STEAM Implementations for Elementary School Students in Turkey

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Abstract

The main aim of the current research was to fill the absence of STEAM activities for primary school students in Turkey. Accordingly, a study in which STEAM activities were implemented was conducted with the primary school students. There were four activities during STEAM implementation. The activities were these: Students recognized circuit components of simple electric circuits, designed simple electric circuits using circuit components by the guidance of researchers, later designed an ecological village via STEAM using simple electric circuits, and presented their ecological village via STEAM. A quasi-experimental design with a pretest-posttest control group design was used in the current research. A qualitative research method was included in this study subsequent to quantitative dimension where a quasi-experimental design was used. At the end of the study, it was seen that there was no statistically significant difference among the pre-test and post-test scores obtained from SoATS for both experimental and control group students. The results of DAST-C test are remarkable for the experimental and control groups. It was seen that the experimental group students started to look at the physical characteristics of the scientist from a broader perspective by giving up the traditional point of view after STEAM implementation. As a result of the data analysis of semi-structured interviews, it was found that they were aware that Science, Technology, Mathematics, and Engineering disciplines were associated with one another and art was necessary both in these disciplines and daily life after the STEAM implementation.

Key Words

Arts integration, STEAM, STEAM Education, Elementary school students, Primary science course

Introduction

The education paradigm of the 21st century requires different learning approaches to be implemented by putting the students at the center with curriculum, instruction, and assessments assisting student engagement in learning and development of analytical, collaborative, and communication skills (Friedlaender, Burns, Lewis-Charp, Cook-Harvey& Darling-Hammond, 2014). Within the scope of this approach, the importance of interdisciplinary education and its contribution to effective and meaningful learning have been emphasized more day by day (Yıldırım, 1996). The objective of an interdisciplinary approach is to enable students to learn the subject selected as a meaningful whole while examining the same subject through lenses of various disciplines (Yalçın & Yıldırım, 1998; Aladağ & Şahinkaya, 2013; Holley, 2017). In this regard, such implementations as Science-Technology-Engineering-Mathematics (STEM) and Science-Technology-Engineering-Art-Mathematics (STEAM) are interdisciplinary approaches to be developed so that students can learn the subjects better. STEM education aims to educate students integrally and to develop their 21st century skills.

This article focuses on a STEAM intervention project at a primary school in Turkey. STEM and STEAM implementations were being used in schools only since 2013 so there are few research studies on STEAM in Turkey. Most teachers were not familiar with using STEAM in classes. Because of this reasons the current practical project and study were conducted as an example for teachers at a primary school.

Literature Review

In this brief review of relevant literature, the STEM education movement is first discussed, followed by the addition of the arts, producing the STEAM movement. Then, attention is turned to STEM or STEAM camps and academies in general and specifically in Turkey, the country in which this project took place.

STEM Education

The STEM education movement was implemented to increase competitive power in science and technology in the United States in 2003. Through STEM instruction, students solve various problems and become innovators, inventors, self-reliant, logical thinkers, and technologically literate people (Morrison, 2006). In general, STEM education makes an effort to integrate science, mathematics, technology, and engineering disciplines by making connections between the content of a unit or a subject and a real-world problem. A concrete example of the argument that science and engineering may be thought as inseparable parts was the development of the Hubble and James Webb Space Telescope, an outcome of advances in science resulting from cooperation of technology and engineering (Bybee, 2011).

STEM education can be considered as a vehicle providing content knowledge of science and mathematics or developing an understanding related to science, for example, through the engineering design approach (Bozkurt, 2014). Instead of learning aforementioned fields in an isolated way, STEM education focuses on authentic learning and generating activities based on such skills as investigation, design, problem solving, teamwork, and effective communication. STEM education activities approach science, technology, engineering, and mathematics disciplines using 21st century knowledge and skills (Baran, Canbazoğlu-Bilici, Mesutoğlu, 2015). Developing students' positive perceptions of scientists can be considered a first step in planning their careers of the future (Painter, Tretter, Jones, & Kubasko, 2006). In this respect, integration of subjects involved in STEM implementation, along with the emphasis on the nature of science and socio-scientific issues, can have an impact on the students' career choices.

Engineering is a field in which the materials and energies of nature or manufactured items are most efficiently turned into constructions, machines, products, and processes by using knowledge acquired through education and experience in the fields of mathematics and fundamental sciences (Özçep, 2007). Engineering is an applied science that uses mathematics in design and construction. Basic functions of engineering are design and construction. Design is a mental process that is intended to present a product, a production method, or a system (Göker, 2000). Instruction involving active participants who interpret and generate knowledge is effective because classroom interaction is at the forefront in teaching science. A problem solving environment is built that enables students to improve their scientific questioning and critical thinking skills. Moreover, students become interested and willing to learn the subject because of the engineering design based scientific education (ÇavaŞ, Bulut, Holbrook & Rannıkmae, 2013). STEM education project work tends to provide technology literacy for all the students from the gifted students to the ones who are considered to have a higher probability of failing academically (Clark & Ernst, 2008).

Integrating the Arts for STEAM Education

STEAM education was created by adding an art dimension to the original STEM implementations in which science, technology, engineering, and mathematics disciplines are taught integrally (Yakman, 2007). Art makes a great contribution to creativity and science. The United States, Britain, Australia, Canada, and other developed countries have pointed out that STEAM has been at the centre of the education reform in recent years (Kim, Kim, Nam, Lee, 2012).

STEAM camps and academies have been opened recently; the educators and students' families have been supported through lessons requiring youth to improve their higher order thinking skills and creativity using both sides of their brains. Art also enables students to enhance creativity with this approach to education. Studies related to arts integrated into STEM topics such as digital media, biomedical, biotechnology, energy, and clean technologies are stressed in these aforementioned STEAM camps. Art education is regarded as a significant factor to support creativity and innovation skills which are necessary to increase the competitive power of the youth in the global economy because creativity and innovation are essential to education and economic development (Eger, 2013). Moreover, STEAM is of vital importance to global culture by providing many opportunities for the students not only to be more interested in science-technology-engineering-art-mathematics fields but also to improve their occupational skills and attitudes (Yakman and Lee, 2012). STEAM-based learning could be a powerful approach when integrated with criticism and interdisciplinary cooperation (Keefe & Laidlaw, 2013). Research findings have demonstrated that students are satisfied with STEAM implementations and enjoyed performing the lessons (Kim, Kim, Nam & Lee, 2012; Park, Kim & Yoon, 2015)

STEM and STEAM Education in Turkey

A comparison of studies of STEM and STEAM education in Turkey with those in other countries indicates that scarcely any studies at the elementary school level have been conducted, resulting in need in this area. Therefore, mathematics, science, and technology-design teachers need to cooperatively develop investigation-based STEM teaching plans that support students' critical and creative thinking skills. Furthermore, career development materials which are adapted to government policies about STEM education have been prepared and tested (Çorlu, 2014). Some reports support government policies prepared as Vision 2023, National Science and Technology and Innovation Strategies 2011-2016, The Report of Vision 2050 by Turkish Industry and Business Association. According to the results of these reports, research is still needed on new topics related to STEM.

The Ministry of National Education of Turkey (MoNE, 2011) recognizes that for people to maintain economic development under the present intense competitive global economic conditions, to prosper, and to continue their cultural heritage requires that they have human potential which internalizes their own cultural values, is fitted with new knowledge and skills, and promotes both self-confidence and respect of differences. Individuals must be educated who have 21st century skills to address environmental, social, and economic problems and take an active part in the community. Because of these developments are emerging in the field of education in Turkey; arrangements were made in 2017 for all curricula from elementary school to high school to be renewed. A new unit for STEM implementations was added into the primary school science curriculum, and targeting enhancement of knowledge and experiences of teacher-implementers.

Students in the 5th grade of elementary school and upper grades (secondary and high schools) were at the centre of the most of the STEM studies in Turkey when the related literature was reviewed (Baran, Canbazoğlu-Bilici and Mesutoğlu, 2015; Çorlu, 2014; Çorlu, Capraro, Capraro 2014; Gencer, 2015; Yamak, Bulut, Dündar, 2015; Şahin, Ayar, Adıgüzel, 2014; Bybee, 2011; Hill, Corbett, Rose, 2011; Morrison, 2006; Sanders, 2009). No STEAM studies at the primary level were located. Therefore, a main objective of this project was to provide STEAM activities for the primary school students in Turkey and to determine their efficacy. Another objective was to showcase effective STEAM activities as examples for practitioners. Accordingly, this article describes the lessons that were conducted with primary students and their effects on student content knowledge and motivation.

The Lessons

The "Simple Electric Circuits" unit has three weeks as nine hours (three hours per week for three weeks) in 2013 primary science curriculum. In this unit on which this paper focuses, students learn about circuit components and how to prepare simple electric circuits with these components.

Participants and Setting

The group of fourth grade student participants of this project consisted of 50 students in the age range of 9 to 10 years, divided into two groups, one of which was the experimental group (12 male, 13 female) and the other was the control group (11 male, 14 female). The lessons took place at Çobanlar Ahmet Özyurt Elementary School in Afyonkarahisar, Turkey in the 2015-2016 academic years. This school was a state school located in a rural area of Afyonkarahisar. There were two classes per grade and approximately 200 students at this school.

Lesson Procedures

The STEAM activities were designed for the unit "Simple Electric Circuits" which was in the learning area "Physical Phenomena" in the 4th grade science course of elementary school. The objectives of this unit were: 1) students would design various electric circuits by recognising the circuit components and their functions; and 2) they would associate simple electric circuits with electric systems in houses. For these activities, nine classroom hours were granted in this unit of the science course which was taught as three course hours per week in the curriculum.

Learning outcomes in this unit as follows:

1. Students will be able to recognize the circuit components, the functions of the simple electric circuits, and to design and operate a circuit.
2. Students will be able to recognize the light switches at home and school as circuit components.
3. Students will be able to conclude that there are connection cables inside the walls between the switches and the lamps.

According to the outcomes of this unit, it was aimed that the students would recognize the circuit components of the simple electric circuits and electric systems in the houses, and then they would design simple electric circuits. Because of STEAM implementations, this aim brought an interdisciplinary dimension. The students were asked to build a project by considering the study field of the engineers and the scientists. Within the framework of the outcomes in this unit of science course were exposure to: various engineering types (electric engineering, agricultural engineering, civil engineering, and environmental engineering); the technological devices based on scientific principles (such as solar panels, street lights); geometry and measurement in mathematics (environmental planning and acreage); and art works (differentiating natural and artificial environment designs, and constructions of three dimensional simple geometric shapes).

The students brought some grains or legumes (pea, rice, lentil, bean, etc.), some hay, and some little pieces of wood from their homes. They made villages and farms using small cardboard boxes and cartons. They attached the seeds, hay, and wood with glue as an art work product.

The lessons were conducted as STEAM based and integrated with learning outcomes in the curriculum of lesson plans of the 4th grade science, mathematics and visual arts courses of elementary school. The lessons were evaluated through a study using a pretest-posttest of attitudes toward science and projective test drawings of scientists.

Research Questions and Design of the Evaluation Study

The implementation study was carried out in the unit "Simple Electric Circuits" which was in the learning area "Physical Phenomena" in the 4th grade science course.

In parallel with this objective, the questions were as follows:

1. Do science courses with STEAM implementations create a meaningful awareness about students' attitudes towards science in the experimental and control groups?
2. Do science courses with STEAM implementations create a meaningful awareness about students' images of scientists in the experimental and control groups?
3. What are the students' opinions about Science-Technology-Engineering-Mathematics and Art studies before and after STEAM implementation?

A quasi-experimental design with a pretest-posttest control group design was used in the current research that evaluated efficacy of the lessons. Quasi-experimental designs are patterns which have high concurrent validity in the researches in learning area where all variables are not possible to be brought under control (Cohen, Manion & Morrison, 2007).

At the beginning and end of the implementation process, data collection tools were used to determine the students' attitudes towards science and perceptions of scientists using this design, revealing the effectiveness of the lesson process. For this purpose, two groups were formed, one of them was the experimental group (Class 4C) and the other was the control group (Class 4A). Before the implementation, "Scale of Attitudes towards Science" was applied to the students in both the experimental and control groups. While the students in the experimental group learned "Simple Electric Circuits" in the unit with the STEAM activities during four weeks, the students in the control group learned as usual in accordance with the curriculum. At the end of the implementation, "Scale of Attitudes towards Science" was reapplied to the students in the experimental and control groups.

Nine students chosen with purposeful sampling for the qualitative part of the research engaged in face to face individual interviews with the researchers. Nine students (three low level, three mid-level, and three high level) who were educated in class 4C were interviewed within the scope of the STEAM before the implementation started. In addition, nine students (three low level, three mid-level and three high level) who were educated in class 4C were interviewed again within the scope of STEAM.

Instrumentation

Quantitative and qualitative data collection tools were used to gather data in the present research. In the pretests and posttests of the research, "Scale of Attitudes towards Science (SoATS)" which was developed by Duran (2008) and "Draw a Scientist Checklist (DAST-C)" which was developed by Finson, Beaver and Cramond (1995) were used.

Quantitative data collection tools. The *Scale of Attitudes towards Science* was used in the evaluation of the lesson unit. In the "Scale of Attitudes towards Science" developed by Duran (2008) and a three-point Likert type scale, there were 19 items which consisted of the options 'agree, partially agree, and disagree.' The scores obtained from Likert scale were between 19 and 57. The content and face validity of the scale were provided in parallel with expert opinions. Factor analysis was made for the construct validity of the scale, and that it was unidimensional was realized. Reliability analysis were calculated with Cronbach's alpha internal consistency coefficient and the measured value was 0.79 (Duran, 2008).

A second instrument, *Draw a Scientist Checklist (DAST-C)* developed by Finson, Beaver and Cramond (1995), was used to evaluate the lessons. Students were asked to draw a scientist who was doing scientific research on the paper given them and to explain the drawings with a couple of sentences. Student drawings were evaluated by locating and tabulating stereotyped and non-stereotyped aspects of their drawings.

Qualitative data collection tools. A semi-structured interview form was used as a qualitative data collection tool. In qualitative studies, internal validity is relevant to whether or not the researcher really measures what s/he asks to measure with the tool or the method which s/he uses (Yıldırım & Şimşek, 2005). The interview form was given to two experts to provide internal validity of the interview form, and the form took its final shape by being reviewed. After a student engaged in the pilot interview the sound recording was transcribed. The interview printout form was computerized to determine whether or not the questions were clear and comprehensible and the answers of the student reflected the answers of the questions. Another expert was asked to check whether or not the questions were clear and comprehensible, and researchers and expert included the context by reviewing the printout form considering the possibility of providing the necessary information. At the end of this study, the validity of the questions was determined. Data collection processes were started after being of the opinion that the questions of the interview provided the data which were expected.

Table 1. *The questions of the semi structured interviews*

1. How and where do you use mathematics in your daily life?
2. What is the relationship of science and mathematics?
3. Which technologic devices do you know?
4. If you were a scientist, what would you want to invent?
5. How do you make a relationship between science, technology, math and engineering?
6. Why do we use art in our daily lives?
7. Is it important that a product is seen well? Why?

Data Analysis

In the present research, independent samples *t*-test was used to analyze the data obtained in order to determine whether or not there was a significant difference between the experimental and control groups. The content analysis technique was used to analyze the qualitative data. Necessary arrangements were made by discussing the subjects on which there were "consensus" and disagreement. Master keys and the printout forms obtained from the interviews were read by the researchers separately. A reliability formula which was suggested by Miles and Huberman (1994) was used for the reliability calculation of the research. As a result of calculation, the reliability of the research was found to be 96%. Reliability calculations above 70% have been accepted as reliable for the research (Miles and Huberman, 1994). Thus, the result which was obtained in the present study was accepted as reliable for the research.

Lesson Procedures

The current STEAM implementation was activated during four weeks. In Table 2, the process of implementation is presented.

Table 2. *The Process of STEAM implementation*

Week	Date	Activity
1	02.05.2016- 06.05.2016	Recognizing circuit components of simple electric circuits.
2	09.05.2016- 13.05.2016	Designing simple electric circuits using circuit components and recognizing the electric systems of houses.
3	16.05.2016- 20.05.2016	Designing an ecological village via STEAM using simple electric circuits.
4	23.05.2016- 27.05.2016	Presenting an ecological village via STEAM

In the first activity of STEAM implementation (Table 2, line 1), students recognized the components of simple electric circuits. The topic was explained, some examples were given by the researchers, and the components of circuits were provided for students to examine. During the second activity of STEAM implementation, students (working in groups) designed simple electric circuits using the circuit components with the guidance of researchers. Also, students watched some videos that contained examples of electric systems of houses. Later, the students and researchers discussed electric systems of their own houses. During the third activity of STEAM implementation, students designed an ecological village, thereby implementing the art component of STEAM education, incorporating simple electric circuits. They used organic products (grains and legume seeds) in their parts of the villages and used components of circuits to make streetlights. Students used equipment (glue, scissors, construction paper, rulers) to help them in the art constructions. See Figure 1. Figure 2 and Figure 3 show different groups' (for example, Group A and Group B) ecological village products. Students put streetlights in the scene and made their farms with feeds (peas, rice, lentils, beans). They made houses and barns in their ecological villages. Finally, in the last week of this art construction activity, students presented their ecological villages that were STEAM implementations. See Figure 4. The biggest problem of this project implementation was the lack of time. Because the unit was scheduled for only three weeks according to the primary school science curriculum, the researchers had to add a week at the end of unit.

Figure 1 (shown at left). The students use equipment for art work in STEAM implementation

Results

Quantitative Findings

Table 3 shows the results of the independent samples *t*-test regarding pretest scores obtained from the Scale of Attitudes towards Science (SoATS) for the experimental and the control group students. Table 4 shows no statistically significant difference among the pretest scores obtained from SoATS for the experimental and the control group students. This result indicates that both groups began the lessons at similar levels, an important factor for quasi-experimental design studies

Figure 2. Ecological village products of Group A.

Figure 3. Ecological village products of Group B.

Figure 4. The presentation of ecological village products of Group C.

Table 3. *The Results of the Independent Samples t-test Regarding the Pretest Scores Obtained from SoATS for the Experimental and the Control Group Students*

Scale	Groups	n	Mean	SD	*t*	*p*
SoATS	Experimental group pretest	25	46.72	7.64	0.697	0.489
	Control group pretest	25	48.08	6.05		

Table 4 shows the results of the dependent samples *t*-test regarding the pretest and posttest scores obtained from the Scale of Attitudes towards Science (SoATS) for the experimental group students. Table 5 shows no statistically significant difference between the pretest and posttest scores obtained from SoATS for the experimental group students. But, the means of experimental group posttest scores (50.52) are higher than experimental group pretest scores (46.72). Maybe significant differences would be seen between groups if the researchers had a longer time for the implementation process, since attitudes often take a long time to change.

Table 4. *The Results of the Dependent Samples t-test Regarding Pretest and Posttest Scores Obtained from SoATS for the Experimental Group Students*

Test	Groups	n	Mean	SD	*t*	*p*
SoATS	Experimental group pretest	25	46.72	7.64	1.741	0.095
	Experimental group posttest	25	50.52	7.48		

Table 5 shows the results of the dependent samples t-test regarding the pretest and posttest scores obtained from SoATS for the control group students. Table 6 shows no statistically significant difference between the pretest and posttest scores obtained from SoATS for the control group students. Because of the traditional approach, the attitudinal development of the students was limited.

Table 5. *The Results of the Dependent Samples t-test Regarding the Pretest and Posttest scores Obtained from SoATS for the Control Group Students*

Scale	Groups	n	Mean	SD	*t*	*p*
SoATS	Control group pretest	25	48.08	6.05	0.331	0.744
	Control group posttest	25	48.68	7.86		

Table 6 shows the results of the independent samples t-test regarding the posttest scores obtained from the Scale of Attitudes towards Science (SoATS) for the experimental and the control group students. Table 7 shows no statistically significant difference among the posttest scores obtained from SoATS for the experimental and the control group students. However, the means of the experimental group posttest scores (50.52) are higher than the control group posttest scores (48.68). The students who took part in experimental group may have been more developed than the control group students; a large sample may reveal this difference through statistical significance.

Table 6. *The Results of the Independent Samples t-test Regarding the Posttest Scores Obtained from SoATS for the Experimental and the Control Group Students*

Scale	Groups	n	Mean	SD	*t*	*p*
SoATS	Experimental group posttest	25	50.52	7.48	0.847	0.401
	Control group posttest	25	48.68	7.86		

Table 7 shows the distribution of the pretest and posttest scores obtained from the Draw-A-Scientist Test (DAST-C) for the experimental and the control group students. The thirteen items on the DAST-C test may be classified into four subcategories: the physical characteristics of the scientist, the work environment of the scientist, the indicators for scientific research, and the indicators relevant to inventions. The distribution of the pretest and posttest scores obtained from DAST-C for the experimental and the control group students is presented in Table 7.

Table 7. *The Distribution of the Pretest and Posttest Scores Obtained from DAST-C for the Experimental and the Control Group Students (Experimental group n = 25; Control group n = 25)*

Category and feature	Percentage of students drawing this feature			
	Experimental Group		Control Group	
	Pretest	Posttest	Pretest	Posttest
Lab coat (not necessary to be white)	52	32	20	40
Eyeglasses	40	16	24	32
Messy hair (pictures like Einstein)	20	4	8	0
Symbols of research (microscope, telescope, and so on, experimental tools)	84	52	60	52
Symbols of knowledge (book, writing, writing on computer if any)	36	40	8	16
Technology (computer, television)	72	32	32	24
Related topics (such as formula, classifications, documents)	4	0	0	0
Male scientist	76	16	72	60
Danger signs	0	0	0	0
Lightbulbs (ideas about the inventions)	0	0	0	0
Legendary characters (Kaloghlan, and so on)	0	0	0	0
Signs of privacy or confidentiality (do not enter, secret lab)	0	0	0	0
Indoors (laboratory, classroom)	80	44	80	64

Figure 5 is a drawing from the experimental group students before the implementation of the lessons. As seen in Figure 5, a representative student from the experimental group drew the scientist as male, with lab-coat, eyeglasses and laboratory work. Figure 6 is a representative drawing from the experimental group students after the implementation (at the time of the posttest). As seen in Figure 6, one of the students from the experimental group drew scientists as both female and male, without lab-coats, both with and without eyeglasses, and working as a group. Additionally, in Figure 6, there is an emphasis on nature with sun, clouds, and trees being shown. There were many differences between Figure 5 and Figure 6, indicating growth in student's attitudes.

Figure 7 is a representative drawing from the control group students before the implementation. As seen in Figure 7, one of the students from the control group drew the scientist as male, lab-coat, eyeglasses and working individual and indoor. Figure 8 is a representative drawing from the control group students after the implementation. As seen in Figure 8, one of the students from the control group drew the scientist as male, lab-coat, and working individual. Only one difference can be seen in Figure 7 and figure 8 was the scientist was not wearing eyeglasses at the time of the posttest.

The results of DAST-C were remarkable for the experimental and control groups. The experimental group students started to look at the physical characteristics of the scientist from a broader perspective by giving up the traditional point of view after the STEAM implementation. For example, at the beginning of the project (at the pretest), the majority of the students drew the scientists with such physical characteristics as male, lab-coat, eyeglasses, working individually and messy hair. On the posttest, most of them drew the scientists with such physical characteristics as female gender, without eyeglasses, working in group, along with neat and well-groomed hair. Moreover, students drew the scientists outdoors (yard, forest, and so on) at the end of the implementation (on the posttest) whereas most students on the pretest drew the scientists indoors (laboratory).

The students also drew theoretical and instrumental indicators about the indicators for scientific research in their pretest drawings. Students used the symbols of research (microscope, telescope, and so on, experimental tools) and technology (computer, television, and so on) on the pretest before the implementation; however, the students removed the earlier symbols from the drawings after the implementation. Finally, despite the fact that there were no differences pre and post tests on the instrumental indicators of the Scale of Attitudes towards Science (SoATS), there were differences on the Draw-A-Scientist-Test (DAST-C) concerning scientists' characteristics, working places (indoor-outdoor), and working types (individual-groups)

Figure 5. Representative student scientist drawing from the experimental group pretest

Figure 6. Representative student scientist drawing from the experimental group posttest.

Figure 7. Representative student scientist drawing from the control group pretest.

Figure 8 Representative student scientist drawing from the control group posttest.

Qualitative Findings

Table 8 shows the themes obtained from the data analysis of semi-structured interviews with the experimental group students who were applied to STEAM on the pretests and posttests. The main themes obtained from the data analysis of semi-structured interviews on the pre-tests and post-tests where the STEAM method was implemented to the classroom environment were the same; however, sub-themes and categories were different. For this reason, various sub-themes and categories obtained from the pre-interviews and final interviews are shown in the following tables, the findings are presented comparatively, the examples are given by direct citations, and some deductions have been made about the differences obtained from the findings. The themes obtained from the data analysis of semi-structured interviews are presented Table 8.

Table 8. *The themes obtained from the data analysis of semi-structured interviews*

Themes
Relationship between Science and Mathematics
Technology Outlook
Engineering for Children
Interdisciplinary Connections from Children's Point of View

Findings Obtained from the Pre-Interviews and Discussion. The sub-themes and categories obtained from the pre-interviews are shown in Table 9. The students expressed their thoughts about how "*Mathematics is used in Science.*" Emre said, *"It is necessary when our teacher asks a question about science. For example, what is the total number of the bones in children and in adults."* Kübra also said, *"We make measurements. For example, we measure the volume of water in a container or when we drop the stone into it, the water level rises, we measure what the stone is."* On the other hand, Fadime said, "Mathematics is not used in Science," *"It is not used, we learn the skeleton of our body in science, the thorax protects our lungs, to keep the environment clean, noise pollution. Mathematics is not necessary in science."* Elif also said, *"It is not necessary because mathematics is not used by learning science."*

Concerning the sub-theme "*Mathematics in daily life,"* Elif said, *"Calculation is required; mathematics is necessary when doing shopping."* Mehmet said, *"We have a shop; it is required when working there."* In the category "*Mathematics at home,"* Ahmet said, *"Mathematics is important for some furniture. For example, it helps us to know what size the fridge is."* Fadime also said, *"It is sometimes required at home. For example, we need to calculate how many people are at home, the mathematics is required at that time."*

Related to the sub-theme "*Technological devices,"* Kübra said that such products as a *"photocopy machine, washing machine, dishwasher;"* are technological devices. In the sub-theme "*Benefits of technology,"* Ahmet said, *"Yes, it is important because I watch the news on television, and technology makes our lives easier."* Fadime said, *"We can find everything which we want to know from the internet, on computer."* When the question *"If you were a scientist and you wanted to invent an electrical device, what would you do?"* was asked, Fadime said, *"I would make an electrical wooden cupboard, it would open by itself when someone came near it, and it also would clean by itself."* However, Ahmet said, *"I would make a car. It would be chargeable and electrically driven. It would be affordable because gas is expensive and we buy it from other countries, so I would invent an electrical car."*

When the types of engineering were asked, Emre said, *"Mechanical engineer, computer engineer, civil engineers."* When their fields of work were asked, Mehmet said *"They set up the lamps of the schools, they construct the buildings."*

In the theme "*Interdisciplinary connection from children's point of view"* about the sub-theme "*Aesthetic,"* Fadime said, *"Looking good is not so important, a small house is enough for us to live."* Elif said, *"Looking good of the buildings or the furniture is not so important, quality is all that matters."* Concerning the sub-theme "*Group work,"* Kübra said, *"I like group work in science. We learn our skeletal system. Also, I am not good at science, for example, I asked my friend named Mehmet Ali how many parts the skeletal system consists of, and he told the answer."*

Table 9. *The Sub-themes and Categories Obtained from the Pre-interviews*

Sub-themes	Categories
Relationship between Science and Mathematics	Mathematics in Science *Yes, there is* *No, there isn't any*
Mathematics in daily life	Shopping
	At home
Technology Outlook	Technological Devices
	Benefits of Technology
	Technological Inventions
Engineering for Children	Types of Engineering
	Fields of Work
Interdisciplinary Connection from Children's Point of View	Independent Comprehension
	Group Work
	Aesthetics

Findings Obtained from the Final Interviews and Discussion. The sub-themes and categories obtained from the final interviews are shown in Table 10. When the question *"Is mathematic used in science?"* was asked, all the students answered *"Yes, it is."* Elif said *"Teacher, you will make something, for example, a table, it is measured with a ruler. We did it to the field in our project, we measured the sizes of field and the houses with the ruler."* Kübra said, *"We form a pattern in the field, make embellishments, and measure the area."* Regarding "*Science topics"* in the project, Fadime said, *"In the project, our science topic is simple electric circuit. The simple electric circuit components are socket, light bulb, switch, battery, battery channel, and wires."*

When the technological devices were asked, Mehmet answered, *"Tablets, computer, television, and telephone."* Regarding their benefits, Emre said, *"Technology makes our lives easier. For example, there are self-driving cars instead of individual drivers."* Elif also said, *"Technology makes everything easier. In doing hard work, for example, we would go to school in the morning. If our school uniforms had been washed, but not dried yet, we would dry them with the iron. Then technology is useful. Hoover, washing machine, fridge, and so on*."

When the question *"If you invented an electrical device, what would it be?"* was asked, Ahmet answered, *"I would invent an electrical car. We buy gas from other countries, so we run out of the money. Our money would not go to waste. Also, I would build a flying house. It would make us fly, we would travel with it. It would be both comfortable and better."* Fadime said, *"It could be electrical glass windows because they would open and smell like spring if it stank at home."*

In the theme "*Engineering for children,"* it was revealed that the students' levels of awareness increased and that the students gave some answers concerning engineering branches. Ahmet said, *"Agricultural engineers. They check through the fertilizer of our fields. They check through minerals. There are also electrical engineers. They make solar panels, street lights, and electric wires. There are civil engineers. They build firms, houses, and shops."* Fadime also said, *"Environmental engineers protect the environment. Forest engineers report the fires in the forests to the fire service. They take care of the forests. Agricultural engineers recycle, feed the animals, take care of the fields, and plant the seeds. Electrical engineers, for example, if the solar panel does not retain heat, then it is defective and they remake it."*

About "*Interdisciplinary connections from children's points of view",* Emre said, *"We worked as civil engineers, electrical engineers, and agricultural engineers in the project. We made a simple electric circuit. We turned it into the energy and used this energy for enlightenment. We used mathematics in pattern and embellishment, for example, edges, tree placements, product placement in the field. For instance, we used mathematics to calculate the area of the houses. We covered the street lights with construction papers and cellophane papers in order that it would look colorful."* Ahmet also said, *"The subject relating science in the project was electricity, simple electrical circuit. Circuit components were socket, switch, light bulb, battery and battery channel. We used mathematics in measurement and symmetry. We formed a pattern during the product placement. We generated electricity with solar energy. We became agricultural engineers, electrical engineers, and civil engineers. We covered the houses with colorful construction papers. We also covered the roads and the bulbs with cellophane papers in order that they would glimmer better, look more beautiful and enlighten much more."*

Table 10. *The sub-themes and categories obtained from the final interviews*

Sub-themes	Categories
Relationship between Science and Mathematics	Mathematics in science Science topics (concepts)
Technology Outlook	Technological devices Benefits of technology Technological inventions
Engineering for Children	Types of engineering Fields of work
Interdisciplinary Connection from Children's Point of View	STEM project Integrated comprehension Aesthetics

Discussion and Conclusion

At the end of the STEAM implementation, the students who took part in experimental group had more developed knowledge than the control group students. And also, according to students' views, the experimental lessons were more enjoyable. Furthermore, the students' ideas about scientists were changed. These results showed that the STEAM activities are effective on students' perspectives about science lesson and scientists.

Quantitative Conclusion and Discussion

The results of the research study revealed no statistically significant difference found between the pretest scores obtained from the Scale of Attitudes towards Science (SoATS) for the experimental group students who experienced the STEAM activities compared to the control group students to whom the traditional curriculum was implemented. Furthermore, there was no statistically significant difference between the pretest and posttest scores obtained from SoATS for both the experimental and control group students. Similarly, there was no statistically significant difference between the posttest scores obtained from SoATS for the experimental and control group students. However, the experimental group students made more progress on the posttest when the arithmetic averages of the posttest were reviewed.

In some other studies, it has been confirmed that STEM activities enhance secondary-school students' attitudes towards science positively (Yamak, Bulut & Dündar, 2014; Guzey, Moore, Harwell,& Moreno, 2016). In the light of these results, the authors suggest that the attitudes towards science will make progress in time and make positive differences as long as STEAM implementations are conducted in long term.

Thirteen items on the DAST-C test may be classified under four subcategories as the physical characteristics of the scientist, the work environment of the scientist, the indicators for scientific research, and the indicators relevant to the inventions. In this regard, the results of DAST-C test are remarkable for the experimental and control groups. According to this, it was seen that the experimental group students started to look at the physical characteristics of the scientist from a broader perspective by giving up the traditional point of view after STEAM implementation. For example, the majority of students drew scientists with such physical characteristics as male, lab-coat, eyeglasses, and messy hair at the beginning.

McCann and Marek (2016) state that scientist drawings of students are considerably affected by culture, gender, and socioeconomic circumstances. When school environment where this study was conducted is considered, the fact that it is of low socioeconomic circumstances may have had an effect on the drawings. Some conducted studies have been revealed that most secondary-school students have stereotyped views (such as male, messy, lab-coat) concerning the physical characteristics of the scientists (Chambers, 1983; Fort & Vanny, 1989; Kara & Akarsu 2015). However, an increase in female scientist drawings of the students has been noted in recent studies (Barman, 1999; Finson, Beaver, & Crammond, 1995; Monhardt, 2003; Painter, Tretter, Jones, & Kubasko, 2006). In the current research, the fact that most of the post-intervention experimental group students drew the scientists as female, without eyeglasses, neat and well-groomed hair may be considered as a sign of that various implementations in learning environments contribute to the change of the perspectives of the students towards science. Moreover, it was pointed out that the students drew the scientists outdoors (yard, forest, and so on) at the end of the implementation whereas most of the students drew the working environment of the scientists as indoors (laboratory, etc.and so on). Likewise, it was inferred that the perspectives of the students about the work environments of the scientists were outdoors from the results obtained from DAST-C test depending on having science classes especially outdoors in Navajo elementary school in the study conducted by Monhardt (2003).

In the current research, it was realized that the students also drew theoretical and instrumental indicators about the indicators for scientific research. It was realized that the students used the symbols of research (microscope, telescope, and so on, and experimental tools) and technology (computer, television, and so on) before the implementation. However, the students removed the earlier symbols from the drawings after the implementation. Finally, there were no findings detected in both the pretests and posttests when the drawings of the indicators relevant to the inventions were examined.

Qualitative Conclusion and Discussion

As a result of the data analysis of semi-structured interviews, the themes “Relationship between Science and Mathematics,” “Mathematics in daily life,” “Technology Outlook,” “Engineering for Children,” and “Interdisciplinary Connection from Children’s Point of View” were constituted. Results indicated that the students considered Science, Technology, Mathematics, and Engineering disciplines as independent from one another and they did not have aesthetic concerns in the pre-interviews. It was pointed out that they were aware of that Science, Technology, Mathematics, and Engineering disciplines were associated with one another and art was necessary both in these disciplines and daily life after the STEAM implementation. As a result of the STEAM study conducted by Park, Kim and Yoon (2015), it was stated that the majority of the students were satisfied with the STEAM implementations and these implementations also had a supportive quality for their future careers and art. Similarly, the students stated that they were extremely satisfied with the STEAM implementations and enjoyed the implementations (Kim, Kim, Nam & Lee, 2012).

In the current study, the students stated that Science, Technology, Mathematics, Art, and Engineering disciplines were associated with one another *after* the STEAM implementations. In parallel with this result of the study, Park, Kim and Yoon (2015) deduced that the students realized convergent relationships of irrelevant disciplines, works, and science principle in appearance in their study.

In the light of the findings obtained in the current research, it was concluded that the students were aware of that each one of the STEAM disciplines was required in daily life. This result supports the emphasis of Yakman and Lee (2012) that not only STEAM implementations make the students interested in the science- technology- engineering- art- mathemetics disciplines, but also provide learning with real-life connections. Bybee (2011) states that students initially learn to use a number of tools (ruler, thermometer, and so on) during their units to solve an engineering problem, they present the measurements as quantitative data in the first years of school experience; experiences that they achieve in science courses improve their mathematics skills as they get to the upper grades. In the current research, it was concluded that “mathematics was used actively in science, and mathematics was also required for engineering studies” in accordance with this view of Bybee.

In the light of the results, it can be suggested that practical studies that improve the students’ perspectives towards the nature of science (the jobs related to science, scientists’ characteristics and field of studies and so on) can be implemented at learning settings. The Ministry of National Education in Turkey has reorganized the primary science curriculum (K4-8) according to STEAM implementations in 2017. MoNE put a new learning area that named as Practical Sciences for all grade levels in the primary science curriculum. In this context, it can be suggested that new learning areas can be added to the curricula of other disciplines (mathematics, technology, and design and so on).

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