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RESEARCH ARTICLE

Effectiveness of STEM-Based Activities on Middle School Students' Views About Socio-scientific Issues

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Abstract

The purpose of this study was to investigate the effectiveness of science, technology, engineering, and mathematics (STEM)-based activities on middle school students' views about socio-scientific issues. The research was designed according to a case study. The study was carried out on 16 seventh-grade students from the eastern part of Türkiye. Over a period of 24 weeks, in the fall and spring semesters, students participated in STEM activities focused on socio-scientific issues. Data collection tools included the socio-scientific issues interview form, student diaries, field notes, and informal interviews. Content and descriptive analysis methods were employed to analyze the data. The results showed that students' views on socio-scientific issues significantly improved, including their knowledge, sensitivity, awareness, ability in scientific reasoning, thinking habits, willingness to conduct research, ability to find solutions, and capability to prepare projects related to socio-scientific issues.

Keywords: Case study, middle school, science-technology-engineering-mathematics, socio-scientific issues

Introduction

Socio-scientific issues are controversial issues that contain economic, political, religious, ethical, and legal dilemmas that lack a clear solution, depend on consensus among scientists, and have simple results (Kolsto, 2001; Nielsen, 2012; Sadler & Zeidler, 2004; Sadler et al., 2006; Walker & Zeidler, 2007; Zeidler et al., 2002). Examples of socio-scientific issues include genetically modified foods, abortion, cloning, stem cells, alternative fuels, environmental pollution, nuclear power plants, global warming, biotechnology, gene therapy, recycling, climate change, and acid rain (Klop & Severiens, 2007; Kolsto, 2006; Puig & Jimenez-Aleixandre, 2011; Ratcliffe & Grace, 2003; Reis & Galvão, 2004; Sadler, 2004; Sturgis et al., 2005). The fact that a subject's content is related to science and has a place and importance in society makes it a socio-scientific issue (Eastwood et al., 2012). Since science and society cannot be separated from each other, they are complex, open-ended issues that involve both science and social factors, often involving dilemmas, without a clear answer (Sadler, 2004). For example, the issue of whether or not to build nuclear power plants is a socio-scientific issue, as it is both a scientific and a social issue and contains various uncertainties and contradictions. The cost of electricity produced in nuclear power plants is viewed positively by some segments because it can produce electricity throughout the year, stores the energy it produces for a long time, occupies less space than other power plants, and produces high amounts of energy, but in an accident that may occur, both nature and it is seen negatively by other groups as it has severe and destructive consequences for human beings.

Socio-scientific issues are open-ended; there is no exact solution, and there may be more than one logical solution (Sadler, 2011). Each individual or group approaches these events from a unique perspective. Their culture, religion, family structure, the education they receive, upbringing affect their thoughts and solutions regarding socio-scientific issues. Socio-scientific issues and their solutions are affected by social factors such as politics, the economy, and ethics (Sadler, 2011). The fact that some scientific subjects are at a level that can affect people's lives makes them socio-scientific issues. When a scientific issue affects human life, it is discussed by people, and everyone produces solutions from a different perspective. Since some scientific studies in fields such as health, environment, space, energy, industry, and economy affect the structure of society, scientific issues in these fields have societal cost. After these issues belong to society, they become controversial issues. These issues, which have become controversial, express both social and scientific problems without simple consequences (Kolstø, 2001; Sadler & Zeidler, 2005).

Socio-scientific issues are subjects that are conceptually related to science and represent important social problems and problems (Sadler et al., 2007), and they are influenced by the ethical and moral structure of students (Powell, 2014). That is, when an individual develops a solution proposal for any socio-scientific issue, his/her moral and ethical concerns affect this situation (Zeidler & Nichols, 2009). For example, regarding the hydroelectric power plant project to be established in any region, the opinions of the individuals living in that region about whether this plant should be established or not are influenced by their moral structure. Since such issues are open to discussion and contain

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uncertainty, and because the moral and ethical values of each individual may vary, different solution proposals arise for the establishment of such a power plant. As illustrated in this example, socio-scientific issues can appear as a global, national, or local field. Subjects that are meaningful and important for society, have a scientific basis, and do not have a single correct answer that contain important national and international issues (Ratcliffe & Grace, 2003). People are likely to encounter these issues, which have both scientific and social bases, in their daily lives (Christenson et al., 2014) because these issues are an important part of real life. With a Hydroelectric Power Plant (HEPP) project set to be established, it is inevitable that the people living in that region will confront it. The HEPP to be established has scientific, social, economic, and political elements. In fact, when a socio-scientific issue is dealt with or discussed, students' political perspectives come to the forefront as much as scientific factors (Dos Santos, 2014).

Characteristics of Socio-scientific Issues

Since socio-scientific issues typically involve moral and legal elements, they are the issues that are still being discussed, have not yet reached a conclusion and have no definitive solution (Nielsen, 2012; Walker & Zeidler, 2007). Socio-scientific issues are found as effective contexts for developing knowledge and processes that contribute to scientific literacy, including evidence-based discussion, consensus building, moral reasoning, and understanding and applying scientific content knowledge (Sadler, 2009; Zeidler & Sadler, 2011). It can be said that socio-scientific issues generally arise as a result of science and technology. Indeed, science and technology have begun to play a significant role in social life (Topcu, 2015). Therefore, an event/case/situation/innovation related to science/science and technology can seriously affect social life. For example, the decisions to be taken on subjects such as genetic copying, global warming, euthanasia, vaccination, nuclear power plants, and hydroelectric power plants, which are related to science, affect the future in regional and global terms (Topcu, 2015).

Every issue we encounter in daily life may not be a socio-scientific issue. There are several criteria that a subject must contain in order to be considered a socio-scientific issue. Socio-scientific issues include two main elements: (1) they should be related to scientific content and (2) they should have importance in social life (Eastwood et al., 2012). According to Mahanoglu (2019), when a researcher, teacher, or preservice teacher decides whether the scope of a subject includes a socio-scientific situation or not, they consider several questions. First of all, they ask, "Is it scientific?" "Does it have a dilemma?" "Does it include the interaction of Science-Society-Technology?" "Is it open-ended and does not have one correct answer?" and "Does the answer change depending on the ethical, moral, and emotional values of the people?"

Socio-scientific issues are issues or problems that have ethical, moral, economic, or even religious concerns but have a scientific basis and explanation (Yahaya et al., 2012). Some researchers stated that there are many disciplines involved in understanding these problems (Morris, 2014). In fact, the most important feature of socio-scientific issues is that it has a multidisciplinary nature (Morris, 2014). For example, HEPPs, which are a socio-scientific issue, have many dimensions such as socio-cultural, economic, ecological, moral and ethical, and political. It is beneficial to make a decision by considering all these dimensions regarding a new nuclear power plant to be established. Socio-scientific issues have various characteristics and qualities. Ratcliffe and Grace (2003) feature characteristics of socio-scientific issues (a) are based on science and are mostly within the scope of scientific knowledge, (b) involves generating ideas, and making choices at the personal or social level, (c) mostly reported by the media using communication tools, (d) related to unfinished information due to conflicting/incomplete scientific evidence, (e) have local, national, and global dimensions associated with political and social factors, (f) includes cost-benefit analysis affecting risk values, (g) involve taking into account sustainable development, (I) include values and ethical reasoning, (j) require an understanding of risk and possibility and (k) is usually related to real life (Ratcliffe & Grace, 2003, p. 2).

Since socio-scientific issues are controversial, relevant to society, and include various perspectives, they have a high potential to arouse interest among students (Eastwood et al., 2012). The use of socio-scientific issues in education is considered as issues related to contemporary society that not only require scientific knowledge to make informed decisions but also encourage active participation of students and develop students' discussion skills (Zeidler & Nichols, 2009). Therefore, it is important to incorporate socio-scientific issues as a context in school education (Christenson et al., 2014).

Socio-scientific issues are frequently used in science lessons due to their "being scientific" feature. In fact, transferring socio-scientific issues to students effectively is one of the important goals of science education (Walker & Zeidler, 2007). Teachers use many methods and strategies in teaching the content of science. Socio-scientific issues-based education proves beneficial for students to learn the content of science (Klosterman & Sadler, 2010). Considering this, it is thought that it will be beneficial for teachers to frequently include socio-scientific issues in their lessons. Unfortunately, it is observed that teachers do not always include such subjects in the desired level of lessons. One of the most important factors preventing the effective application of social problems to science education programs is teachers' personal beliefs (Hofstein et al., 2011). Teachers' personal beliefs, mentality, experiences, ideology, private life, etc. circumstances should not prevent such matters from being addressed.

Importance of the Research

Recently, many studies on science, technology, engineering, and mathematics (STEM) education have been conducted in the national and international literature (Adams, 2017; Akar, 2019; Akin, 2019; Chittum et al., 2017; English et al., 2017; Hare, 2017; Harris, 2018; Hebebci, 2019; Higde, 2018; Hinton, 2017; Jolly, 2017; Kager, 2015; Kavak, 2019; Kurtulus, 2019; Mahanoglu, 2019; Meadows, 2018; Taylor, 2019). These studies on STEM include scale development; teacher, preservice teacher, and student views toward STEM; attitude toward science, motivation; academic achievement; persistence of knowledge; creativity; knowledge transfer; critical thinking skills; problem-solving skills; and attitudes toward STEM. As a result of the examinations, it is seen that there are few studies used STEM-based activities to examine students' views about socio-scientific issues.

This study organized the learning-teaching process by integrating STEM activities to help middle school students to create awareness, to construct knowledge and skills, to develop their views, and opinions, and to have a sense of responsibility about socio-scientific issues.

Purpose of the Research

Within the scope of this study, the aim is to develop awareness, sensitivity, reasoning, and the ability to develop scientific solutions, as well as positive thoughts about issues such as global warming, environmental pollution, domestic waste, recycling, solar energy, wind and motion energy, beneficial and harmful use of technology, space pollution, and life in space. In accordance with this purpose, the effectiveness of STEM-based activities on middle school students' opinions and thoughts on socio-scientific issues was sought.

Methods

Research Model

In this study, a case study, one of the qualitative research methods, was utilized. In the case study, events, situations, or individuals

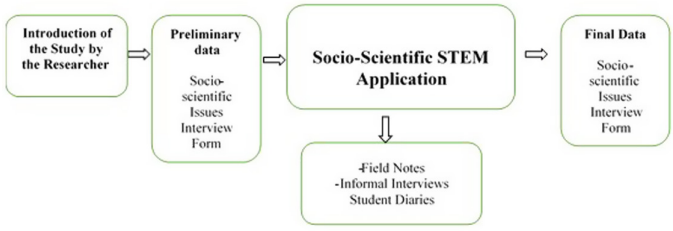


Figure 1.
Flow Diagram of the Study.

under investigation are examined within their natural environment, and the obtained data is interpreted and investigated in depth (Ekiz 2003; Hancock & Algozzine, 2006; Merriam, 2002; Yıldırım & Şimşek, 2013; Yin, 2008). In this study, it was tried to determine in detail the effectiveness of STEM-based activities on middle school students' views on socio-scientific issues. The flowchart of the study is given below in Figure 1.

Study Group

The sample of the study was selected from a middle school located in a region with a minimal level of development in Türkiye's central province of Van. The school where the study was conducted is located in a socio-economically and socio-culturally disadvantaged neighborhood of the city. The school is a prefabricated building and has a single floor. The school does not have a science lab, information technology and software classroom, visual arts workshop, gym, music classroom, and dining hall.

The study was conducted with 16 seventh-grade students. Eleven of the students are female and five are male. Fourteen of the students are 12 years old, one is 13 years old, and one is 11 years old.

Three of the students live in rented accommodations and 13 of them live in their own houses. Among them, 11 of them do not have their own rooms, while five do. Six students' houses are heated by a stove, while the others' houses are heated by a radiator (coal, natural gas, etc.). Only one student comes to school by their father's vehicle; the rest walk. Eleven students do not have a computer or Internet at their home. Also, it was determined that they did not receive any additional assistance (private teaching institutions, private lessons, etc.) for their studies. In addition, it was found that they live in crowded families, with a minimum of 2–14 siblings. All mothers of the students are housewives.

Data Collection Tools

Socio-scientific Issues Interview Form

With this form developed by the researchers, the aim was to investigate the opinions of the students on socio-scientific issues and how the application affected their views on these issues. In the process of developing the socio-scientific issues interview form (Table 1), a draft form consisting of 20 questions was first created and presented for expert opinion. The form was revised in the light of the feedback from experts, consisting of field experts and linguists, and a pilot application was conducted with five students. The finalization of the form consists of three parts and includes a total of 11 questions.

In the first part, the first nine questions are included. In this section, what the teachers think about whether to include socio-scientific issues in their lessons, whether they conduct research on socio-scientific issues, whether they discuss socio-scientific issues with their family or friends, their thoughts about recycling, people/countries using wind energy or solar energy, whether they were encouraged to express their thoughts on seeking ways of obtaining them, their ideas about domestic waste and global warming, humanity's emergence into space, research on space, research on the existence of life in space, and whether alternative energy is beneficial to humans. In the second part, the 10th and 11th questions in the interview form are included. With these questions, it is about whether the students can prepare a project on socio-scientific issues, whether the project they want to prepare is a product/tool/tool/invention or a social project, whether they can create a drawing if it is a product, and what the purpose, usefulness, and usefulness of the project they have prepared are. Thoughts are aimed to be determined. In the third part, a table of 23 common socio-scientific issues is provided. The students were asked which of these topics they had heard before, had information about, could research in their future life, and could prepare a project on, and they were asked to mark the most appropriate one for them. Based on the markings made: (1) socio-scientific issues, (2) detailed descriptive statistics on the basis of students were revealed under the themes "heard before," "had knowledge about," "wanted to do research on in his/her future life," and "wanted to prepare projects on it," and (3) detailed descriptive statistics on the basis of students were revealed.

The socio-scientific interview form was administered to all students in the study group in the form of pre- and post-structured interviews in the classroom environment. In order for the students to write their opinions more easily, a course time was given to them.

Student Diaries

Throughout the applications, "student diaries" were utilized for document analysis to determine the experiences, feelings, and thoughts of the students regarding the process. During the process, studies were carried out on a total of six different subjects, and a total of six separate diaries related to these studies were maintained. Each study was filled in by the students on the last day of the study and collected by the researcher the next day. The students in the study group were informed by the researcher about the purpose for which the diaries were attached and what should be considered while filling them. The diaries and dates kept by the students during the implementation of socio-scientific STEM designs are given in Table 2.

Field Notes

During the research process, the researcher opted not to use a formal observation form because the researcher was the person who carries out the applications in the role of "researcher-teacher" and takes an active role in the process of working together with the students in the applications tried to take notes as "participant observer." The researcher tried to identify in detail the important experiences of the students during the application process and immediately after the application, the researcher kept detailed "field notes" for the application process. The researcher kept own field notes at the end of each course in which studies were conducted in the "engineering design process." While the researcher was keeping the notes, the researcher tried to determine the feelings (i.e., likes, joy, hating, getting bored, etc.) and the levels of satisfaction felt by the students by means of the challenges experienced by the students during the application process, whether the students work in harmony with their group mates, the communication, and interaction levels of the students among themselves, the lack of materials used during the application process, the behaviors of the students in the application process, the performance of the groups, and the students' gestures and mimics, thus keeping notes for this purpose. The data obtained from the field notes are intended to support quantitative and qualitative data. Therefore, direct quotations from students assisted the researcher in the process of finding a solution to the research problem.

Informal Interviews

The researcher spent a lot of time with the students in practice before and after the applications (during breaks, in the hallway, in the garden, etc.) and conducted various informal interviews in a conversation style, both at their request and of their own request. Students' experiences

Table 1.
Socio-scientific Issues Interview Form

Chapter 1
1. Do you think that socio-scientific issues should be included in the lessons by teachers, why?
2. Magazines, Internet, etc. about socio-scientific issues do you research from sources, why?
3. Do you like talking about socio-scientific issues with your family or friends, why?
4. What do you think about the importance of recycling for humans and nature?
5. Do you think people/countries should look for ways to obtain energy using wind energy or solar energy, why?
6. What do you think about domestic waste?
7. Is global warming harmful to humanity, if it is, what can states do to prevent global warming?
8. What do you think about humanity's going to space, researching about space, researching that there is life in space?
9. Do you think alternative energy is useful for us, how?

Chapter 2
10. Can you design a project on socio-scientific issues, can you picture your project?
11. Do you think the project will benefit you or your family, friends, society, how?

Chapter 3
Please fill in the table below. Put an X in the box you think OK with you.

	Socio-scientific issues	I Have Heard About It Before.	I Have an Information About It.	I Can Do Research on This Subject in My Future Life.	I Can Prepare a Project on This Subject.
1	Domestic waste				
2	Genetically modified food				
3	Abortion				
4	Cloning				
5	Stem cell				
6	Alternative fuels				
7	Environmental pollution (water, soil, air pollution, etc.)				
8	Nuclear power plants				
9	Global warming				
10	Biotechnology				
11	Recycling				
12	Climate change				
13	Acid rains				
14	Blood donation				
15	Organic farming				
16	Extinct animals and plants				
17	Solar energy				
18	Earthquake				
19	Fuels (natural gas, coal, oil, etc.)				
20	Ozone layer				
21	Space technology				
22	Wind power				
23	Obesity				

during the implementation process, their suggestions and demands regarding the process, their curiosity about the socio-scientific issue dealt with in the application, and their views, and opinions about the implementation process were discussed, and a situation/event deemed important was noted. The data obtained from informal interviews are aimed at supporting qualitative data. Therefore, direct quotations from students assisted the researcher in the process of finding a solution to the research problem.

Data Analysis

In order to analyze the data, first of all, the transcript of all interviews, diaries, field notes, and informal interview notes were computerized. While transferring the students' answers to the computer, codes such as student 1, student 2, etc., were assigned to each student.

"Descriptive analyses" were made on the data obtained from the socio-scientific issues interview form. In the interview form, the answers that all students gave to the questions in the pre- and post-interviews were analyzed separately. A form was developed for students to analyze the first nine questions in the first part of this form. The developed form is given below in Table 3.

The first nine questions in the first part of the interview form were determined as themes, and they were given under these themes by

Table 2.
Socio-scientific STEM Applications and Diaries

Socio-scientific Topics	Draft Study	Date the Journal Was Filled
Recycling—domestic waste	Plastic bottle glass/tin can candle holder/surprise egg night lamp	November 2, 2017
Wind power—motion energy	Wind to light/from movement to light	December 7, 2017
Solar energy	Sun fan/fruit saw	January 4, 2018
Technology	Remote control with a bell	March 1, 2018
Global warming	Digital story	March 29, 2018
Space	Space rocket/space shuttle	May 3, 2018

Table 3.
Analysis Form of Student Answers Given to the First Nine Questions of the Socio-scientific Issues Interview Form

	Interviews (Student Expressions)		Researcher	Conclusion		
Themes	**Pre-interview**	**Final Interview**	**Assessment**	**No Change**	**Positive Change**	**Negative Change**

directly quoting the students' views. Afterward, the responses provided by the students to these questions in both the pre- and post-interviews were evaluated one by one by the researcher, and as a result, it was decided whether there was a change in their views during the application process, and if there was a change, whether this change was "positive" or "negative."

A separate form was developed for the analysis of the 10th and 11th questions in the second part of the socio-scientific issues interview form. This developed form will be provided on the following pages. The drawings that the students created and described regarding the project topic they wished to address within the scope of socio-scientific issues, as prompted by the 10th and 11th questions, were compared. The frequency values of the data obtained from the table in the third part of the socio-scientific issues interview form were also examined.

"Content analysis" and "descriptive analysis" methods were used on the data obtained from the student diaries. In analyzing the diaries, readings were made on the interview data on the computer. After the readings, the codes were created by the researcher, and the created codes were gathered around certain themes. In the study, a second researcher independently reexamined the compatibility of student views to the codes and themes created by the first researcher, and the consistency percentages between the coding of the two researchers were calculated according to the formula proposed by Miles and Huberman (1994). According to this formula, the percentage of consistency between all coding of the two researchers was found to be sufficient in terms of demonstrating the reliability and consistency of the coding since it was above the 70% rate suggested by the mentioned researchers.

A "descriptive analysis" was made about the notes taken by the researcher in the field notes and the formal interview form, and the data obtained from the interview form and the data obtained from the diaries were used as supportive by triangulation, and direct quotations were made from these data.

Role of the Researcher in the Application

The practitioner is also the teacher conducting the science course of the study group and has assumed the role of researcher. The researcher is a 36-year-old male with 10 years of experience in the same school for 9 years and holds a PhD in science education. From the beginning to the end of the study, the researcher himself served as a tutor and participant observer. During the process, the researcher gained experience with the students, working with them in various locations such as the corridor, garden, canteen, etc. He spent time in the fields of study, took notes in the classroom where the study was conducted, and conducted informal interviews with students about the application. The researcher recorded all necessary data using data sources and analyzed the data, taking an active role in all stages of the study.

Application

This study was conducted during the first and second years of the 2017–2018 academic year, and was carried out in a period covering the semester. Before starting the study, necessary permissions were obtained from the Ministry of Education and the parents of the students, after the necessary permissions were obtained, the school administration was interviewed, and a road map was drawn for the study as a result of the meeting. After obtaining the necessary permissions and conducting the interviews, the study started to be carried out with 16 students in the seventh grade of a secondary school in Van. The study lasted for 24 weeks. In this context, the application started in September 2017 and continued until the last week of May 2018 (Table 4).

The studies were carried out by taking into account the official calendar published by the Ministry of National Education for the 2017–2018 academic year. In the first week of the study, detailed information about the work to be done was presented to the study group students. Working groups were formed, and pre-interviews were conducted. The groups were formed by the students and named their groups as "4 × 4," "Ladybug," "Crazy," "Fantastic," and "Talented." The study was implemented in the Science Applications elective course given for 2 hours a week. In the first semester of the study, three and II. STEM drafts were prepared on a total of six socio-scientific issues, three of which were in the semester. In the fall semester, students made "glass from plastic bottle," "tin candle holder," and "night light from surprise egg" on "Domestic Waste/Recycling." They have developed "wind to light" and "motion to light" designs on "Wind Energy/Motion Energy." They designed a "solar propeller" and a "fruit saw" on the subject of "Solar Energy." In the spring semester, students designed "bell control" on "Technology," "digital story" on "Global Warming," and "space rocket" and "space shuttle" on "Space."

In the process of forming their designs, the groups followed the "engineering design process" outlined by Hynes et al. (2011). The design process for each socio-scientific issue was conducted over 4 weeks. One of the studies (Global Warming: Digital Story) that the groups carried out during the application depending on the engineering design process is detailed below in Table 5. The engineering design process, which is followed weekly, is given below as follows:

Studies Performed in the First Week

The teacher said that he would study global warming and primarily provided information to the students about global warming by using various audio-visual equipment. The groups first defined the global warming problem and identified needs related to this issue. The students attempted to get an idea about the design to be made by using the tablet, mobile phone, and computers provided by the teacher for one lesson. The students both exchanged ideas with the teacher in the

Table 4.
Application Process of the Study

Period	Week	Application	Total Class Hours	Data Collection Tools
Fall	1 week	Pre-interview	2	Socio-scientific issues interview form (front)
	4 weeks	Recycling—domestic waste	8	- Field notes - Informal interviews - Student diaries
	4 weeks	Wind energy—motion energy	8	
	4 weeks	Solar energy	8	
Spring	4 weeks	Technology	8	
	4 weeks	Global warming	8	
	4 weeks	Space	8	
	1 week	Making the last interview	2	Socio-scientific issues interview form (last)

Table 5.
Engineering Design Process Followed Weekly

Engineering Design Steps	Week	Hour
1. Describe the need or problem 2. Researching the need or problem	Week 1	2
3. Developing possible solutions 4. Choosing the best solution	Week 2	2
5. Prototyping 6. Testing and assessing the solution 7. Offering the solution	Week 3	2
8. Redesign/revision 9. Decision to finalize	Week 4	2

group and discussed the type of project they would develop on "global warming." They discussed whether the draft to be made in this regard would be useful, beneficial, necessary, and impactful. Each group initially brainstormed within their group, recorded the decisions they reached on a piece of paper, and submitted them to the teacher. The teacher evaluated the ideas received from all groups together with all the students. With the teachers and students reaching a common idea, it was discussed how to develop a solution to realize the problems that global warming has and will create for the world and how to make a design for this.

Studies Performed in the Second Week

This week, the groups developed their possible solutions and chose the best one. For this, they have reconsidered the bill they are considering making about global warming and developed their ideas. All ideas were discussed in detail, and as a result, it was decided to design a "digital story" as the best solution for global warming, with the teachers and students reaching a common idea. Teachers and students have determined what materials are required for the design. The materials required for the draft are given in Table 6.

Student 12 in the study group stated that he had information on this subject, that he/she was doing this and similar studies, and that he/she could help his/her friends. The next day, both the teacher and student 12 taught all students in the classroom for one class hour on how to create a digital story. Student 12 is a student who is knowledgeable and skilled in using the Internet, technology, computer, and computer programs. In addition, S12 has a social media channel where his/her videos are broadcast. This student has the knowledge, ability, and experience to create videos in digital media. Therefore, he/she has technical knowledge about video creation programs and running these programs.

Studies Performed in the Third Week

After learning how to create a digital story the previous week, all students made a prototype for a solution, tested, and presented the solution. The teacher, along with student 12, had instructed all students in the class on how to create a video using a computer program during the previous week. The program was installed on the teacher's own computer and the other three computers provided by the teacher (five computers in total). Student 12 brought these additional computers from home, which were then distributed to all groups. For this purpose, all groups shared the materials brought by the teacher, and necessary checks were made regarding the deficiencies.

The groups rethought their proposals and further refined their ideas. All group members created their first videos about the design that their group will make and share them with their group friends. As a group, they evaluated each video and decided which photo, which music, and which image to use. In addition, each group member wrote a story on global warming and evaluated the stories they wrote. Then they determined which story they would use and which order in the group they would sing the story they wrote. All groups presented the videos, pictures, images, sounds, music, and stories they had prepared for prototype production. Necessary controls were made by them and later with the assistance of the researcher-teacher. Any missing music, images, or sounds were requested from the teacher, and they addressed their deficiencies accordingly. Later, all groups created the first prototypes of their video. The groups tested their digital stories, and as a result of the examination, it was seen that all the designs made by the groups worked effectively. All groups recorded their videos for rework the following week. The work performed by the groups during the application are given in Figure 2, Figure 3, Figure 4, Figure 5, and Figure 6 in detail;

1. Students first gathered information about global warming from various sources (books, magazines, Internet, etc.) and formed a story based on this information.
2. Then, they installed the video creation program on the computer.
3. At this stage, the students started running the program and uploaded the photos, animations, cartoons, and pictures they had prepared before. While making these uploads, they calculated which photo or picture would follow which order and how many seconds these photos and pictures would remain on the screen. In addition, during the installation, which text, slogan, warning sign, etc. on the screen arranged that it would be.
4. At the end of the process, they vocalized the previously written story using microphone and headphones. At this stage, how many seconds the voiceover will be made, which sentences in which image will be said in what seconds/time, etc. They made detailed time/time measurements regarding. A quiet environment was created, allowing all groups to create and save their digital stories sequentially.

After all groups finalized their digital stories, all digital stories created were watched in front of the classroom, and it was determined that the designs created by all groups worked in the desired quality.

Studies Performed in the Fourth Week

In the last week of the engineering design process, all groups revised their designs and made decisions. In the last week of their work, all groups reconsidered their designs and further developed the design. Those, who have completed the missing parts, and those, who wanted to revise, have revised and finalized their designs. After making the necessary corrections, they finalized their digital stories.

Table 6.
Materials Required for "Digital Story" Design

Computer	Video Recording Program	Microphone	Speaker–Headphone
			
Photo/image/video on global warming	Photo, picture, music, clip, etc. to be used in the digital story.		

Figure 2.
The Draft-1 Stages of "Digital Story." (A) Ladybug Group and (B) Fantastic Group.

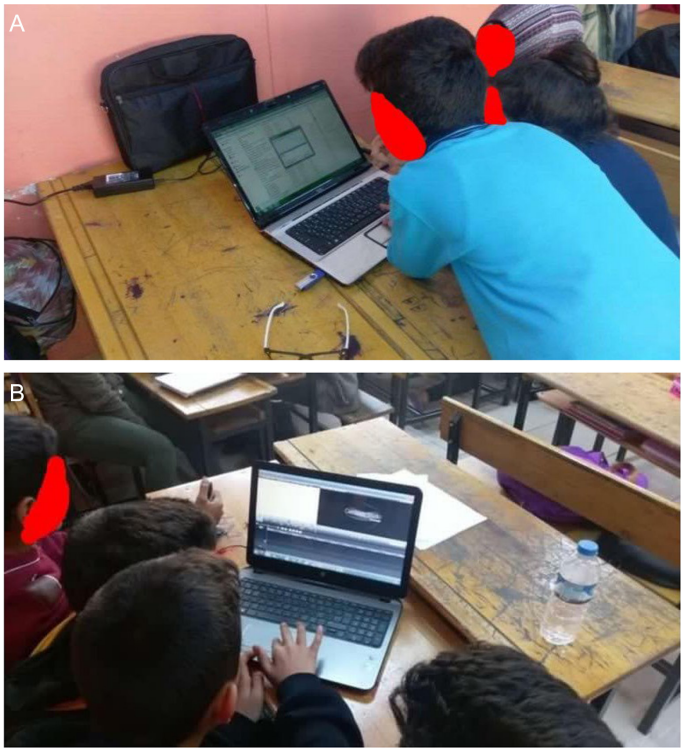


Figure 3.
The Draft-2 Stages of "digital story." (A) Talented Group. (B) Fantastic Group.

All groups benefited from the fields of science, mathematics, engineering, and technology while working on creating their designs. The STEM fields utilized by the groups and the work they have carried out regarding these fields are given in Table 7.

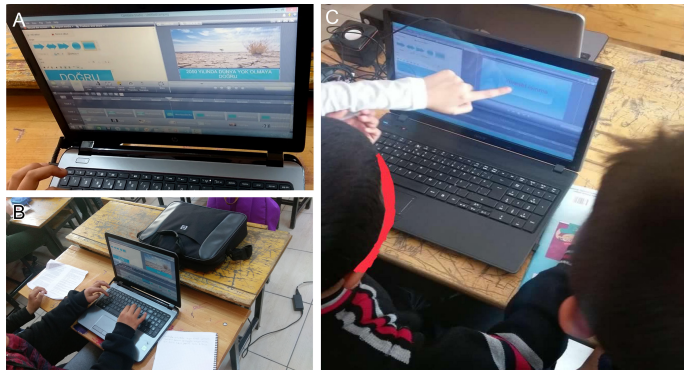


Figure 4.
The Draft-3 Stages of "Digital Story." (A) Crazy Group, (B) Crazy Group, and (C) Ladybug Group.

Figure 5.
The Draft-4 Stages of "digital story." (A) Group of 4 × 4.

Figure 6.
Final Version of "Digital Story." (A) Crazy Group.

When Table 7 is analyzed, it is seen that the groups benefit from all fields of STEM in their studies. Based on this, it was concluded that the studies of the students on "digital story" are suitable for STEM education.

Throughout the drafting process on the "digital story," the researcher-teacher observed the students and kept the developments they deemed necessary in the form of notes. He also conducted informal interviews with students throughout the process. On the day the application ended, the teacher asked the students to keep a diary to write down their feelings and thoughts about their work, and collected the diaries the next day.

Above, only STEM studies on "Global Warming" are presented in detail. All of the detailed studies on technology were progressively

Table 7.
STEM Fields Used by Groups for the Digital Story Project and Their Studies in These Fields

Draft	STEM Fields	Works Done
Digital Story	Science	- Scanning various sources such as Internet, books, magazines, and collecting information about global warming, which is one of the socio-scientific issues. - Making studies on climate/weather events/seasons.
	Mathematics	- Calculation of duration/time control.
	Engineering	- Designing a video using the given materials (picture, photo, music, sound, etc.).
	Technology	- Using a cell phone/computer/tablet. - Using the Internet - Taking pictures/videos

carried out on the subjects of "Domestic Wastes/Recycling," "Wind Energy/Motion Energy," "Solar Energy," "Global Warming," and "Space," hence obtaining similar results.

Internal and External Validity of the Research, and Ethics

In order to increase internal validity (credibility) in the study, data diversity was provided to reveal whether the data support each other or do not contradict each other, and many qualitative data collection tools such as diaries, field notes, and informal interviews were used for this purpose. In the analysis of qualitative data, an independent expert other than the researcher was involved in the process. In the study, the researcher observed the students throughout the research, took field notes, made informal interviews with them during the lecture, between lectures, in the recess, in the corridor, and took note of the important data he obtained. Thus, the researcher had a long-term interaction with qualitative data sources. In the study, the data obtained were continuously compared with each other, combined, interpreted, and inferences were taken from these data. The data obtained from the interviews were shared with the participants and confirmation about their accuracy was obtained. In the study, in order to increase external validity (transferability), attention was paid to transferring all steps of the study in a way that the reader can understand and to make detailed descriptions of the data. In order to increase the transferability, the characteristics of the students in the study group were also presented in detail, care was taken not to be biased in the application of data collection tools, data collection, data analysis and interpretation, and direct quotations were made from the students' opinions on socio-scientific issues.

In addition, within the framework of the ethical study, all necessary legal permissions have been obtained for the actual implementation. The study received ethical approval from the İstanbul University (File No: 2017/89, Approval No: 126531, Date: 26.10.2017). The approval of the students and parents in the study group was obtained before the actual implementation, they were informed that participation of all the students in the study group is voluntary as well as on the reason for the research, how long the research will take, what phases will be completed, and where, how, and for what purpose the data collected in the research will be used. In the photographs used in the study, it was ensured that the student's faces were not visible as much as possible, and the visible face was covered. In addition, the real names of the students were not used in the study, instead, a code was given to each student in accordance with ethical rules and reported.

Results

Results Obtained from the Socio-scientific Issues Interview Form

Results obtained from the first part of the socio-scientific issues interview form (questions 1–9) was used to analyses the data (Table 8). The first nine questions in this form were determined as themes and the answers given by the students in the pre- and post-interviews were placed directly into these themes and the researchers evaluated whether there was a change in their views. Table 8 is related to the analysis of Student 1's views as an example.

The opinions of all students in the study group in the pre- and post-interviews were analyzed individually as above, respectively, and the results of the opinions of all students are given in Table 9. As a result of the analysis, students' views were marked as + for "positive change," − for "negative change," and 0 if there was no change.

When Table 9 is analyzed, it is seen that Student 1's views on alternative energy did not change and that there was a "positive change" in all his/her other views. On April 28, 2018, the researcher; "S1 came to me today during the lecture and shared with me his/her ideas that the effects of global warming are very bad, that he examined photos, pictures, videos, and texts written about global warming, that he/she is very sorry for the world, and if it goes on, living things will disappear." "I don't know" in the preliminary interview and in the last interview, "Domestic wastes damage the environment." We can create useful products from some household waste, and his/her views support this finding.

It was concluded that there was a "positive change" in all of Student 2's views on socio-scientific issues. Researcher, on January 5, 2018, noted in an informal interview, "S2 said that he had never known that solar energy is a very useful energy today, and from now on, he wants to make various projects using solar energy continuously." In S2's preliminary interview, he stated, "I have not heard of this issue before." In the last interview, "It is necessary to evaluate the domestic wastes. I think we can use them in projects and recycle them. Thus, we turn something harmful into something useful." His views support this finding.

It was observed that there was no change in the views of Student 3 about space, which is one of the socio-scientific issues, while there was a "positive change" in his views on all other issues. Regarding the subject of space, the student already had positive thoughts in the preliminary interview, and it is thought that there was no change since he had similar positive thoughts in the last interview. On November 2, 2017, the researcher noted, "I liked that when S3 was making a design about the surprise egg, he said, "Sir, I used to throw them all away. This means that our students are becoming aware of recycling and domestic waste." In the preliminary interview about global warming, and the field note he received in the form of "Both harmless and not harmless. While it affects some people badly, it affects other people for the better." In the last interview, the student stated, "Global warming is, of course, harmful. Public transportation should become a rule so that the environment is less polluted." This supports the positive change in the student's opinion on socio-scientific issues.

It was observed that there was a "positive change" in the views of Student 4 about all socio-scientific issues. On December 7, 2017, the participant-researcher noted, "While the designs were being made in today's lesson about wind energy, S4 said to me, "My teacher, I never knew that we could generate electricity with wind, it is a very enjoyable job, so if we use it at home, our electricity bill may not come at all." "I don't think anything about it." In the last conversation, he stated, "This way, fewer trees are cut down. Because paper is made

Table 8.
Change in Student 1's Opinions on Socio-scientific Issues According to the Pre- and Post-interview Forms

	Interviews (Student Expressions)			Conclusion		
Themes	**Pre-interview**	**Final Interview**	**Researcher Evaluation**	**No Change**	**Positive Change**	**Negative Change**
Teachers include socio-scientific issues in the lessons	*No. Because it is good not to use socio-scientific issues as information.*	*Yes, Perhaps*	In the preliminary interview, the student does not know exactly what socio-scientific issues are, so the student thinks that having information on these issues is negative. In the last interview, it was seen that the student had information about these issues and the student found it positive that teachers included these topics in their lessons.		✓	
Making research about socio-scientific issues	*I don't know.*	*Yes, Perhaps*	In the preliminary interview, the student does not know whether he/she has done research because he/she does not know what these issues are. In the last interview, he/she views this positively.		✓	
Talking about socio-scientific issues with family or friends	*It doesn't because it's not nice.*	*Sometimes we talk.*	The student stated that he/she did not talk about these issues with his friends and family in the preliminary interview, but that he/she did talk sometimes in the last interview.		✓	
Thoughts about recycling	*It can be a useful thing.*	*Recycling is important and a good thing.*	In the preliminary interview, he/she predicts that the recycling can be good, and in the last interview, he/she states that it is important with certain expressions.		✓	
Searching for ways people/countries use wind or solar energy	*Yes, because the house warms better in winter.*	*Yes. Because these energies are beneficial energies.*	In the preliminary interview, he/she cannot fully express her thoughts, and in the last interview he/she states that these energies are beneficial energies.		✓	
Thoughts about domestic waste	*I don't know.*	*Domestic wastes harm the environment. We can create useful products from some of the domestic waste.*	While he/she did not have any thoughts about domestic wastes in the preliminary interview, in the last interview, he/she thinks that domestic wastes harm the environment and that useful products can be obtained from these wastes.		✓	
Thoughts about global warming	*Not harmful.*	*Very harmful. People die, animals die, plants die.*	While he/she thinks that global warming is not harmful in the preliminary interview, in the last interview he/she states that it is harmful and that living things are negatively affected by it.		✓	
Thoughts about space	*So, living in space is not very good because they can die in space, which is a bad thing.*	*Space exploration is very important. They can find new worlds, which will be good for us.*	While he/she had negative thoughts about space in the preliminary interview, he/she thought that space exploration was important and could be beneficial for humans in the last interview.		✓	
Thoughts about alternative energy	*I don't know.*	*I have no idea.*	He/she did not have any thoughts about alternative energy in the pre-interview and the last interview.	✓		

Table 9.
Change of Students' Opinions in the Study Group on Socio-scientific Issues According to the Pre- and Post-Interviews

	Students															
Themes	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**	**S11**	**S12**	**S13**	**S14**	**S15**	**S16**
Teachers include socio-scientific issues in the lessons.	+	+	+	+	+	+	+	+	+	+	+	+	**0**	+	+	**0**
Making research about socio-scientific issues.	+	+	+	+	+	+	+	+	+	+	+	+	+	**0**	+	**0**
Talking about socio-scientific issues with family or friends.	+	+	+	+	**0**	+	+	+	**0**	+	+	+	+	**0**	**0**	**0**
Thoughts about recycling.	+	+	+	+	+	+	+	**0**	**0**	+	**0**	**0**	**0**	**0**	**0**	**0**
Searching for ways people/countries use wind or solar energy.	+	+	+	+	+	+	+	+	**0**	+	+	+	+	+	+	+
Thoughts about domestic waste.	+	+	+	+	+	+	+	+	**0**	+	+	+	+	+	+	+
Thoughts about global warming.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	**0**
Thoughts about space.	+	+	**0**	+	+	+	+	+	+	**0**	**0**	**0**	**0**	+	+	**0**
Thoughts about alternative energy.	**0**	+	+	+	+	**0**	+	+	+	+	+	+	+	+	+	+

from trees, and if we recycle them, fewer trees would be cut down. If we collect the plastic bottle caps, we will provide cars for the disabled." His views support this finding.

It was observed that there was no change in the idea of talking about socio-scientific issues with the family and friends of the Student 5, and there was a "positive change" in his views on all other issues. S5 stated that he/she talked about these issues with his/her family both in the pre-interview and in the last interview, so it was considered normal that his/her views on this issue did not change. The researcher said on January 4, 2018, "While S5 was running the project they made about solar energy in the garden of the school, this solar energy of the teacher was a great thing. It's free." "This situation made the students realize the importance of solar energy, and in the preliminary interview of S5

about recycling, they said "I don't think anything." In the last meeting, they stated, "Very important. If we recycle rather than throw away, we create very useful products. Thus, our country develops."This supports the positive change in the student's opinion on socio-scientific issues.

It was observed that there was no change from the pre-interview to the last interview in the opinion of the Student 6 about alternative energy, and that there was a "positive change" in his/her views on all other issues. S6 thinks that alternative energy benefits us both in the pre-interview and in the last interview but cannot explain how it does. On May 3, 2012, the researcher noted, "While chatting with S6 during recess, he/she said that he/she had no knowledge of space before, after these practices, he/she now had knowledge and became curious about space-related issues, and that if he/she had not adopted the profession of lawyer so much, he/she had an interest in the astronaut profession. In the informal interview note and during S6's preliminary interview about global warming, they responded, "I don't know. No idea." In the final interview, they stated, "Harmful. Because the glaciers are melting. States should say use public transport to prevent global warming, or suggest using bicycles instead of cars." This supports the positive change in the student's opinion on socio-scientific issues.

It was observed that a "positive change" occurred in the views of Student 7 on socio-scientific issues. On November 3, 2017, the researcher noted, "While talking to S7 in the garden, he said that it is a very good thing to do useful things from household waste by not throwing it away, that he/she will not throw away things that he/she has never done before but now consider important, maybe he/she can do good things from them. In the preliminary interview about the informal interview note he/she received and S7's thoughts on including socio-scientific subjects in teachers' lessons, they initially responded, "I don't want it, because there are enough lessons already." In the last meeting, they stated, "I want it because I want to be more knowledgeable and careful about these issues." This supports the positive change in the student's opinion on socio-scientific issues.

It was observed that there was no change from the pre-interview to the last interview in the opinion of the Student 8 about recycling, and that there was a "positive change" in his views on all other issues. S8 explained in both the pre-interview and the last interview that recycling should be done and discussed the possible damages that may occur in case of not being done. On December 7, 2017, the researcher noted, "The S8 came to me while the design was being made and said, "My teacher is very windy here too, it would be very useful if a wind turbine was installed there." Thanks to this application, the student realized the benefits of wind energy." "I don't know." In the last interview, they stated, "It is harmful because if global warming cannot be prevented, global warming will destroy the world." It supports the positive change in the student's opinion on socio-scientific issues.

Student 9 talks with his/her family and friends about socio-scientific issues, people/countries looking for new ways to use wind and solar energy, and there is no change in their thoughts about domestic wastes has been seen. S9, both in the preliminary interview and in the last interview, had positive thoughts on socio-scientific issues with his/her family and friends about recycling, domestic waste, wind, and solar energies. Therefore, we cannot expect these to change anyway. In the student's preliminary interview about global warming, "It is harmful, but I don't know what to do." In the last interview, they stated, "Harmful. (1) It should ensure that public transportation vehicles are used instead of automobiles, (2) measures should be taken not to spill oil into the water, (3) it should create rules in order not to pollute the environment. The opinions expressed in the form support that there is a positive change in the student's views on other socio-scientific issues that he/she is distant from.

It was observed that the Student 10's views on space did not change during the process, and that a "positive change" occurred in all other issues. S10 has positive thoughts about space exploration both in the pre-interview and the last interview. Therefore, we cannot expect these to change anyway. On December 1, 2017, the researcher noted, "During the course, S10 said that it would be very good to heat the house by using other energy instead of coal, for example, a mechanism could be designed using wind and this mechanism could heat the house. But he/she has no idea how this mechanism could be." In the preliminary meeting about the informal interview note that S10 received in the form of "I do not know." and in the last interview "Yes." Bad fuels are damaging to us. For example, coal. We use useful energies instead." It supports the positive change in the student's opinion on socio-scientific issues.

It was observed that the Student 10's views on space did not change during the process, and that a "positive change" occurred in all other issues. S11 has positive thoughts about recycling and space exploration in the pre-final interview. Therefore, we cannot expect these to change anyway. The researcher noted on March 29, 2018, "During digital story creation, S11 said, "Friends, let's put this video on the Internet so everyone is aware of global warming." It was seen that other friends in the group of 4 × 4 approached this idea with enthusiasm and S11's pre-interview on alternative energy. No idea." In the last meeting, "I think it is beneficial for people and the environment."It would be more beneficial, comfortable, and easy to use instead of electricity." This supports the positive change in the student's views on socio-scientific issues other than recycling and space.

It was observed that the Student 10's views on space did not change during the process, and that a "positive change" occurred in all other issues. S11 expressed positive thoughts about recycling and space exploration in the pre-final interview. Therefore, it seems normal that their thoughts on these issues do not change. In the pre-interview about global warming, the student said, "We should try to reduce the fumes of factories." In the last interview "Our water resources dry up, glaciers melt. To stop this, factories should make it mandatory to put a filter at the end of their pipes." This supports the positive change in the student's views on socio-scientific issues other than recycling and space.

It was observed that the Student 13's views on space did not change during the process, and that a "positive change" occurred in all other issues. S13 expressed positive thoughts about recycling and space exploration both in the pre-interview and in the last interview. Therefore, it is natural to expect no change in these views. In the pre-interview about global warming, the student said, "It is harmful." In the last interview "I think the state should warn people, to keep the environment clean and protect nature and living things. Everyone should do their best." This supports the positive change in the student's views on socio-scientific issues other than recycling and space.

It was observed that the views of the Student 14 about conducting research on socio-scientific issues, chatting with his/her family and friends on these issues, and recycling did not change during the process, while there was a "positive change" in his/her views on all other issues. S14 had positive thoughts about researching socio-scientific issues, chatting with his/her family and friends on these issues, and recycling in both the pre- and post-interview. Therefore, we take it naturally for them not to change. In the pre-interview about global warming, the student said, "I have no idea." In the last interview, "Now let them build new gardens and parks instead of building buildings, industries, factories."These opinions generally support the positive change in the student's opinion on socio-scientific issues.

It was observed that the views of the Student 15 about conducting research on socio-scientific issues, chatting with his/her family and

friends on these issues, and recycling did not change during the process, and there was a "positive change" in his/her views on all other issues. S15 had negative thoughts about chatting with his/her family and friends on these issues both in the pre-interview and in the last interview. On the contrary, he/she had positive thoughts about recycling. In the pre-interview about global warming, the student said, "I do not know what it is." In the last interview, "I think household wastes should be recycled." The opinions expressed in this form support the idea that there is a positive change in the student's opinion on socio-scientific issues in general.

Student 16's views on socio-scientific issues in teachers' lessons, researching socio-scientific issues, chatting with family and friends on these issues, recycling, global warming, and space did not change during the process (both in the pre-interview and in the last interview). It has been observed that there has been a "positive change" in his/her views on other issues. The researcher noted on January 5, 2018: "Speaking with S16 today, he/she said that he/she loved the activity they carried out on solar energy, realized that solar energy is a useful energy, and that it would be good to use solar energy in home lighting." In the informal interview and the pre-interview about alternative energy, S16 said, "I do not know." In the last interview "Yes, I think: for example, we use solar energy instead of electrical energy. This is also beneficial to us." The opinions expressed in the form support that there is a positive change in the student's opinion on socio-scientific issues in general.

When evaluated in general, it was observed that three students underwent a "positive change" in all nine themes, six students in eight themes, three students in seven themes, two students in six themes, one student in five themes, and one student in three themes, and no student had a "negative change." Thirteen (13) students did not have a metamorphosis in at least one theme. As a result of the detailed examination of the views of these students, it was concluded that they had positive thoughts in both the pre- and post-interviews about the themes that did not change their views.

Findings Obtained from the Second Part of the Socio-scientific Issues Interview Form

In the socio-scientific issues interview form, it is determined whether the students will be able to prepare a project on this subject, whether the project they want to prepare is a product/tool/equipment/invention or a social project, if it is a product, whether they can draw it, the purpose of the project they have prepared, and its benefit and usefulness. Two questions were asked related to these aspects. The projects of the students in the pre-interview and the last interview are given in Table 10.

When Table 10 is examined, eight students on socio-scientific issues stated in the pre-interview that they could prepare a project. It is seen that all of the projects carried out by these students are in the form of products/tools/devices. Four of these projects were not conducted on any socio-scientific issue. The remaining four include socio-scientific issues. It appears that there are two projects to collect the garbage around us, one project related to recycling and global warming.

In the last interview, it was observed that all of the students (16 people) in the study group definitely considered doing a project. Nine of the students thought of preparing social projects about the product/tool/device, while the remaining seven students planned for social project. It is seen that only one of the product/tool/device projects is not related to socio-scientific issues, and the remaining eight projects are related to these issues. It is seen that four of these projects are about space, one is about collecting garbage in our environment, one is about preventing water and environmental pollution, one is about obesity, and one is about recycling. It is seen that one of the social projects is not related to socio-scientific issues, and the remaining six issues are related to these issues. It is seen that one of these projects is about preventing the pollution of our environment by oil, one is about preventing environmental pollution, one is about finding solutions to obesity, one is about global warming, and two is about increasing the importance of blood donation. There is another remarkable result here, it is observed that four of the students who make product/tool/device projects on socio-scientific issues are male and four are female students, but all of the students who prepare social projects (S1, S3, S4, S6, S7, S10, and S15) are female students.

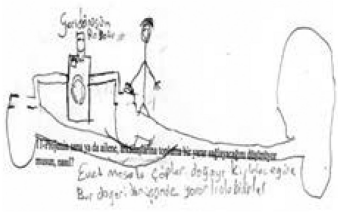
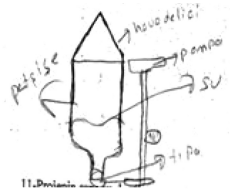
Findings Obtained from the Third Part of the Socio-scientific Issues Interview Form

In the last part of the socio-scientific interview form, students were given a table about "which of the socio-scientific issues they have heard before, which socio-scientific topics are knowledgeable about, which socio-scientific issues they want to do a research on in their future life and prepare a project"" (Table 11), and they were made to mark the one that suits them best.

Based on the markings made: (1) socio-scientific issues, (2) detailed descriptive statistics on the basis of students were revealed under the themes "heard before," "had knowledge about," "wanted to do research on in his/her future life", and "wanted to prepare projects on it" and (3) detailed descriptive statistics on the basis of students were revealed. In order to collectively evaluate the approaches of the students in the study group to socio-scientific issues in the pre- and post-interviews, the attitude tables of all students to socio-scientific issues were examined in the pre- and post-interviews and various descriptive statistics related to these views were revealed.

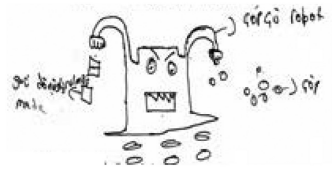
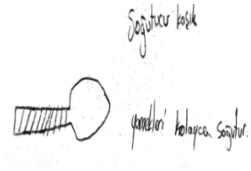
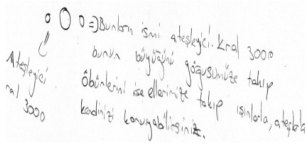
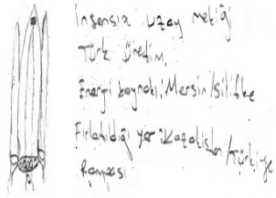
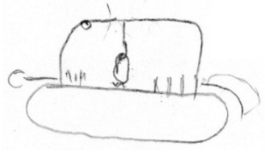
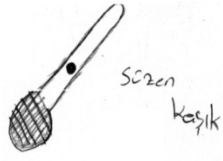
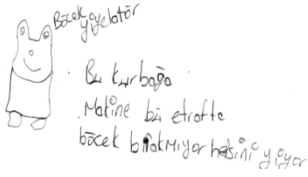
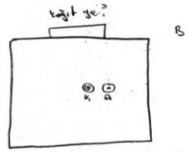
The students in the study group completed the table in the socio-scientific issues interview form based on their responses. This table comprises 23 common socio-scientific issues. The students were made to mark the topics that they had heard before, that they had knowledge, that they would do research on their future life, and that they could prepare a project on them. Accordingly, a total of 418 markings were made in the pre-interview, while 744 markings were made in the last interview. In the pre-interview, it is seen that the most marked theme is "the socio-scientific issue that you have heard before" (292 markings), and the least marked theme is "socio-scientific issue that can prepare a project on it" (9 markings). In the last interview, it is seen that the most marked theme is again "the socio-scientific topic that he heard before" (357 markings) and "the socio-scientific issue that can prepare a project on it" (88 markings). While the students made a total of 292 markings on socio-scientific topics that they had heard about before in the pre-interview, it was seen that the number of these increased to 357 in the last interview. While a total of 71 markings were made in the pre-interview regarding the "socio-scientific issues they had information about," the number of these increased to 192 in the last interview, 46 markings were made in the pre-interview on socio-scientific topics that they could "do research on," 111 markings were made about this in the last interview. While there are 9 markings in the pre-interview about the subjects that can prepare a project, it is seen that the number of them increased to 84 in the last interview. According to this, it is seen that the biggest increase in the pre- and post-interviews is the "socio-scientific topics that students have knowledge about," the least increase is "the socio-scientific topics that they have heard about before" and "the socio-scientific topics that can research on." Although the most and the least markings were made in the pre- and final interviews in the themes of "socio-scientific topic that the student had heard before" and "a socio-scientific topic that can prepare a project on it," it is seen that the biggest difference is "the socio-scientific topic on which the student has knowledge" and "the socio-scientific subject that can prepare a project on it."

Table 10.
Students' Pre- and Post-Interview Data on Socio-Scientific Issues Projects Prepared

	Project		Type of Project	
	Pre-interview	**Final Interview**		
Students	**Project and Student Expressions**	**Project and Student Expressions**	**Product/Tool/ Device**	**Social Project**
S1	X	*Oil harms people. I make a project to make it less harmful.*		✓
S2	 *For example, garbage can be useful in recycling, instead of polluting the nature.*	 ***Space Rocket:*** *We can build a space rocket powered by water. We filled with air in it, it ensures pressure and it flies. Thus, we do not use harmful fuels. In this way, it benefits society.*	✓	
S3	X	*Project name: "Environmental pollution": I can protect the environment by throwing the garbage into the garbage bin or recycling instead of throwing them away. I explain that throwing garbage away and in water is harmful. Because they kill the nature and cause the death of livings in the water, I am going to tell people about this. I think the project that I am going to do will be useful. I tell my family and friends that they are beneficial to society, they also tell other people in their environment, and people do their best to prevent environmental pollution.*		✓
S4	X	***Flying Ship.*** *Thus the ship can navigate without sinking. When traveling by ship, they will not have to be afraid when the ship breaks down, the ship will fly.*		✓
S5	 ***Flash Shoes.*** *Ensure us to be faster. We never late to anywhere with this.*	 ***Spacecraft.*** *This car can go to space. Now, anyone can go to space, because going to space is easy with this car.*	✓	
S6	X	*Every day we would gather people who suffer from obesity and walk for 1 hour. Thus, they get rid of obesity in a short time.*		✓
S7	X	*I will hang notification the importance of blood donation everywhere. I would say that people need blood and should be written everywhere. I make sure that is written the packages we receive and on the shoe box. This would be helpful. Because at least people show mercy and donate blood.*		✓
S8	X	 ***Garbage Collection Tool.*** *It allows waste to be collected comfortably so that our environment is always clean.*	✓	

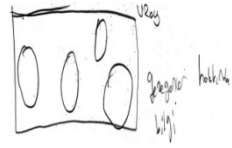
(*Continued*)

Table 10.
Students' Pre- and Post-Interview Data on Socio-Scientific Issues Projects Prepared (Continued)

	Project		Type of Project	
	Pre-interview	**Final Interview**		
Students	**Project and Student Expressions**	**Project and Student Expressions**	**Product/Tool/ Device**	**Social Project**
S9	 *It collects garbage, prevents the environment from smelling bad.*	 ***Water and Land Cleansing Tool.*** *Yes, it would be useful, land and water will not be polluted anymore.*	✓	
S10	X	Blood donation. *I make blood donation studies. I tell people its importance. Thus, many people's lives are saved. This exercise is helpful; because they also donate blood and save many people's lives.*		✓
S11	 ***Cooler Spoon.*** *Yes. It cools babies' hot food.*	 ***Cooler Spoon.*** *It cools the food easily. More for babies. It can cool a hot soup easily and quickly, which makes it easier for mothers. Babies can also eat a cold food.*	✓	
S12	 ***The Igniter King 3000.*** *When I became a soldier, I would protect myself and my friends. This is called the igniter king 3000. We can wear the bigger one on our chest, put the others on our hands, shoot with rays and protect ourselves.*	 ***Unmanned Space Shuttle.*** *Turkish production. Energy source: Mersin/Silifke. Launch Location: Kazakhstan Türkiye ramp. Purpose: to improve the economy.*	✓	
S13	 *Recycling Machine. There is a lot of waste paper in the house. I take an eraser that wipes everything, plug it into the dynamo, and suck the paper in.*	 ***Draining Spoon.*** *This project is for obesity. This spoon filters excess fat and harmful things and makes it easier to go to the stomach.*	✓	
S14	 ***Insect Eater.*** *This frog machine doesn't leave any insects around, it eats them all. So there will be no deaths due to scorpions*	 ***Paper Machine.*** *You put old paper in this machine, it makes new paper. Very helpful. Because the trees are not cut down anymore.*	✓	
S15	X	*In order to prevent global warming, my warnings are: (1) Recycle the wastes, (2) Install filters in factory chimneys, (3) Prevent forest fires. This way, my family and people around me live healthy.*	✓	

(*Continued*)

Table 10.
Students' Pre- and Post-Interview Data on Socio-Scientific Issues Projects Prepared (Continued)

	Project		Type of Project	
	Pre-interview	Final Interview		
Students	**Project and Student Expressions**	**Project and Student Expressions**	**Product/Tool/ Device**	**Social Project**
S16			✓	
	Global Warming *Yes, it benefits society. Very much. Because I prepare a project about our future, about our life.*	***Space*** *To give information about the planets. It is beneficial to society because they get more information. This also makes me happy.*		

In addition, it is observed that the student who made the most markings in the pre-interview was S5 (47 marking), and the student who made the least markings was S1 (11 marking) regarding the subjects that the students had heard before, had knowledge, could conduct a research on, and prepare a project. In the last interview, it is seen that the student who made the most markings was S9 (65 marking), and the student who made the least markings was S1 (29 marking). In the pre-interview, it was observed that the students named S11, S13, and S16 had heard all of the socio-scientific issues given before. The student who heard these topics the least was S1 (11 subjects), and the student who had not heard any of these subjects before was not observed. It is noted that the student with the most knowledge on the subjects given in the pre-interview is S5 (14 subjects), while the students with the least knowledge are S4 and S7. S1, S2, S10, and S15 do not have any knowledge about these subjects. In the pre-interview, it is seen that the student who wants to do most research on these issues is again S5 (10 subjects), and seven students (S1, S2, S3, S4, S6, S7, and S16) do not want to do research on these subjects. In the pre-interview, it is seen that the student who wants to prepare most projects on these subjects is S13 (5 subjects), and 13 students do not want to prepare projects on any subject. In the last interview, it was seen that 12 students had heard all of these topics before, and the student who heard these topics the least was S15 (17 topics). In the last interview, it is seen that the student who has the most knowledge on these subjects is S6 (16 subjects), the student with the least knowledge is S1 (6 subjects), and also the student who does not have any knowledge on these subjects does not exist. In the last interview, it was seen that the student who wanted to research the most on these subjects was S9 (19 subjects), the students who wanted to do research at least were S2 and S14 (1 subject). Additionally, S1 did not want to conduct research on any subject. In the last interview, it was seen that the student who wanted to prepare the most projects was S3 (12 subjects), while the students who wanted to prepare at least one project were S6 and S10 (in 1 subject), and also S1 and S7 did not want to prepare a project on any subject. The researcher noted on March 30, 2018: "Even though S3 is a student who is introverted and does not speak much with his teachers, he/she said that he/she wanted to raise awareness among people on issues such as global warming, domestic waste, recycling, and that he/she would work for this when he/she grew up so that people would pay attention to their environment, not pollute the world and behave well to nature." The informal interview note he/she received supports the finding of "S3's student who wants to prepare the most projects." When the markings made by the students in the pre- and post-interview are examined, it is seen that the markings made by all students in the last interview

Table 11.
Frequency Values of Students' Approaches Toward Socio-scientific Issues in Pre- and Post-Interviews

	Pre-interview					Final Interview				
Students	**Socio-scientific topic heard before**	**Socio-scientific topic of knowledge**	**Socio-scientific topic on which he/she can research in his/her future life**	**Socio-scientific topic on which to prepare a project**	**Total**	**Socio-scientific topic heard before**	**Socio-scientific topic of knowledge**	**Socio-scientific topic on which he/she can research in his/her future life**	**Socio-scientific topic on which to prepare a project**	**Total**
S1	11	–	–	–	11	23	6	–	–	29
S2	14	–	–	1	15	22	9	1	7	39
S3	14	4	–	–	18	22	18	9	12	61
S4	15	1	–	–	16	23	10	6	2	41
S5	20	14	10	3	47	23	12	9	4	48
S6	19	–	–	–	19	23	19	6	1	49
S7	20	1	–	–	21	23	14	3	–	40
S8	20	13	3	–	36	23	18	6	4	51
S9	22	4	2	–	28	23	12	19	11	65
S10	18	-	9	–	27	23	8	7	1	39
S11	23	7	7	–	37	23	13	12	10	58
S12	19	9	4	–	32	23	15	10	10	58
S13	23	6	9	5	43	23	12	10	13	58
S14	16	4	1	–	21	20	9	1	2	32
S15	15	–	1	–	16	17	9	4	4	34
S16	23	8	–	–	31	23	8	8	3	42
Total	**292**	**71**	**46**	**9**	**418**	**357**	**192**	**111**	**84**	**744**

are more than they did in the pre-interview. Throughout the application process, it is seen that the biggest change in the thoughts of the students to hear about socio-scientific issues, to have information on these issues, to conduct research on these issues, and to prepare projects was seen to be in S3 (43 differences) and the least change in S5 (1 difference).

In the pre- and post-interview, it is seen that all students have heard about a socio-scientific issue before. In the pre-interview, 11 students have information about at least one of these topics and five students do not have any information. In addition, in the last interview, all students absolutely have information about at least one of these subjects (the student who made the least marking was S1 and he/she said that he/she had knowledge on 6 subjects). In the pre-interview, it is seen that nine students want to do research on at least one of these issues, while seven students do not. Besides, in the last interview, it was seen that 15 students wanted to do research on at least one of these topics, and one student did not want to do research. In the pre-interview, it is seen that only three students can prepare projects on these topics and the remaining 13 students will not prepare any projects. In addition, in the last interview, it is seen that 14 students can prepare a project on at least one of these topics, while two students will not.

Findings Obtained From Student Diaries

In order to better understand the opinions and thoughts of the students in the study group on socio-scientific issues, the thoughts written in their diaries regarding these issues were examined in detail. In the study, a draft study was made on a total of six different topics and six separate diaries were collected from the students. The diaries filled in by the students were collected by the researcher the next day. Later, students' opinions were computerized and written down, various readings were made on these opinions. As a result of the readings, the opinions were analyzed by content analysis, and as a result, codes were created, similar codes were collated, creating themes and sub-themes. Since there are similar themes and codes in different diaries, the themes and codes obtained from the diaries are presented to the reader by collecting them. In addition, direct quotations were made from the student opinions. The themes, sub-themes, codes created as a result of the analysis of the data and the frequency values of these codes are given below.

When Table 12 is examined, in the third diary, 2 students realized that their work was beneficial for humans, other creatures and nature, on the third diary, 2 students became aware of the importance of socio-scientific issues, learned the benefits of solar energy, and realized that this energy is an environmentally friendly energy, in the first diary, 4 students will be more sensitive about domestic waste and recycling and will be sensitive to these topics, 1 student in the first diary and 1 student in the fifth diary can be protected from the negative effects of global warming and measures can be taken regarding global warming, in the fifth diary, 4 person learned about the effects of global warming thanks to this application, 1 person stated that they kept the environment clean thanks to the practices they made, in the first diary 4 person obtained electricity from the wind, 10 person in the fourth diary were about the benefits of technology, t is seen that he/she gave his/her opinion and in the sixth diary, 1 person gave his/her opinion on space studies. Some of the student views that make up these themes and codes are given in Table 13 below:

When the students' diaries were examined, they became aware of socio-scientific issues thanks to the application, learned the importance of recycling, gained awareness about the reuse of domestic wastes, discovered that recycling and reuse domestic wastes are beneficial for their people, they learned that solar energy is an environmentally friendly energy and that its use is beneficial, realizing that global warming causes serious damage to living things and natural life, developed various solutions to protect from the effects of global warming and thought to take measures for global warming, environmental problems, recycling, alternative energy, etc. It was concluded that they developed sensitivity skills towards socio-scientific issues, realized the benefits of technology and the importance of generating electricity from wind energy, learned the importance of space studies and gained the ability to keep their environment clean. The researcher on March 29, 2018 "While students were creating their digital stories about global warming, it was observed that they were saddened, surprised and realized this destruction due to the contents (photographs, pictures, videos, etc.) that reveal the destruction of global warming on nature and the field grade received on November 3, 2017 "We chatted with some students in the study group in the garden of the school. Regarding the event we held yesterday, they stated that they have just learned that recycling of domestic waste is important and that from now on, they will not throw away every domestic waste but will make use of it. "His informal interview note supports these findings.

Discussion and Conclusion

As a result of the analysis of the data obtained from the study, it was concluded that the socio-scientific STEM application positively affected the views of all students in the study group on socio-scientific issues, their knowledge of socio-scientific topics, their awareness and sensitivity toward these topics, their ability to find solutions to these problems, to conduct research, and to prepare projects. Kaya and Surmeli (2019) concluded in their study with seventh-grade secondary school students that science education based on socio-scientific issues has a positive effect on students' environmental literacy levels. Yavuz Topaloğlu and Balkan Kıyıcı (2017) stated in their studies with seventh-grade students that they thought hydroelectric power plants had negative aspects in terms of creating environmental pollution and environmental problems before the implementation and destroying the living spaces of these power plants after the implementation. Bakırcı, Artun, Şahin, and Sağdıç (2018) used the Common Knowledge

Table 12.
Themes and Codes Obtained From Student Diaries

		First Diary (11 person)		Second Diary (12 person)		Third Diary (15 person)		Fourth Diary (14 person)		Fifth Diary (12 person)		Sixth Diary (15 person)		Total
Theme	**Code**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**
Socio-scientific Topics	*Useful*					2	13							**2**
	Awareness					2	13							**2**
	Sensitivity	4	36											**4**
	Preventing/taking measures to global warming	1	9							1	8			**2**
	Realizing the effects of global warming									4	33			**4**
	Keeping the environment clean	1	9											**1**
	Producing electricity from wind			4	33									**4**
	The benefit of technology							10	71					**10**
	Space studies											1	7	**1**

Table 13.
Statements of Students Regarding Themes and Codes Obtained From Student Diaries

Themes and Codes	Student Expressions
Useful and awareness	- *"Because of this event, I realized that solar energy should be used correctly. I realized that solar energy is actually a very useful energy…." (S1)* - *"…This application was very useful to me. And we did something useful for people too. I also learned this well that solar energy is a very useful energy. I didn't know solar energy before, but now I know all of them. Turns out it was very important…." (S12)* - *"Hello diary… In this event, we made water glasses from domestic waste. These domestic wastes have been very useful for us. We recycled a lot of waste plastic bottles. This thing we have done has also been beneficial to the people in a word to the society. If we always do such activities and recycle domestic wastes, we will prevent global warming in the future. What I mean is that we can save people's futures. But of course also with their contributions. If people think of their future, they can recycle domestic waste. So society lives a lot. We all appreciate this. Today was a very good day…." (S16)*
Sensitivity	- *"…Instead of throwing it away, we can evaluate it very well…." (S3)* - *"…We evaluated waste materials and domestic wastes ... " (S6)* - *"…This is the most logical and most useful one…." (S14)*
Global warming	- *"We prepared a video about global warming. In the video, we learned how global warming happens, how it affects animals, who causes it, who tries to prevent it." (S8)* - *"Today I will tell you about the projects we have made regarding global warming. We have prepared 5–6 digital stories about global warming that we have been working on for 2–3 weeks, and the reason we prepared these stories is that people take the necessary precautions in this regard. We showed people that our world will disappear if the necessary precautions are not taken. We said that people should take precautions in this regard. We have been successful on this project that we have been dealing with for 2–3 weeks and we told people to take the necessary precautions. I hope we have been successful." (S13)*
Keeping our environment clean	- *"… It was piece of cake. We made it from unnecessary and useless waste materials. We made a glass from plastic bottle which we are going to throw away. We use it instead of throwing it away and do very good things…." (S11)*
Producing electricity from wind	- *"Today we have obtained electrical energy from motion energy. We tried to get energy with my groupmates. Together with my group, we tried to get electrical energy from motion energy and we succeeded." (S3)* - *"Hello dear diary, today we were again in the science applications class. This time we obtained electrical energy from wind energy. I think that is very sensible." (S14)*
Benefits of technology	- *"Our work with our group is to find the missing remote. Most people have a hard time finding the remote. We made a study called "remote control with bell" so that people would not live difficulty. We are pleased with the product we made with our group. We made such a product to find the lost remote easier. " (S3)* - *"Diary, I had so much fun doing this activity. Now, when the remote is lost, we can press the bell and find the remote. We got rid of the trouble of looking for the remote and if the remote is lost when I go home, I can easily find it by pressing the bell and watch TV." (S4)*
Space studies	- *"This rocket was lovely. I felt like an astronaut. Of course, as always, mine got the highest. This is a nice activity. I like my space studies very much. I hope we can work them in the eighth grade. This time we will work with hydrogen. It goes all the way to the atmosphere. If I am S12, I will do it." (S12)*

Structuring Model (CKSM) in their studies with seventh-grade secondary school students and found that the students realized that socio-scientific topics are complex, open-ended, mostly controversial, and have no definitive answers, besides, their students, they found that their decision-making skills on socio-scientific topics improved, their ability to solve problems they would encounter in daily life and their science literacy improved. These findings in the literature match up with the findings we reached in our research. As a result of analyzing the diaries, students gained awareness of socio-scientific topics, and as a result of analyzing the third part of the interview form, the results of students giving more examples to socio-scientific topics in the last interview compared to the pre-interview results in Bakırcı et al. (2018) are similar to the result that they can give examples of subjects. In the same study, it was determined that the majority of the students did not have information about GMO products before the application, and after the application, the students had opinions that GMO products are harmful to human health, cause death in people, and harm the environment (Bakırcı et al., 2018). These findings are also in our study, where they learned the importance of recycling, gained awareness about the reuse of domestic wastes, discovered that recycling and reusing domestic wastes are beneficial for their people, learned that solar energy is environmentally friendly energy and that its use is beneficial, and that global warming is beneficial for living things and natural life, which supports their conclusions, realizing that they cause serious harm. Yavuz Topaloğlu and Balkan Kıyıcı (2018), in their study with 21 secondary school seventh-grade students, took the students to the dialysis center and as a result, they found that students approached organ donation positively due to vital aspects such as providing quality life opportunities, saving lives, and the proliferation of those waiting for organs. Besides these, Küçükaydın (2019), in own study with eighth- grade students, concluded that the scenario given about a socio-scientific topic had positive effects on students' both presenting their opinions and developing arguments. These results coincide with the result that "socio-scientific STEM application improves students' views on socio-scientific issues positively" that we reached in our study.

The Ministry of National Education (MoNE) stated in the Science Curriculum that one of the special aims of the curriculum is to improve students' reasoning skills, scientific thinking habits, and decision-making skills by using socio-scientific issues (MoNE, 2018). In our study, students realized the importance of recycling domestic waste, scientific solutions about the use of solar and wind energy in daily life, and the dissemination of these energies in life will contribute to the family and country economy, and technology in daily life It has been concluded that it is beneficial and provides solutions to some problems in daily life. Klosterman and Sadler (2010) stated that students' discussions about global warming, the greenhouse effect, and these issues are more accurate, more detailed, and more sophisticated in their practice. In our study, we concluded that the students' level of knowledge about global warming increased, and they produced solutions to stop global warming. In addition, it was concluded that the students emphasized the importance of space exploration for humans, set goals related to space studies, and positively affected their opinions about the importance of people's continuing space exploration for humanity.

Regarding socio-scientific issues, it was observed that eight students in the pre-interview and all of the students in the last interview stated that they could prepare a project on these topics. From this point of view, it was concluded that socio-scientific STEM application has a positive effect on students' ideas of preparing projects to find solutions

to socio-scientific issues. In the pre-interview, it was observed that all of the projects carried out by the students were in the form of products/tools/devices, and it was seen that four projects included one socio-scientific issue (two projects related to keeping our environment clean, one project related to recycling and global warming). In the last interview, it was seen that eight of the students in the study group stated that they could prepare a product/tool/device in socio-scientific issues, while the remaining six students stated that they could prepare social projects. In the last interview, it was determined that four of the students who worked on a product/tool/device project related to socio-scientific issues were male, and four were female students, but all of the students who wanted to prepare a social project were female students. Students who aimed to prepare social projects on socio-scientific topics (especially global warming, environmental/air/water pollution, alternative energy sources such as sun and wind), "raise awareness of people," communicate with them and tell them about the damages of these issues, "he/she stated that he/she could prepare projects such as taking initiatives to prevent their harms, "persuading people for a healthy life" and "doing various studies with them." From this point of view, it is concluded that socio-scientific STEM application has a more positive effect on the "social sensitivity skills" of female students towards socio-scientific issues, unlike males. Luther et al. (2013) stated in their studies that they are aware of the importance of citizenship in student education, so they can encourage responsible citizenship by using socio-scientific issues. We also think that by using socio-scientific STEM activities in our study, we enable students to realize the importance of a socially responsible citizenship.

The opinions of the students in the study group regarding socio-scientific issues that they have heard before, that they have knowledge, that they will do research on their future life, and that they can prepare a project on them were also investigated. It was observed that the students made 418 markings in total in the pre-interview, and 744 markings in the last interview. From this point of view, it was concluded that the socio-scientific STEM application had a positive effect on students' hearing about a socio-scientific issue, having knowledge on socio-scientific issues, their opinions about the ability to conduct a research on their future lives, and their thoughts that could prepare a project on it.

Recommendations

In this study, STEM activities/applications were carried out on topics such as domestic waste, recycling, solar energy, wind energy, global warming, benefits/harms of technology, and space. In new studies, we believe that socio-scientific STEM applications will be useful in teaching all other socio-scientific issues (gene therapy, cloning, acid rain, HEPP, nuclear power plants, environmental pollution, etc.). In addition, we think that the selection of new research/studies from "local socio-scientific issues" to which they are closer to students will attract their attention, excite them, so they will participate in the activities more willingly and this situation may affect them positively. In this study, socio-economically and socio-culturally disadvantaged students' views and opinions on socio-scientific issues were investigated. In new studies, we think and suggest that it is important to investigate how socio-scientific STEM practice affects students with medium and high profile socio-economic and socio-culturally.

Ethics Committee Approval: Ethics committee approval was received for this study from the Ethics Committee of İstanbul University (File No: 2017/89, Approval No: 126531, Date: 26.10.2017).

Informed Consent: Written informed consent was obtained from students who participated in this study and their parents.

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