., 2015; Kuvaç, 2108; Oware et al., 2007; Lyons & Thompson, 2010). Engineers benefit from the engineering design process when reaching the best design in the face of a problem (Katehi et al., 2009). The engineering design process is defined in three stages, namely, define, design and optimize (Next Generation Science Standards [NGSS], 2013). The engineering design process brings together STEM disciplines as it requires the use of basic engineering knowledge and skills, as well as science and mathematics disciplines (Cantrell et al., 2006; Householder & Hailey, 2012; National Academy of Engineering [NAE] & National Research Council [NRC], 2009). In STEM Education, out-of-school learning environments can be used to bring the disciplines together and to realize an effective learning/teaching process.

Out-of-school learning is experiences that enable the realization of in-curricular and extra-curricular learning outside the school environment. It is student-centered learning that is structured with events and facts from the life and provided by interacting with primary sources (Department for Education and Skills [DfES]), 2006; Resnick, 1987). Students spend most of their daily lives outside of school (Eshach, 2007). In addition, it is thought that students can learn in these environments at their own learning pace and according to their individual differences (Melber & Abraham, 1999), and the use of out-of-school learning environments in a formal instructional design can increase the quality of learning and teaching processes. Furthermore, since STEM education aims to solve real-life problems for students (Burghardt & Hacker, 2004; Moore et al., 2014; Sevian et al., 2018), it is thought that out-of-school environments can provide opportunities for real-life problems for students, while at the same time, they can be used to integrate STEM disciplines into the teaching process. In addition, one of the 21st century interdisciplinary themes is environmental literacy (P21, 2009). STEM Activities in Nature can contribute to students' environmental literacy. In this research, environmental attitude was included in the research as a variable and it was also aimed to determine the effects of STEM activities taking place in nature on environmental attitude. Buldur et al. (2018) investigated the effect of an interdisciplinary nature education on environmental awareness, and they concluded that the nature education project reached the targeted levels in terms of environmental affective characteristics of the participants. Çalışıcı and Benzer (2021) stated that STEM practices they carried out with 8th-grade students positively affected the environmental attitudes of the students.

When STEM activities carried out in out-of-school environments are examined in the literature, Naizer et al. (2014) reported that, as a result of a summer STEM program in a group of secondary school students studying in the countryside, students' interest in mathematics, technology and problem-solving increased and the gap between male and female students in favor of males was closed. Şahin et al. (2014) reached the following results in realizing the goals set within the scope of STEM-related after-school program activities: collaborative group work is important; these activities increase students' interest in STEM disciplines; and, they encourage people to choose science and engineering disciplines in their future careers. Dabney et al. (2012) investigated the relationship between out-of-school science activities and majoring in STEM fields in university students. The results of the research revealed that participation in out-of-school science activities was as effective as gender and interest in science and mathematics in secondary school in majoring in STEM fields. According to Weber (2011), informal STEM education carried out in a natural environment with students' own experiences is extremely important in the development of STEM knowledge and interests of especially female students in STEM fields. Kong, et al. (2014) investigated the relationship between participation in science summer camps over two years and students' probability of choosing science and engineering professions. They revealed that students who attended the summer camp were more likely to choose a profession in science and engineering in the future than those who did not attend the summer camp. Baran et al. (2016) organized combined out-of-school STEM activities and investigated the participants' perceptions of these activities and reported that the students acquired meaningful knowledge about technology and computers via the activities; they developed skills; they would use the activities in the future; and they were able to offer suggestions about the activities. Dieker et al. (2012) revealed that STEM summer camps steered high school students with low socioeconomic status but were talented in STEM fields to STEM vocational fields. Dubetz and Wilson (2013) concluded that the activities implemented in the girls in engineering, mathematics, and science project provided students with additional learning experiences and increased their interest in STEM.

Research shows that well-designed out-of-school learning environments increase students' interest in STEM and their chances of pursuing a career in STEM. Out-of-school activities improve students' STEM competencies and increase their interest in STEM (Kitchen et al., 2018). The literature on the effectiveness of STEM instructional designs is increasing, but there are fewer STEM studies in out-of-school settings.

Purpose of the research:

This study aimed to determine the effects of STEM Activities in Nature on the environmental attitudes, STEM career interests, and engineering perceptions of seventh grade students. For this purpose, answers to the following questions were sought:

Is there a significant difference between the environmental attitudes of the experiment and control groups?
Is there a significant difference between the STEM career interests of the experiment and control groups?
Is there a significant difference between the STEM career interests of the experiment and control groups in relation with gender before and after the intervention?
What are the engineering perceptions of the experiment and control groups before and after the intervention?

Method

Research Design

In this research, an embedded mixed-method design, in which qualitative research is embedded into quantitative research, was used (Creswell et al., 2011). The pretest-posttest quasi-experimental research model was used as the quantitative method. The qualitative method was based on a case study. First, quantitative data were obtained and analyzed. Then, interviews were conducted with the participants selected from the experimental group in order to investigate the results in more depth. A program based on STEM Activities in Nature was applied in the experimental group for 2 hours a week for 11 weeks. In the control group, the students carried out activities and applications within the scope of the Science applications course curriculum guided by Turkish Ministry of National Education (MoNE, 2018). The research design and process are shown in Figure 1.

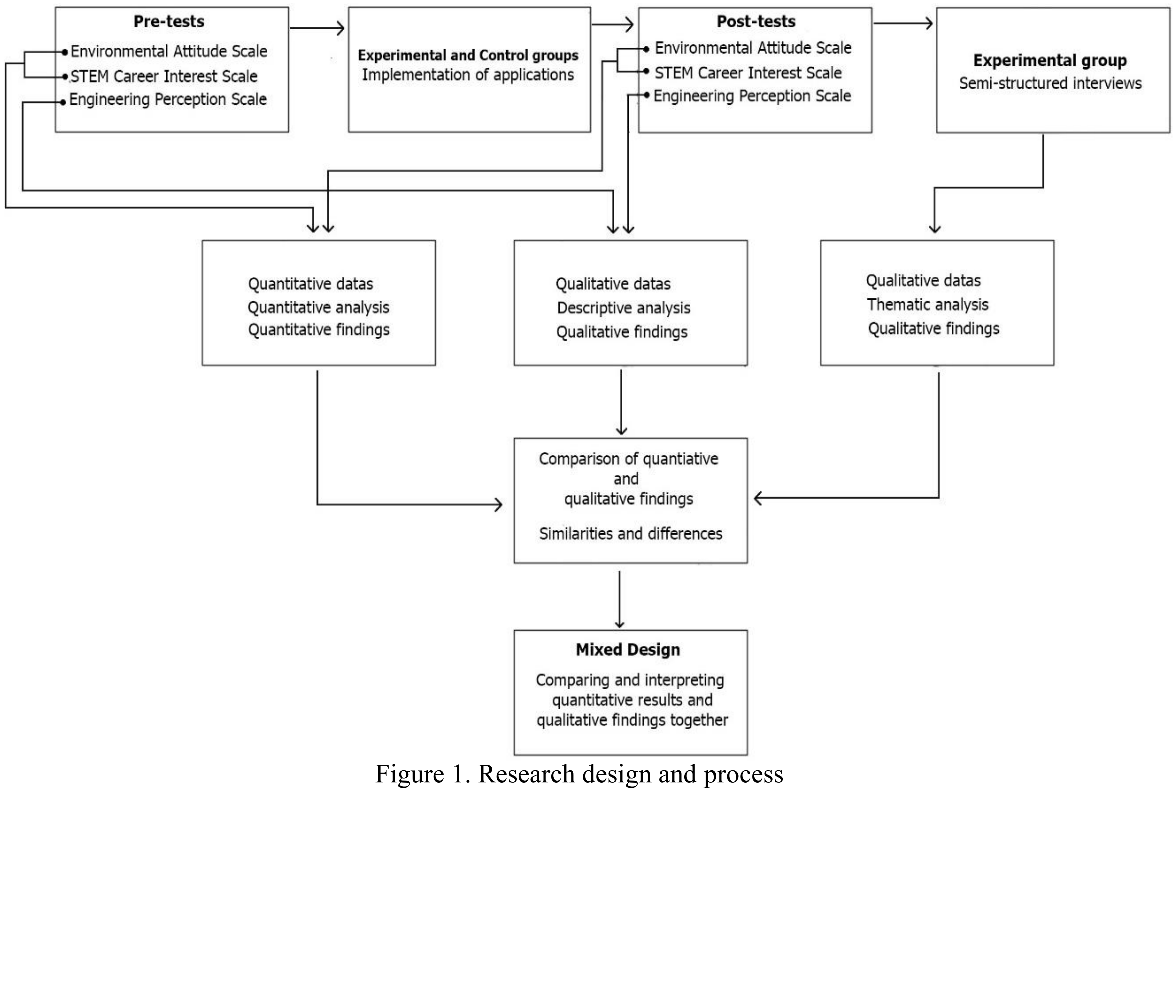

Figure 1. Research design and process

Study Group

Two classes were selected out of four classes of students who chose the science applications course in a secondary school located in a moderate socioeconomic region ın Turkey. Seventy-four students from these two classes formed the study group. One of the two classes was randomly selected as the experimental group and the other as the control group. Experimental and control group students were compared in terms of their academic success in science and mathematics in previous years, and there was no significant difference. Students in the groups were similar in terms of socioeconomic level, parental education level, academic achievement, and access to technological tools. The experimental group consisted of 28 girls and 10 boys, and the control group consisted of 20 girls and 16 boys. Semi-structured interviews after the experimental application were conducted with nine students from the experimental group. These students were selected on a voluntary basis from students who were high- and medium-levels from the posttest STEM career interest and Environmental Attitude scales according to the criterion sampling method. Six of the students were female and three were male.

Developing and Implementing STEM Activities

STEM activities were out-of-school-based and were developed to provide students with an experience in nature. The relevant literature was used in the development of the activities. Environmental awareness and human-environment interaction were taken into account. In the design of the activities, it was aimed to integrate STEM disciplines based on a problem or a need. Each activity was held outside of school. Three activities were performed as a STEM camp in nature. Students worked in groups of four or five.

Table 1. STEM activities and their relationships with STEM disciplines

STEM activities in nature	Science	Technology	Engineering	Mathematics
1-Let' s build our bridge in the nature 	Finding the center of gravity/ effects of force on objects	Making products using different techniques and materials	Designing a durable bridge	Dimensions of a bridge/measuremen t of force
2-Let' s build the tallest stone tower 	Friction force and effect of gravity	Creating products using different techniques	Designing a tower that is resistant to external factors	Calculating the dimensions of the tower and determining the placement angles of the stones
3-Let' s design a shelter for stray animals 	Balanced forces, thermal insulation	Creating an ideal shelter using suitable materials	Making an ideal design by considering many factors	Temperature measurements, geometric measurements
4- Let' s create an ant ecosystem and examine it 	The importance of biodiversity/needs of living things	Determining the method and material for an ant farm	Designing an ant farm	Measuring Dimensions calculation

5-Let' s design the best parachute 	Air resistance/friction force/gravity	Choosing the material for a parachute	Designing a parachute	Measurement of the dimensions of a parachute; Calculating airtime
6- Let' s design a treehouse 	Simple machines/Net force	Experimental selection of suitable materials	Treehouse design	Measurement of materials/calculation of joining angles
7- Let' s make our own pinwheel 	Energy production-saving resources	Determining the shape of the wing and determining the way it is created	Designing a pinwheel	Dimensions of the model and calculation of rotational speed
8- One-day STEM camp in a tent 	Human environment interaction/Balanced forces	Materials, techniques, and tools used during tent setup	Tent design	Calculation of tent dimensions (rope-slope-height, etc.)
9- Let' s observe the sky with our own telescopes (STEM camp) 	Lens/Features of celestial bodies	Selection of lenses and materials for the telescope	Designing a telescope	Calculating the dimensions of lenses and the tripod
10-Let' s design the best swing model.(STEM camp) 	Energy Conversion/gravity/friction force	Selection, testing, and identifying materials	Swing design	Calculating energy conversion; calculating the height-velocity relationship; calculation of oscillation period and aspect-to-mass ratios
11-Let' s produce our own vegetables with organic farming 	Required conditions for plants/photosynthesis	Determining the needs for organic farming/Selecting tools to be used	Determination and implementation of the irrigation system of the organic farm garden	Preparing the growth charts of the grown plants over time-calculating the distance between the seedlings-calculating the amount of fertilizer per seedling

In the applications, the engineering design process was utilized, which is defined as the identification of the problem or need, development of possible solutions, finding the optimal solution, prototyping and testing, and communication skills and sharing. First of all, the students determined the design criteria for the solution of the problem and conducted research about the design by asking questions. Second, they brainstormed possible solutions. They drafted reports and created prototypes for the proposed solutions, conducted group work, and used experimental data. Third, the students made a decision by making a profit-and-loss analysis and presenting the most appropriate solution and justifications for the best solution. Fourth, they tested the prototypes via appropriate methods, evaluated the prototype according to the test results, and finalized it. They made improvements and redesigned. Finally, students presented the final design, tested it, and modified it for optimization.

In the research, STEM applications in nature were carried out for 11 weeks and 2 hours a week in the experimental group. An implementation plan was prepared for each activity. In the control group, it was carried out in line with the Science Application course curriculum. Table 1 presents the list of STEM activities and their relationships with STEM disciplines.

Data Collection Tools

The Environmental Attitude Scale, the STEM Career Interest Scale, the Engineering Perception Questionnaire, and semi-structured interviews were used as data collection tools in the research.

Environmental Attitude Scale

The Environmental Attitude Scale developed by Özata Yücel and Özkan (2014) was used to determine the environmental attitudes of the students. The 5-point Likert-type scale consists of 35 items and two sub-dimensions. The first 14 items constitute the behavioral dimension of the scale, and the last 21 items form the emotion, thought, and willingness to take action dimension. The Cronbach’s alpha internal reliability coefficient of the scale was calculated as 0.88 by Özata Yücel and Özkan (2014). In this study, it was calculated as .86.

STEM Career Interest Scale

The STEM Career Interest Scale developed by Kier et al. (2013) and adapted into Turkish by Bilen et al. (2015) was used to determine students' career interests in STEM (for professions in the fields of science, technology, mathematics and engineering). The scale consists of 44 items and four sub-dimensions (Science, Technology, Mathematics, and Engineering). There are 11 items in each sub-dimension of the scale. The scale is in the form of a 5-point Likert scale, where answers are: strongly agree, agree, undecided, disagree, and strongly disagree. In the adaptation process of the scale, it was stated that the reliability coefficients in the sub-dimensions ranged from .84 to .88. The reliability coefficients in this study were calculated between .80 and .86 in the sub-dimensions.

Engineering Perception Questionnaire

It is a measurement tool created to determine the engineering perceptions of students by examining the literature and consists of these questions: What is engineering? What does an engineer do? Explain by a drawing. Students were asked to answer the questions on an A4 paper. After their answers, the students were asked these questions so that the data was clear: what is the gender of the engineer in their drawings? Where are they currently working? What type of engineer is it? The Questionnaire was applied as a pre-test and post-test.

Semi-structured interviews

For the qualitative exploratory phase after the experimental process, interviews were conducted with students who scored moderate or high on the STEM Career Interest Scale and the Environmental Attitude Scale, using the criterion sampling method. With semi-structured interviews, it was aimed to reveal students' experiences, thoughts, and feelings about STEM Activities in Nature. For this purpose, a semi-structured interview form was created with five open-ended questions. In all of the questions, students were asked to elaborate more on their answers by using probe questions. The teacher's field notes and literature were used in the preparation of the questions. Interviews with students took between 4 minutes and 6 minutes and 35 seconds.

Data Analysis

Analysis of the Quantitative Data

A statistical software program was used in the analysis of the data. First, according to each sub-problem, a normality test was conducted to check whether the data showed normal distribution or not. Considering the number of samples and the numbers in the subgroups, an appropriate test of normality was applied. The Shapiro-Wilk test was considered appropriate when the number of subgroups was 30 or more, and the Kolmogorov-Smirnov test was considered appropriate when they were below 30. In addition, the skewness and kurtosis coefficients were examined, and when the skewness and kurtosis coefficients of the sub-dimensions ranged from +3 to -3, these sub-dimensions were considered to have conditions suitable for normal distribution parameters (Jondeau & Rockinger, 2003). One-way manova was not applied because the correlation values between dependent variables were lower than .80 (Field, 2013). In cases with normal distribution, t-test for independent samples and t-test for dependent samples were applied, and the Mann Whitney-U test was used in cases that did not show normal distribution. Effect size values in t-tests for independent samples were calculated using the $d = t\ x\ \sqrt{\frac{N1+N2}{N1\ x\ N2}}$ formula using the t value. It was calculated using the formula $d = \frac{t}{\sqrt{N}}$ for dependent samples. D effect size value is .80 for a large effect, .50 for a medium effect, and .20 for a small effect. In the Mann Whitney-u test applied in cases that did not show normal distribution, the effect size values were calculated with the $r=\frac{z}{\sqrt{N}}$ formula. Effect sizes were evaluated as .10 for a small effect, .30 for a medium effect, and 0.50 for a large effect (Green & Salkind, 2005).

Analysis of the Qualitative Data

Qualitative data obtained from the Engineering Perception Questionnaire were analyzed with the descriptive analysis method. A thematic analysis method was used in the analysis of the qualitative data obtained from the interviews. Thematic analysis is a strategy that enables the analysis of common points and similarities and differences between the data (Gibson & Brown, 2009). In this research, within the scope of the thematic analysis, firstly, a written transcript of the interview records of the students was prepared, and then all of these written documents were read and examined. Then, the interview records were re-examined and analyzed in order to generate the codes. The codes were evaluated together and categories were formed. Related themes were created by examining the categories, and the themes were named. Finally, the write-up was completed.

Validity and Reliability

Scales with established validity and reliability were used for quantitative data. In addition, internal reliability coefficients (Cronbach alpha values) were recalculated. In providing validity and reliability in qualitative data, in accordance with the qualitative methodology, credibility for internal validity, transferability for external validity, consistency for internal reliability, and confirmability for external reliability were found more appropriate (Yıldırım & Şimşek, 2016).

Persuasiveness: In the research, qualitative data were mainly collected after experimental applications in order to support the quantitative data in the research, and data diversity was provided in this way. Semi-structured interviews were conducted by the researcher who carried out the research practices. The researcher has been teaching these students science courses for two years. For this reason, it was thought that long-term interaction with the students before the interviews would enable the students to give sincere answers. Efforts were made to ensure that the interviews were conducted in a friendly atmosphere. The researcher aimed to reveal the connections between them by constantly comparing the results with each other. In order to diversify the data sources, interviews were conducted with both male and female students, and for a similar purpose, interviews were conducted with students with different levels of quantitative scores. The researcher sought expert support regarding the entire qualitative process, and the researcher's approach in this process was evaluated and he received feedback. The written transcripts of the data obtained in the interviews were examined with the students and they were confirmed.

Transferability: It was ensured that the qualitative data were transferred by adhering to their nature without adding comments, and they were described in detail by reference to direct quotations from the interviews. The students who will be interviewed were determined according to the purposeful criterion sampling. Receiving a medium or high scores from the STEM Career Interest Scale and the Environmental Attitude Scale was the only criterion. In this way, it was aimed to obtain more in-depth information.

Consistency: A similar approach was followed in all processes of qualitative research, such as preparing the interview questions, conducting the interviews, and analyzing the data obtained, and it was tried to establish the relationship between the data and the results.

Confirmability: It was ensured that the data, coding, and reports were recorded in a way that would enable the comparison of the results with the raw data.

Findings

Quantitative Findings

Quantitative findings on the effects of STEM Activities in Nature on students' environmental attitudes and STEM career interests are included.

The Effect of STEM Activities in Nature on Environmental Attitude

It was aimed to determine whether there was a significant difference between the environmental attitudes of the experimental and control groups. First, it was determined that the data showed normal distribution in subgroups according to the Kolmogorov-Smirnov test results ($p>.05$), and a t-test was applied for independent groups based on pre-test and post-test data. Analysis results are presented in Table 2.

Table 2. Environmental attitude scale independent t-test results

Tests	Environmental attitude and sub-dimensions	Groups	*N*	*X*	*S*	*SD*	*t*	*p*
Pre-test	Environmental Attitude	Experimental	38	3.69	.45	72	-.81	.89
		Control	36	3.77	.40			
	Behavior	Experimental	38	3.47	.57	72	-1.38	.17
		Control	36	3.46	.52			
	Emotion-Thought Willingness to take action	Experimental	38	3.83	.48	72	.13	.41
		Control	36	3.98	.41			
Post-test	Environmental Attitude	Experimental	38	3.99	.34	72	2.21	.030*
		Control	36	3.76	.51			
	Behavior	Experimental	38	3.80	.40	72	2.03	.046*
		Control	36	3.56	.62			
	Emotion-Thought Willingness to take action	Experimental	38	4.11	.44	72	1.74	.086
		Control	36	3.90	.58			

For the pre-test results, no significant difference was found between groups in terms of the environmental attitude and sub-dimension scores ($p>.05$). In the post-test results, a significant difference was found between groups in favor of the experimental group in environmental attitude scores (t (72) =2.21, $p<.05$). In the sub-dimensions, a significant difference was found in favor of the experimental group in the behavior dimension (t (72) =2.03, $p<.05$). It was determined that the effect sizes were moderate in both significant differences.

The Effect of STEM Activities in Nature on STEM Career Interest

Pre-test and post-test independent t-test results related to STEM career interests are presented in Table 3.

Table 3. STEM career interest pre-test post-test independent t-test results

Tests	STEM career interest and sub-dimensions	Groups	N	X	S	SD	t	P
Pre-test	STEM Career Interest	Experimental	38	167.78	24.59967	72	-0.335	0.739
		Control	36	169.72	25.01498			
	Science	Experimental	38	44.02	7.56767	72	-1.214	0.229
		Control	36	45.88	5.38133			
	Technology	Experimental	38	42.10	6.78149	72	-0.263	0.793
		Control	36	42.52	7.03658			
	Engineering	Experimental	38	39.15	7.90664	72	0.010	0.993
		Control	36	39.13	7.96834			
	Mathematics	Experimental	38	42.50	7.57931	72	0.171	0.865
		Control	36	42.16	9.15735			
Post-test	STEM Career Interest	Experimental	38	180.2368	21.73605	72	2.108	.038*
		Control	36	168.9722	24.20919			
	Science	Experimental	38	46.6842	5.80356	72	0.838	.405
		Control	36	45.4722	6.62673			
	Technology	Experimental	38	44.7632	7.12223	72	2.033	.046*
		Control	36	41.5000	6.66119			
	Engineering	Experimental	38	44.5526	8.08969	72	2.475	.016*
		Control	36	39.5556	9.26574			
	Mathematics	Experimental	38	44.2368	7.55318	72	0.989	.326
		Control	36	42.5000	7.54983			

Table 4. Control group STEM career interest pre-test and post-test Mann-Whitney U test results

Tests	STEM career interest and sub-dimensions	Gender	N	Rank mean	Rank sum	U	P
Pre-test	STEM Career Interest (Pre-test)	Female	20	14.98	299.50	89.50	.025*
		Male	16	22.91	366.50		
	Science (Pre-test)	Female	20	17.48	349.50	139.500	.513
		Male	16	19.78	316.50		
	Technology (Pre-test)	Female	20	14.33	286.50	76.50	.008*
		Male	16	23.72	379.50		
	Engineering (Pre-test)	Female	20	14.50	290.00	80.00	.011*
		Male	16	23.50	376.00		
	Mathematics (Pre-test)	Female	20	16.10	322.00	112.00	.126
		Male	16	21.50	344.00		
Post-test	STEM Career Interest (Post-test)	Female	20	13.90	278.00	68	.003*
		Male	16	24.25	388.00		
	Science (Post-test)	Female	20	16.53	330.50	120.550	.207
		Male	16	20.97	335.50		
	Technology (Post-test)	Female	20	13.93	278.50	68.500	.003*
		Male	16	24.22	387.50		
	Engineering (Post-test)	Female	20	13.88	277.50	67.500	.003*
		Male	16	24.28	388.50		
	Mathematics (Post-test)	Female	20	15.85	317.00	107	.091
		Male	16	21.81	349.00		

According to the pre-test results, no significant difference was found between groups in terms of STEM career interests and sub-dimensions (p>.05). When the experimental and control groups were compared in terms of post-test STEM career interests, a significant difference was found between groups (t (72) =2.108 p<.05). While there was no significant difference between groups in the post-test in science and mathematics sub-dimensions, a significant difference was determined in the sub-dimensions of technology (t (72) =2.033 p<.05) and engineering (t (72) =2.475 p<.05). Effect size values were calculated as moderate in the STEM career interest and engineering sub-dimension, and small in the technology sub-dimension. The Mann-Whitney U-test results, which were conducted to determine whether there was a significant difference between the pre-test and post-test scores of the control group in relation with the gender variable of STEM career interests, are presented in Table 4.

In the control group, a significant difference was found between male and female students in both pre-test and post-test results in STEM career interest and technology and engineering sub-dimensions ($p<.05$). No significant difference was found in both pre-test and post-test sub-dimensions of science and mathematics ($p>.05$). The results of the Mann-Whitney U-test, which was conducted to determine whether there was a significant difference between the pre-test and post-test scores of STEM career interests in the experimental group in relation with the gender variable, are presented in Table 5.

Table 5. Experimental group STEM career interest pre-test and post-test Mann-Whitney U test results

Tests	STEM career interest and sub-dimensions	Gender	N	Rank mean	Rank total	U	P
Pre-test	STEM Career Interest (Pre-test)	Female	28	17.36	486.00	80.00	.047*
		Male	10	25.50	255.00		
	Science (Pre-test)	Female	28	18.64	522.00	116.00	.426
		Male	10	21.90	219.00		
	Technology (Pre-test)	Female	28	16.20	453.50	47.50	.002*
		Male	10	28.75	287.50		
	Engineering (Pre-test)	Female	28	17.27	483.50	77.50	.038*
		Male	10	25.75	257.50		
	Mathematics (Pre-test)	Female	28	18.45	516.50	110.50	.327
		Male	10	22.45	224.50		
Post-test	STEM Career Interest (Post-test)	Female	28	18.95	530.50	124.500	.607
		Male	10	21.05	210.50		
	Science (Post-test)	Female	28	18.66	522.50	116.500	.434
		Male	10	21.85	218.50		
	Technology (Post-test)	Female	28	17.73	496.50	90.500	.100
		Male	10	24.45	244.50		
	Engineering (Post-Test)	Female	28	19.66	550.50	135.000	.881
		Male	10	19.05	190.50		
	Mathematics (Post-Test)	Female	28	19.75	553.00	133.000	.816
		Male	10	18.80	188.00		

In the experimental group, a significant difference was found between male and female students in the STEM career interest pre-tests in favor of male students. A significant difference was found in favor of males in the sub-dimensions of Technology and Engineering ($p<.05$). There was no significant difference between male and female students in Science and Mathematics sub-dimensions ($p>.05$). In the post-test results of the experimental group, no significant difference was found between male and female students in STEM career interest and all sub-dimensions ($p>05$).

Qualitative Findings

Qualitative findings obtained from the engineering perception Questionnaire and semi-structured interviews are included. The codes created by analyzing the answers to the questions "What is engineering and what does an engineer do?" of the experimental and control group in the pre- and post-tests are presented in Tables 6 and 7.

When the answers given to the question “What is an engineer?” by the experimental and control group students were examined, the answers given by both groups in the pre-tests showed similarity. In addition to the students who did not have any knowledge about engineering, there were those who described engineering as a worker or a repair person. It is seen that the experimental group concentrated on more similar codes in the post-test. It is seen that the post-test codes of the control group were similar to the pre-tests.

Table 6. What is engineering?

Pre-test/ Codes	Experimental	Control	Post-test/ Codes	Experimental	Control
Design	8	9	Design	15	9
Development	3	3	Develop	12	4
to invent/make	4	3	Invent/Make	7	4
Doing/helping to do something for people	4	2	Making something		1
Using/calculating dimensions	-	2	Calculate/use dimensions		2
Engineering is a profession. That's what engineers do.	1	2	Engineering is a profession.		2
It is a profession that deals with all kinds of branches.		1	Realization of thoughts.		1
It is the making of thoughts. Planning / Adjusting	1	1	Being an expert in a subject.	2	1
To be an expert on something.	1	1	Construct.	1	4
To construct.	3	4	Mending		1
An engineer is a worker.	2	3	Drawing.		3
repairing something	3	1			
Does draw.	1	1	I don't know.	-	3
I don't know.	7	5			

Table 7. What does an engineer do?

Pre-test /Codes	Experimental	Control	Post-test /Codes	Experimental	Control
Designs	8	5	Designs	13	8
Designs homes.	2	2	Designs construction-building.	7	2
Makes house/bridge/machine-works	9	8	Designs computer-machine-tool-product.	6	2
Works/makes new things.	3	3	Develops product.	3	1
Makes plans/drawings of houses.	3	2	Invents/maintains and develops.	1	
Other (Computer engineer, civil)	2		Develops.		3
Takes care of/control food.	1		Draws- vehicle/home	1	6
Develops product.	3	6	Performs genetic tests.	2	
Makes calculations.	3	3	Inventor of new and useful products.	2	2
No answer	4	7	Makes house-bridge/works/makes new things.		7
			Makes new inventions using technology and brings them to life.		1
			Designs airplanes.	2	
			Software engineer codes new programs	1	
			No answer	-	4

It is seen that the pre-test responses of the experimental and control groups formed similar codes. In the post-tests, it was seen that the answers of the experimental group students focused on the code "designs". The codes created by the post-test responses in the control group were similar to those in the pre-tests. In addition, the control group student responses concentrated on the codes "Makes house-bridges/works/makes new things" and "Draws vehicle/home". Table 8 was created by analyzing the data obtained from the engineer drawings in terms of the gender and location of the engineers.

The pre-test drawings of the students in the control group and their post-test drawings were similar. The post-test drawings of the experimental group differed from the pre-tests in which female engineers were depicted more. When the drawings were examined in terms of space, the experimental group included engineer drawings in different environments. The pre-test and post-test drawings of the students in the control group were similar.

Engineer drawings of the experimental and control group students were analyzed in terms of engineering types in the pre-test and post-test and are presented in Table 9.

Table 8. Engineering perception in terms of gender and space

Pre-test	Groups		Post-test	Groups	
Engineer gender	Experimental	Control	Engineer gender	Experimental	Control
Male	20	22	Male	20	22
Female	4	4	Female	16	5
Unclear/no drawing	14	10	Unclear/no drawing	2	9
Space	Experimental	Control	Space	Experimental	Control
Indoor	15	15	Indoor	8	16
Outdoor	15	14	Outdoor (construction site)	4	12
None	8	7	Outdoor (Garden-Field-nature)	8	1
			Laboratory	5	
			Office	3	
			Classroom	4	

Table 9. Engineer perception of experimental and control group students in terms of engineering type

Code	Pre-test		Code	Post-test	
Engineer type	Experiment	Control	Engineer type	Experiment	Control
Construction engineer	18	16	Construction engineer	10	20
Mechanical engineer	4	3	Mechanical engineer	4	5
Mathematics Engineer	1	1	Mathematics Engineer	1	1
Electronics engineer	1		Electronics engineer	3	1
Computer engineer	5	4	Computer engineer	2	1
Food engineer	1		Food engineer	2	
Makes Design	3	4	Genetic engineer	2	
No answer	8	9	Agricultural engineer	3	
Electrical engineer	1		Plane engineer	3	
			Software engineer	1	
			Environmental engineer	6	
			Chemical engineer	2	
			Makes Design	-	4
			No answer	-	4

When Table 9 is examined, 7 types of engineers were drawn in the pre-test in the experimental group and 4 types of engineers in the control group. In the post-test, 11 types of engineers in the experimental group and 5 types of engineers in the control group were drawn. In the pre-test, it was observed that the students in the experimental and control groups made drawings that were similar in terms of engineer types and represented a limited number of engineer types. In the post-test, it was seen that the experimental group included more different types of engineer drawings compared to the control group.

Findings Obtained from Semi-Structured Interviews

As a result of the analysis of the semi-structured interviews with the students, the themes of *environmental attitude and awareness* and *getting to know STEM fields and engineering* were formed. Explanations on the features of the themes were supported by direct quotations.

Environmental Attitude and Awareness

This theme covers exploring the environment, awareness of the nature, and enjoying the nature. While the students were performing STEM Activities in Nature, it was observed that they associated their experiences and observations about nature with exploring the environment and awareness of nature. S-2, one of these students, emphasized that the activities carried out in nature and outside the classroom made them realize the characteristics of nature: *"We were able to find materials from the nature for the activities we did. There was everything we needed in nature. Nature is actually a great resource, but we must use those resources correctly. Otherwise, everything will run out."* S-3, while emphasizing the relationship between nature and science, stated that they liked the time they spent as follows: *"Being in nature for a lesson made us forget that we were in a lesson. We had a very good and fun time. Science actually means the lesson of nature anyway"*.

S-1 explained the order in nature and the role of man in that order with the following statement: *"During our activities, we also had the opportunity to watch and examine nature. There are many living things in nature. They all live in harmony with nature. For example, they do not leave their garbage to nature or they do not harm nature. I think we also need to protect nature for all living things."*

Based on the students' views, we thought that STEM activities in nature created environmental awareness in students. For example, S-4: *"We studied the life of ants in an event we held and we were astounded. We only had the opportunity to examine the ants. Many living things in nature have such a life and it is necessary to be in touch with nature and to explore them."*

S-5 explained their thought as follows: *"It was nice to touch the soil freely in the activities we did in nature, rather than always learning the lessons in the classroom. Nature has a feature that relaxes people, but the fact that people build buildings everywhere shrinks the nature and harms it."*

One of the students, S-6, expressed their opinion as follows: *"When we look at the old photographs of our city, we see that the wooded areas are much more than they are now. If it continues like this, it will be very difficult to see nature. I think about ways to avoid this."*

S7 emphasizes that they observe the effects of the human factor in nature and how they should behave: *"During our time in nature, we saw many garbage belonging to people. We even wanted to use some of them as activity material, but we know that this garbage has a very long time to disappear in nature and harms the environment. We were careful not to harm the environment while leaving nature. We collected all our waste."*

S-8 explained their thoughts as follows: *"Many creatures live in nature and benefit from many resources. They can choose and find the most suitable place for them. When we wanted to build a home for them, we could not decide whether they would like it or not. If there is more living space for them in nature, they will be more comfortable."*

S-7 stated that nature has a structure that provides every opportunity for living things and that thus its protection is important for all living things. Regarding STEM activities, S-9 stated that the activities increased their curiosity about nature and provided fun time: *"It was very nice to spend time in nature. I think that the lessons do not have to be taught only in the classroom, there are many things we can learn outside the classroom that we can explore and use in the lesson. I want to learn more about the characteristics of nature and living things. These activities can be done with any class. It may be more beneficial for 5-6-year old children to play with soil instead of playdough.*"

S-1 similarly explained their views as follows: "*We had a lot of fun during our activities. At the same time, we learned about living things and nature. We should get to know nature and living things closely. There is so much to discover."*

Getting to Know STEM Fields and Engineering

This theme includes the interest of the participants in STEM fields and the engineering profession as a result of the STEM Activities in Nature. Students associated STEM activities in nature with an interest in engineering and recognizing different engineering fields.

S-1 is one of these students and explained their thoughts as follows: *"I didn't really think about becoming an engineer in the future. Engineering is a profession that seemed different to me. I didn't know exactly what engineers did, but the activities we did caught my attention. And I think engineers are doing good work for society. I would like to be an engineer in the future."*

S-7 stated that they learned about different engineering fields thanks to the activities: " *The first engineering type that came to my mind was civil engineering. However, now I realized that there are other engineers such as agricultural engineers and software engineers."*

S-8 explained their perspective on engineering and thoughts on their career plan as follows:

"*There are engineers in my family, but I always considered engineering as a male profession. However, when I thought about what we did at the events we held, it made me realize that engineering is not a gender-based profession and that girls can be engineers too. I wanted to be a teacher in the future, but I could also be an engineer. For example, an environmental engineer.*"

It was determined that the activities carried out affected students' interest in STEM professions positively. As a matter of fact, S-5 said that: "*During the activities, we had to use not only science but also mathematics. While making new designs, we had to try to think of many things at the same time and try to find the most appropriate one. And while it was hard, it was fun."* These statements of S-5 showed that they experienced the way engineers work.

S-2 explained that STEM activities provided them with the opportunity to get to know engineering closely*: " I understood that before I had little knowledge about engineering and how engineers work. We tried to make different designs during the events. We examined. We calculated. We thought about what materials we could use. When I think about what we've done, engineers do good things."*

S-6 expressed their views with the following statement: *"Engineering is fun. I saw this at the events we held. I wanted to be an engineer in the future, my opinion hasn't changed. Because engineers do useful work for people."*

S-9 expressed their appreciation of the events and their perspective on the engineering profession as follows: *"During our activities, we tried to solve a problem like engineers. This process was a lot of fun for me. It was even better to see that they were working when we tested our projects. In this process, we used different school subjects. Science alone was not enough for us."*

S-3 said regarding STEM activities that: *"During the events, the applications positively affected my thoughts towards engineering. Engineering must be an enjoyable job because it was very enjoyable in our work."* S-6 drew attention to areas other than science regarding the characteristics of the activities carried out and said that: "*Solving questions about these activities gave me a lot of insight into what engineers do. Now I think that engineering includes different courses."*

S-4 said: "*When it comes to engineering, my thoughts have changed with the applications we have made because I realized that I didn't have a full knowledge of what engineers did before."*

Conclusion, Discussion, and Recommendations

In this study, the effects of STEM Activities in Nature on students' environmental attitudes, STEM career interests, and engineering perceptions were examined. STEM Activities in Nature significantly affected the environmental attitudes of the experimental group students compared to the control group students. It was concluded that the activities carried out in nature outside the school improved the environmental attitudes of the students. In the semi-structured interviews held with the experimental group students after the activities, the opinions of the students regarding their environmental attitudes showed that STEM education was effective. Quantitative and qualitative findings obtained in the study support each other in terms of the students' environmental attitudes. In particular, it was observed that environmental attitude was more effective in the behavioral dimension. It is important that the students stated that their desire to explore nature increased and that they have gained environmental awareness. It was determined that the STEM Activities in Nature developed the environmental attitudes of the students. In this study, the active participation of students in out-of-class practices may have been effective in the emergence of this result. In the literature, there are many studies reporting that applied trainings are effective in improving environmental attitudes. In this study, environmental attitude was included as a variable as a sub-dimension of environmental literacy, one of the 21st century interdisciplinary themes. The effects of STEM Activities in Nature on environmental attitudes can be interpreted as an indirect effect on environmental education. The result of this research is similar to the results of Buldur et al. (2018) and Çalışıcı, and Benzer (2021) in terms of improving environmental affective characteristics. Even if all the activities did not focus directly on the environmental theme, it can be said that the realization of the activities in nature ensures that the application environment is effective on affective characteristics.

While there was no significant difference between groups in terms of STEM career interests before the applications, a significant difference was determined in favor of the experimental group in the post-tests. STEM activities in nature positively affected students' STEM career interests. This interest was seen in especially engineering and technology careers in the STEM disciplines. There was no significant difference between groups in science and mathematics career interests. STEM Activities in Nature had a positive impact on students' STEM career interests, especially in the fields of engineering and technology careers. Another purpose of STEM education is to ensure students' interest in professions in STEM disciplines and to encourage them to choose that profession in the future. Studies conducted in the out-of-school setting in the literature have reported similar results, such as Dieker et al. (2012)'s STEM summer camp and Şahin et al. (2014)'s after-school program activities, both of which have shown an increase in students' interest in STEM careers.

When the STEM career interests of male and female students in both the experimental and control groups were compared before STEM Activities in Nature, it was seen that male students in both groups had a higher level of interest and they differed significantly from female students. Many studies (Christensen & Knezek, 2018; Naizer et al., 2014) have shown that female students are less interested in STEM careers than male students. In this study, the difference in favor of boys between male and female students before the applications supports this situation. After the experimental application, there was a significant difference between male and female students in the post-test results of the control group, but no significant difference was found in the experimental group. It was seen that male and female students in the experimental group had similar STEM Career interest levels. STEM Activities in Nature resulted that the difference in the level of interest in STEM career fields between male and female students observed in the pre-test disappeared. It increased the interest level of female students more. The following research results agree with the present results: Weber (2011) stated that STEM activities in an informal environment were effective in increasing STEM interests and knowledge of female students; Dubetz and Wilson (2013) stated that STEM education increased the interest of female students in STEM fields; and, Naizer et al. (2014) stated that STEM education closed the STEM career interest gap between male and female students. It is important to increase interest in STEM fields at an early age for female students to be able to steer them to STEM career fields.

To determine the effects of STEM Activities in Nature on the engineering perceptions of the students, the data obtained from the Engineering Perceptions Questionnaire of the experimental and control groups were compared. In addition, the experimental group interview responses were analyzed. The answers of the experimental and control groups in the pre-test to the question of “what is engineering?” appeared to be similar. As a matter of fact, before the application, the students explained the concept of engineering as “a profession", "builder", and "repairer". The answers to the question "What does an engineer do?" given by the experimental and control groups in the pre-tests were similar. While the students incorrectly defined engineers as "workers", it was observed that some students defined engineering as making calculations by generalizing operations such as "calculation" that engineers do. Looking at these definitions, it is thought to be due to the lack of knowledge about engineering. Similarly, in studies in the literature (English et al., 2011; Fralick et al., 2009, Liu & Chiang, 2019), it has been reported that students perceive engineering as "equipment repairing and assembly" and engineers as "working outdoors doing hard work", which supports this conclusion of the research. In the post-test, while the definitions of the control group students were similar to the pre-tests, it was determined that the experimental group students focused on definitions like "design-development" and made more accurate definitions. While the answers of the control group in the post-tests were similar to those obtained before the application, the answers of the students in the experimental group showed positive changes. Students focused on "designer", "developer", and "problem solver" answers. Engineering drawings of the students were examined. In the pre-tests, it was seen that the gender of the engineers whose drawings were drawn by the experimental and control groups were mostly males in both groups. Many studies have shown that engineering is perceived as “men's work” (Cunningham et al., 2005; Karataş et al., 2011; Koyunlu Ünlü & Dökme, 2017). While the post-test drawings were similar to the pre-test drawings in the control group, the proportion of female engineer drawings increased in the experimental group. This is a result consistent with the research findings in the literature (Koyunlu Ünlü et al., 2018). In particular, the fact that female students in the experimental group made drawings of female engineers can be interpreted as an indicator of their identification with engineering. The findings obtained from the interviews also supported the positive change in the engineering perceptions of female students. Engineer drawings were also analyzed in terms of space. In the pre-tests, the drawings of the students in the experimental and control groups were similar. In these drawings, engineers were usually seen indoors using computers or outdoors at construction sites. When the post-test drawings after STEM activities were compared with the pre-tests, the control group drawings were similar to the pre-tests. The post-test drawings of the experimental group differed from the pre-test results. It is seen that more outdoor drawings were made in these drawings and that the spaces in the drawings differed from the pre-tests, such as garden/field/forest. When the drawings of the students were examined in terms of engineering types, it was seen that the experimental group students knew different engineering fields compared to the control group. Although the students' drawings of civil and computer engineers before the application were mostly similar after the application, the fact that the students had drawings of Genetic Engineers, Agricultural Engineers, Aeronautical

Engineers, Software Engineers, Environmental Engineers, and Chemical Engineers can be interpreted as a positive effect of the application on students' knowledge and awareness of engineering fields. This research shows that STEM activities affect students' engineering perceptions positively. This result is similar to the results of applied studies in the literature (Hammack et al., 2015; Kuvaç, 2108; Oware et al., 2007; Lyons & Thompson, 2006) that have improved students' perceptions of engineering. In the interviews, the experimental group students expressed their thoughts on the following subjects: they gained knowledge about engineering, they noticed the types of engineering, and that women can be engineers too. In addition, the definition of engineers as "problem solvers" and "designers" shows that STEM Activities in Nature improve students' perception of engineering.

In the research, experimental evidence was obtained that STEM Activities in Nature, applied in an 11-week period, positively affected students' environmental attitudes and engineering perceptions, and increased students' STEM career interests. In addition, educators can benefit from the activities included in the research, considering that the students had a good level of motivation during the STEM Activities in Nature and had an enjoyable education process. The research has a limitation. The data were obtained from students studying in a secondary school. Therefore, this should be taken into account when generalizing the results.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in JESEH journal belongs to the authors.

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