The effect of informal learning environment upon students' understanding of science-technology-society-environment

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Abstract

It is known that an informal learning environment (i.e., out-of-school) increases the quality of teaching and learning activities. Informal environments also provide many advantages such as enriching the content of learning. Moreover, it is emphasised that the science-technology-society-environment (STSE) learning does not effectively involve in the Turkish education system. From this point of view, informal learning environments should be considered in order to enable students' understanding of the STSE relation. Within the scope of this study, it was aimed to determine the effectiveness of study visit on students' understanding of STSE. The research was conducted with 14 male students in the 5th-grade level in the 2016–2017 academic year. This research, which used a recycling-solid waste collection centre, a botanic garden, a planetarium, a science centre and a zoo, a few informal learning environments, was conducted according to the case study design method. In the study, views on science-technology-society questionnaire, semi-structured interviews, observation forms and diaries were used as data collection tools. The data indicated that the informal learning environments were inadequate to promote conceptual change; however, it was effective to comprehend newly learnt concepts. In addition, it was also concluded that informal learning environment provided students to capture the understanding of STSE relations.

Keywords: Science-technology-society-environment (STSE), informal education, out-of-school environment.

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1. Introduction

Informal learning has been defined as learning out-of-school environment. It was also stated that these environments provided efficient and rich opportunities for understanding the concepts (Berberoglu, 2017; Sontay, Tutar & Karamustafaoglu, 2016; Tatar & Bagrıyanık, 2012). Informal learning environments have been described as the natural history museums, science-technology centres, observatory, zoo, planetarium, aqua parks, botanic gardens, parks, nature centres, environmental education centres, scientific research centres and so on (American National Science Teachers Association, 1999; MEB, 2013). In fact, informal learning, which revealing its own existence in every point of life, is defined as learning that occurs as a result of the interaction with the environment from the moment the individual is born and that takes place spontaneously in life. Informal learning can be in many different forms like the individual learning from his friends during a play, apprentice's learning from his master, learning from newspaper reading and child's learning from social relations with adults. It also includes everything that is done in the effort to adapt to life and society and give meaning to it (Sen et al., 2011).

Science education aims to understand the interaction between science, technology and society and to use information in the daily decision-making, to educate scientifically literate individuals (Bora, Arslan & Cakiroglu, 2006). Science-technology-society-environment (STSE) training, one of the four learning areas expressed in the Turkish Science Curriculum, aims to improve science awareness for all and to educate the persons as a scientific literacy. In the STSE training, obtaining the required learning outcomes was grouped as follows: 'science and nature of science', 'the nature of technology', 'human, society and science', 'science and technology', 'technology and environment', 'science and environment', 'man, society, science and the environment' and 'human, society and technology' (Cepni & Cil, 2009). The main purpose of modern education reform movement is to provide an understanding of relations among STSE (Yalvac, Tekkaya, Cakiroglu & Kahyaoglu, 2007). The most important goal of STSE training is to gain competencies such as critical thinking, advanced mental skills, creativity, moral values and disclosure of values, universal opinion, decision-making and problem-solving capacity, understanding the interaction between science-technology-society and evaluating technological and scientific activities (Cepni, Bacanak & Kucuk, 2003). Understanding of the STSE approach and the nature of science should facilitate students to make social decisions and to enhance problem-solving ability. In addition, the STSE approach should develop thinking more scientifically about real-world problems, critical thinking and problem-solving skills (Tal, Dori & Keiny, 2001).

The STSE approach in science has not been of great importance in most cases, according to the quantitative learning areas in the curriculum. The related literature indicates that the STSE area reflecting the essence of the science course did not see enough interest, while the research on science course mostly includes attitudes and values towards the science and nature of science. Therefore, elementary school students' understanding of STSE was not at the expected level, which is a sub-dimension of scientific literacy (Afacan, Aydogdu, Akgul & Tasar, 2012).

In recent years, STSE training attaches importance, to integrate the learning beyond the period of the classroom and the school, in other words, by projects, educational trips and out-of-school research (Fleming, 1988). Therefore, it is necessary to overcome classroom walls and benefit from informal learning environments in order to realise STSE education. In our country, STSE training which was included in the curriculum for the first time in 2005 (MEB, 2005) in most instances did not find the significance that it deserved in the 2005 curriculum or in the following 2013 and 2017 curriculums (MEB, 2013, 2017). The positive effect of informal learning environments on learning has been revealed through studies (Badri et al., 2016; Jirasek, Veselsky & Poslt, 2017; Scott & Boyd, 2016; Skar, Gundersen & O'Brien, 2015; Sturm & Bogner, 2010). Although one of the areas of science learning is STSE training, which reflects the essence of the science course, it is an ignored area in the literature review. It is thought that students will break down the prejudices against the science course if they recognise it effectively.

Taking into consideration the aforementioned explanation, the STSE approach and out-door education have not been given great importance in the formal school environment. If it is given satisfactorily in schools, it should facilitate the students to understand the STSE approach. Moreover, there are few national studies on informal learning environments. When students depart from the formal school atmosphere, it has been demonstrated in related studies that, students have increased the sense of curiosity and are more open to learning (Cavus, Topsakal & Kaplan, 2013; Guilherme, Faria & Boaventura, 2016; Ozdemir, 2010; Sozer, 2015). Informal environments, both because of the positive contribution to the course, to the contribution to the affective and cognitive domain and because they have developed the basic objectives of the teaching–learning activity what self-actualisation, teaching learning, raising awareness around and society, should be carried out in cooperation with educational activities. Using the advantages provided by informal learning environments, it is easy to elicit the learning outcomes regarding science is often expressed (Bodur, 2015; Turkmen, 2010; Weinstein, Whitesell & Schwartz, 2014).

In this study, the influence of informal learning environments such as a recycling-solid waste collection centre, a botanic garden, a planetarium and science centre and a zoo on students' understanding of STSE relation was investigated. Within the scope of this aim, the research problems sought for answers are given below. The research was designed in this problematic framework, and it was attempted to find answers to the following research problems at the end of the research.

1. How do students define science and technology?
2. How do students express the influence of society on science/technology?
3. How do students express the influence of science/technology on society?
4. How do students explain the characteristics of scientists?
5. How do students explain the social construction of scientific knowledge?
6. How do students explain the social construction of technology?
7. How do students express the epistemology of nature of scientific knowledge?

2. Methods

The study utilised a qualitative case research methodology. Within the scope of this methodology, a sample group consists of 14 male students on the 5th grade level in a middle school in the Sanlıurfa region was used. The students are in the same class, in which students' earlier grade performance score ranges between 75 and above.

Four different data collection instruments were used for the research. The instruments used and explanations about the instruments are presented as below.

2.1. Views on Science Technology and Society (VOSTS)

The views on science-technology-society (VOSTS) questionnaire comprised from 14 questions with multiple choices. Each item was chosen from the seven subtitles of the instrument (see Table 1). The questions were prepared by Kahyaoglu (2004) depending on their representative, and appropriateness of the Turkish context. Only 14 items were extracted from very large pool of VOSTS items. During the selection of the items, a collective study was performed by the researcher, a professional in the field of science education and a Turkish teacher.

Table 1. Sub-scales of the items used in the questionnaire

Science and technology	1 and 2
Influence of society on science/technology	3 and 4
Influence of science/technology on society	5, 6 and 7
Characteristics of scientists	8, 9 and 10
Social construction of scientific knowledge	11

Social construction of technology	12 and 13
Nature of scientific knowledge	14

The questionnaire was revised before not applied to the sample group, in the direction opinion of a professional in the field of science education with the Turkish teacher who entered the course of the sample group and who is closely acquainted with the students. Questions have simplified in a way suitable to the 5th grade level, and they have been replaced with unknown words with synonyms. As a pilot study, the questionnaire was applied to three students not included in the sample group. After the pilot study, the questionnaire was applied as a pre- and post-test to the same sample group. From the obtained data, it was revealed the changes in students' understandings.

2.2. Interview

The semi-structured interviews were conducted to get detailed information about the views of students on science-technology-society concepts. Interview questions were developed by Kahyaoglu (2004), considering the VOSTS items and main points of its sub-scales. The interview schedule was very flexible for students to express their thoughts freely and to follow-up questioning in order to encourage students. Questions were organised jointly by a professional in the field of science education. The intelligibility of the questions was examined with the help of a Turkish teacher and the pilot studies were carried out by making necessary rectifications. Unknown concepts in the questions were replaced by concepts having the same meaning. The interview questions were implemented as pilot studies, with three students at the 5th grade level, not included in the sample group. To identify the students' views on STSE details, each student was interviewed by the second author of the study. The interviews were carried out after all of the visits had been performed to informal learning environments.

2.3. Observation form

The observation form was developed by the second author of the study. The observation form was revised based on the specialists in both science education and Turkish language. It was designed to measure the outcomes before, during and after the out-door trips. Observation forms were scored by school teachers accompanying the trips, and not participating research periods.

2.4. Students' diary

Based upon the specialist in the science education domain, a diary was maintained for each student in the evening before the trip, during the trip and post-trip. The students' diaries included their expectations, learning during the trip and their views after the trip. As a data collection instrument, students' diaries determined their prior knowledge, to remember the education activities during the trips and to measure the effectiveness of the method and technique after the trips.

The students visited four different informal environments in which they practiced many experiences as follows.

2.4.1. Sanlıurfa Recycling-Solid Waste Collection Centre

The centre consists of four departments: separation, the storage and disposal of medical waste and energy production. Solid wastes in the separation department are classified as plastic, paper, glass, metal and medical waste and those who have the recycling characteristic are transferred to the related department and brought to the nature. Medical waste department is the unit where the harmful wastes brought from the hospitals on the ground are collected and disposed of properly. Storage department is a place where methane gas is obtained by stacking non-recyclable wastes. In the energy production department, the methane gas obtained from the storage section is converted

to electricity energy through purification processes. The centre produces electricity to 40,000 households daily.

The students were informed by visiting each department of the centre, guiding the responsible agricultural and environmental engineers.

2.4.2. Gaziantep Botanic Garden

The garden contains nine different thematic gardens that are different from each other. They were visited by students in the guidance of four school teachers in the Ottoman garden, Japanese garden, rock garden, rose garden, gymnosperms garden, color and fragrance garden, medical and endemic plant garden, zen garden and water plants garden. The researcher guided the students about the place of plants in taxonomy, plant naming and reading of plants' marking tags. The plants were studied in detail in order to consolidate the information about parts of the plant and their tasks learned in the science courses.

2.4.3. Gaziantep Planetarium and Science Centre

The centre consists of a space simulator room, a robot theatre, a planetarium where astronomy education was given and a science workshop was formed which continuously updated experimental exhibitions of physics, chemistry, biology, astronomy, geology and environmental science. The planetarium section was still under repair when the centre was visited, so it could not be visited. After learning about the Solar System and Milky Way Galaxy by Robot Theater, the students spent free time in the science workshop. The students experienced all experiments and exhibitions following the directions in this area in that were not accompanied by a guide. Experimental units related to the topics covered in the science course were explained in detail by the researcher who had previously worked at a science centre, and the aim was to consolidate the knowledge of the students. Science centre exhibitions were experienced within the 1-hour time constraint of the officials.

2.4.4. Gaziantep Zoo

The zoo is the largest one in our country. The students joined the safari trip and visited all in-door and out-door areas in the zoo under the teachers' guidance. Informative signboards such as the places of animals in taxonomy, nutritional characteristics and living areas were examined.

3. Results, implications and discussions

Gathered data were analysed using descriptive statistical methods (percentage and frequency). VOSTS questionnaire data were analysed together with the semi-structured interviews, observation form and students' diaries. Students' responses to the VOSTS questionnaire have been analysed in a similar way to related studies in the literature, using 'realistic', 'acceptable' and 'insufficient' categories (Aikenhead 1984; Alonso, Carmona, Mas & Roig, 2013; Rubba & Harkness, 1996). The percentages of the categorised responses to the questions of the questionnaire were given in Table 2. However, the 3rd and 7th items in the questionnaire were resolved differently than the other questions chosen from the uncategorised questions pool. Percentages of the marked options of the 3rd and 7th questions have also been expressed separately in Table 3.

Table 2. Percentage distribution of pre- and post-test responses to questionnaire by categorisation

Items	Pre-test			Post-test		
	Realistic	Acceptable	Insufficient	Realistic	Acceptable	Insufficient
1	42.86%	42.86%	14.29%	28.57%	57.14%	14.29%
2	28.57%	42.86%	28.57%	14.29%	35.71%	50.00%

4	28.57%	50.00%	21.43%	35.71%	35.71%	28.57%
5	-	21.43%	78.57%	14.29%	21.43%	64.29%
6	57.14%	35.71%	7.14%	35.71%	42.86%	21.43%
8	57.14%	-	42.86%	71.43%	-	28.57%
9	-	21.43%	78.57%	7.14%	28.57%	64.29%
10	64.29%	35.71%	-	42.86%	42.86%	14.29%
11	21.43%	71.43%	7,14%	50.00%	42.86%	7.14%
12	21.43%	57.14%	21.43%	28.57%	50.00%	21.43%
13	28.57%	71.43%	-	-	92.86%	7.14%
14	14.29%	-	85.71%	28.57%	-	71.43%

Table 3. Percentage distribution of pre- and post-test responses to 3rd and 7th items

	Pre-test				Post-test				
	A	B	C	F	A	B	C	D	E	H
Item 3	21.43	35.71	42.86	-	21.43	21.43	35.71	7.14	7.14	7.14
Item 7	57.14	14.29	21.43	7.14	64.29	14.29	14.29	7.14	-	-

Realistic, acceptable and inadequate perspectives are categorised as the following to make the findings more understandable.

Table 4. Categories and descriptions

	Categories								
	A	B	C	D	E	F	G	H	I
Pre-test	+	+	o	o	-	-	+	o	-
Post-test	+	o	o	+	+	o	-	-	-
			Positive change				*Negative change*		

Realistic: +; Acceptable: o; Insufficient: -

In comparison with the pre- and post-test, changing category 'realistic' and 'acceptable' opinion was appointed as positive change. The change has been appointed as a negative change to insufficient opinion. In the questionnaire, there was more than one answer option that expresses an opinion. For example, a student who has marked one of the answer options that expresses a realistic opinion in the pre-test may mark another answer option that also expresses a realistic opinion in the post-test. This situation can be perceived as if there was 'no change' because the student initially gave the answer in the same category. Even so, there was a change and showing this change was important for the study. For this reason, the 'C' and 'I' categories are integrated into positive and negative changes. The coding system as like S1, S2, ... was utilised in order to track each student throughout the analysing data.

Table 5. The categories, frequencies and percentages of responses to the VOSTS questionnaire

Subtitles	Items*	Categories									√**		X***	
		A	B	C	D	E	F	G	H	I	f	%	f	%
Science and Technology	1	S11,S12	S1,S3,S4,S6	S10,S13	S7,S9		S8,S14		S2,S5		12	86%	2	14%
	2		S9,S13	S1,S3,S4	S5,S12			S6,S10	S14	S2,S7,S8,S11	7	50%	7	50%
Influence of Society on Science/ Technology	4	S3	S1,S5	S8,S10,S14	S7,S9,S12	S4		S6	S13	S2,S11	10	71%	4	29%
Influence of Science/Technology on Society	5				S5,S12		S3,S7,S9		S6	S1,S2,S4,S8,S10,S11,S13,S14	5	36%	9	64%
	6	S10,S13,S14	S7,S11	S1,S3,S4	S8,S9		S5	S2,S6,S12			11	79%	3	21%
Characteristics of Scientists	8	S1,S4,S8,S11,S12		S3,S6,S9,S10,S14				S2,S5,S7		S13	10	71%	4	29%
	9			S4	S10,S12,S13	S5			S2,S6	S1,S3,S7,S8,S9,S11,S14	5	36%	9	64%
	10	S1,S5,S8,S13,S14	S4,S11	S3,S6,S9,S12	Ö10			S2,S7			12	86%	2	14%
Social Construction of Scientific Knowledge	11	S8,S12	S1,S13	S2,S5,S6,S9,S10	S3,S4,S14	S10	S5				13	93%	1	7%
Social Construction of Technology	12	S1	S8,S10	S3,S4,S6,S11,S12	S2,S14	S9			S13	S5,S7	11	79%	3	21%
	13		S5,S6,S7	S1,S2,S3,S4,S8,S9,S10,S11,S12,S14				S13			13	93%	1	7%
Nature of Scientific Knowledge	14					S3,S5,S10,S14		S6,S12		S1,S2,S4,S7,S8,S9,S11,S13	4	29%	10	71%

* 3rd and 7th items are not categorized	** Positive change	***Negative change

The data obtained from the VOSTS questionnaire were discussed below within the frame of the research problem, taking together the data from other data collection instruments. The data from the 1st and 2nd items included in the VOSTS questionnaire were used to find the answer to the first sub-problem of the research. As seen in Table 2, opinions of the science and technology, in the pre-test positive change of 85.72%, were predominant and in the post-test this rate has not been changed (item 1). From the 2nd item data, in the pre-test, the positive change of 71.43% was predominant and in the post-test of 50%. In the interview for this sub-problem, two questions were asked to the students which as follows:

'What is your mind about science? How do you define science?'

'Is there a relation between technology and science? Please explain.'

When asked about the definition of science and technology, no consensus about the definition of science was observed. Answers were quite different. Every respondent gave his/her own definition. They defined science as follows:

'…Science is having knowledge of technology'. (S1)

'... Science makes technological tools'. (S3)

'…Science is inventing something. It is also discovering planets'. (S6)

'... The knowledge of how the car engine works is a science'. (S10)

'... Science is learning, and is curiosity'. (S12)

Some of the students defined technology as follows:

'…Technologies are revealing new things'. (S3)

'... Technology is a tool such as computer'. (S4)

'... Science makes technological tools'. (S6)

'... Science is how the car engine works and the technology is what the engine is'. (S10)

It is understood from these definitions made by the students that even if they said that the concepts of science and technology are different from each other, it is difficult for students to find a related example in daily life.

There was no positive increase between the pre- and the post-test about the concepts of science and technology from the subscales of the questionnaire. It is seen that informal learning environments, such as recycling centre, botanic garden, science centre and zoo, do not provide the expected level of contribution to the learning of the concepts of science and technology and the relation between them. Similar to the results of this study, Tasdemir and Demirbas's (2010) study has also reached the conclusion that secondary school students cannot associate science concepts, they have learned at school, with their daily lives. Likewise Gokler (2012) conducted an environmental education performed by the 9th grade level students in the natural environment, and there was no significant difference between the pre- and post-tests in the concept definitions of the students. In addition to all these studies, Yager, Choi, Yager and Akcay (2009) conducted a study performed with 15 teachers working in the 4th, 5th and 6th grade levels where the STS approach was implemented and not implemented; in the section of 'concept' which is one of the six sections to be assessed, there is no difference between the two classes in which the STS approach is implemented and not implemented. As is known, the conceptual change in persons is often difficult in a short period (Costu, Karatas & Ayas, 2003), and four strategies must be fulfilled to realise this change (Yılmaz, Tekkaya, Geban & Ozden, 1999). As it is understood that, providing conceptual change is difficult in many cases in studies that do not take enough time like this study. Also, Botton and Brown's (1998) research on graduate students emphasised the difficulties in learning the concepts of science and

technology,investigated in the first two questions of the VOSTS questionnaire, even the graduate students defined technology as an application of science. This study shows that the difficulties of learning the concepts of science and technology related to the STSE, continue in the upper levels of education. The attained conclusion is that, the informal environments, visited within the scope of the study, they do not use the abovementioned strategies in most cases and they are not enough in the process of eliminating the misconceptions. During the visits, it was realised that informal environments were organised and operated as entertainment environments for social activities. It has been noted that, serving as an educational environment is subordinate purpose of such environments. For instance, Gaziantep planetarium and science centre do not declare a mission about education. It is thought to be the reasons that prevent the misconceptions and blocked the learning of the relation between concepts that, the presentation of Gaziantep zoo stated as 'there are children's play groups, recreation parks for children in our garden' and it does not specify a mission and vision for education.

Yet, in some of the student's trip diaries, there are some concepts like methane gas, oxygen, cubic meters, etc., which used by the environmental engineer to describe the electricity generation department of recycling centre, like methane gas, oxygen, cubic meters, etc. and there are the concepts of taxonomy such as mammals, marsupials and reptiles. It is noteworthy that some of these concepts are learned concepts within the scope of science lessons. Hence, although informal environments are inadequate to transform the misconceptions, it is effective in learning new concepts and reinforcing learned concepts.

The data from the third and fourth items included in the VOSTS questionnaire were used to find the answer to the second sub-problem of the research. The third item was assessed based on the percentage of response options marked because it was not from the questions pool categorised using the 'realistic', 'acceptable' and 'insufficient' (Table 3). The third item indicated that in the pre-test marked the option C *(Money should be spent on scientific research, because by understanding our world better, scientists can make it a better place to live in (for example, using nature's environment and resources to our best advantage, and by investing helpful technology)* for most of the students. In the end-test, the C option was also marked with the highest rate. As seen in Table 2, opinions of the influence of society on science/technology, in the pre-test positive change of 78.57 %, are predominant and in the post-test this rate has not changed (item 4). In the semi-structured interview for this sub-problem, the following question was asked to the students:

Can science/technology affect the society?

78.57% of the students said yes and 21.43% said no.

Some of the answers of the students are as follows:

'…Yes. The robot car did not do here, it did in Russia. They have more possibilities'. (S5)

'…Yes. The scientists in Turkey think differently but in Germany think differently. Science is the same, but walkthrough is different'. (S8)

'No interest in society'. (S13)

The majority of students (92.85%) in the interviews claimed that science and/or technology are affected by the society like the results of the Kahyaoglu's (2004) study. As a reason for the insufficient opinions to shift to acceptable opinions, which is in the VOSTS questionnaire, it is thought that students perceive the related question science/technology as being influenced by the society. During the interviews, the students' answers stated as that the influence of science/technology on society, and they could perceive the true meaning with the researcher's questions that led to the correct understanding. Data of the questionnaire are not having similar results with interviews. As the reason, it is considered that the content of the question is not fully understood.

It is remarkable that the students of insufficient opinions are scored low on the trip observation form. Students who did not get the learning outcomes of the trip observation form effectively did realise that they marked insufficient opinion in the post-test (e.g., S6, S8, S10). Another reason why there is no increase in the number of students with acceptable opinions, tools, machines, robots and plants of recycling centre, science centre and botanic garden, are regarded as technological products, and the society does not affect science/technology, the perception that these technological products are influencing the society was formed. Also the positive increase in the question 'how do students express the influence of society on science/technology?' investigated in the third sub-problem supports this.

The data from the fifth, sixth and seventh items included in the VOSTS questionnaire were used to find the answer to the third sub-problem of the research. As seen in Table 2, opinions of the influence of science/technology on society, in the pre-test positive change of 20%, are predominant and in the post-test of 35.72% (item 5). On the sixth item data, in the pre-test, positive change of 92.85% is predominant and in the post-test of 78.57%. The seventh item was assessed based on the percentage of response options marked because it was not from the questions pool categorised using the 'realistic', 'acceptable' and 'insufficient' (Table 3). The item 7 indicated that in the pre-test marked option A *(Military strength depends a great deal on science and technology, because the greater the development in science and technology, the more modern, accurate and destructive the weapons)* for most of the students. In the post-test, the same option was marked with a higher rate. In the semi-structured interview for this sub-problem, the following questions were asked to the students:

How can science/technology affect the society? (For example, mobile phone, computer, cancer medicine and pollution.)

You have taken science courses since primary school. Do you think it has an effect on your daily life, whether positive or negative?

Some of the answers of the students are as follows:

'... For example, we get rid of dying by the cancer drug. Rockets are being built to explore space. Factories are making things for what will come in handy'. (S19)

'…We used to travel by plane now as we traveled by horseback. It made our life easier' (S14)

'…When my mother could not open the jar lid, I told him to heating on stove like we learned in science course' (S16)

'…When the slaves saw on TV by my sisters, they said the seal is a fish. I said it was not a fish, but a mammal' (S12)

All of the students within opinion that society is influenced by society's science/technology. During the interviews, they were able to explain these opinions with examples from daily life. It is also understood from the answers that they could reconcile the learnings with the events they encounter in their life and they are able to explain.

There is a relatively positive increase in the influence of science/technology on society. Especially, science centre, botanic garden and recycling centre, both the presentation of the guideline, and the signboards of the exhibitions in the way that technology has emerged as the result of scientific activities that has been effective in understanding this relation. The environmental engineer who guided in the recycling centre, presented the machine and other elements in the form of products of scientific information. It is thought that percentages obtained from the questionnaire and interviews are different because of that the questions in the questionnaire are complex and long. When asked the question directly and simply as asked in interview, all of them said that science and technology affected by the results of society. It is concluded that informal learning environments are effective in understanding science-technology-society relation.

The data from the 8th, 9th and 10th items included in the VOSTS questionnaire were used to find the answer to the fourth sub-problem of the research. As seen in Table 1, opinions on the characteristics of scientists, in the pre-test positive change of 57.14 %, are predominant and in the post-test of 71.43% (item 8). On the 9th item data, in the pre-test, positive change of 21.43 % is predominant and in the post-test of 78.57%. The last question that measures this sub-problem (item 10) data; in the pre-test, positive change of 100% is predominant and in the post-test of 85.72%. In the semi-structured interview for this sub-problem, the following questions were asked to the students:

What can you say about the personality of ordinary scientists?

What can you say about the gender of the scientists; Is there a numerical difference between two sexes; Does gender have an effect to the result of the discoveries?

What do you think about the daily life of a scientist?

Some of the students' responses to the characteristics of the scientist are as follows:

'... Researcher, curious, hardworking, willing and patient, like Edison'. (S7)

'... They are patient, excited and very hardworking' (S6)

One of the responses to the scientist's gender is as follows:

'... Gender does not matter due to scientist contribute to human'. (S13)

Some of the students' responses to the daily life of the scientist are as follows:

'... They are investigating and wondering what they see around them'. (S7)

'... They have healthy diet. They do not smoke. They do not sleep late'. (S10)

Students have always used the term 'patient' when defining scientists. Students have lined up good traits when describing scientists (e.g., hardworking, non-smoker, curious, patient, courageous, critical thinker and intelligent). All of the respondents claimed that gender does not have an effect on the results of discoveries. 85.71% of the students claimed that males are higher in numbers. 14.29% of the students claimed that males and females are equal in numbers. In the interviews, the students stated that both male and female guides in the informal environments and named as man of science instead of scientists previously. Characteristics of the scientists have learned by experience in the informal learning environments. Knowledges about scientists in the science centre, engineers and technicians guiding and employed in the recycling centre provided learning about the characteristics of the scientist.

The data obtained from the interviews are supportive of the data in the questionnaire and show that students have a positive change of the characteristics of the scientists.

The data from the 11th items included in the VOSTS questionnaire were used to find the answer to the fifth sub-problem of the research. As seen in Table 2, opinions about social construction of scientific knowledge, in the pre-test, positive change of 92.86 % is predominant and in the post-test this rate has not changed. On the other hand, there has been an increase in the realistic point of view.

In the semi-structured interview for this sub-problem, the following question was asked to the students:

Does a group of scientists from any part of the world examine a subject for example 'atom' in the same way? (e.g., in Germany, in Turkey and in France)

Some of the students' responses to the social construction of scientific knowledge are as follows:

'... The topic is approached differently because; scientists in Turkey are different, in Germany are different. Their walk-through are different' (S2)

'... Thinking skills of scientists are different from each other. They handle a problem in different ways'. (S1)

92.96% of the students said that the scientists in the different regions of the world would deal with a common theme differently and 7.14% of students said they would deal with it likewise.

The percentages of the data obtained from the interview and the data obtained from the interview are the same. There is a high rate of increase was observed in realistic opinions of national influence on scientific knowledge and technique. Causing of this increase is thought to be due to the fact that some of the topics in the science course (e.g., light and sound, vertebrate-invertebrate creatures, plants, animals and environmental pollution) and some of the informal contexts are in parallel. Consequently, concluded that the informal learning environments positively influence the social structure of scientific knowledge.

The data from the 12th and 13th items included in the VOSTS questionnaire were used to find the answer to the fourth sub-problem of the research. As seen in Table 2, social construction of technology, in the pre-test, positive change of 78.57 % is predominant and in the post-test his rate has not changed (item 12). On the 13th item data, in the pre-test positive change of 100% is predominant and in the post-test of 92.86%. In the semi-structured interview for this sub-problem, the following question was asked to the students:

Who decides on the technological developments?

Some student answers about the social structure of technology are as follows:

'... The scientists decide'. (S5)

'... The citizens decide. Society' opinions are taken'. (S7)

Half of the respondents claimed that the decisions on the technological developments should made by public. The other decision agencies thought as politics (28.57%) and politicians (2.04%). Thus, the opinion that technology is influenced by society has reached the conclusion that it is dominant.

It is seen that the students which had acceptable opinions in the 12th item on the questionnaire about taking technological decisions and the autonomy of technology have a realistic opinions on the post-test. This positive change reveals that informal learning environments provide an understanding of the strength of society on taking technological decisions. In item 13, it is thought that although the root of the question is understandable and simple, students had shifted to acceptable opinions because of the complexity of the options that reflect the realistic opinions. In the answers to the interview questions, the majority of the students stated that the citizens are the maker on taking the technological developments decisions. In consequence of that, informal environments have had a positive impact on the understanding of technology–society relation. The contents and operating style (like there are guides) of the recycling centre, science centre exhibitions, contents of botanic garden have an important place in understanding this relation. The process of recycling of wastes at the recycling centre without harming the environment, the knowledge were obtained in the science centre about the discovery of the planets, space vehicles and the exhibitions displaying scientific information and the knowledge about the contents of the botanic garden, especially the medicines, was derived the medical plants. All of them may create opinions that the society is effective in taking decisions on the technological developments. In the case of guides accompanied by other informal learning environments such as recycling centre, this subtitle of STSE is considered to be understood more effectively. In the case of guides accompanied in the other informal learning environments such as recycling centre, this subtitle of STSE is considered to be understood more effectively.

The data which obtained from the 14th item in the VOSTS questionnaire were used to find answer for the seventh sub-problem. As can be seen from Table 2, while 14.29% of the opinions in the pre-test about nature of scientific knowledge were positive, this rate increased to 28.57% in the post-test. The following two questions about the 'nature of scientific knowledge' have been directed to the students in the semi-structured interview for this sub-problem.

Is there any method followed by scientists during the scientific investigations, if yes how?

Does scientific knowledge change in time? (e.g., Does our current knowledge of the planets change in time?)

Some of the students' responses to the nature of scientific knowledge are as follows:

'…Scientists make plans. They keep everything balanced. They move forward thinking about the next step (Ö1)'.

'…We are going to school with a curriculum. In the same way, they have a program (Ö12)'.

'…Information may change over time. Now we cannot reach some of the planets. The technologies we have are not suitable for it. We can reach it later'. (Ö10)

'…Scientific knowledge may change. Now we do not know much about black holes. We do not know because we have not gone to distant planets. As technology evolves over time, we can learn new things', (Ö13)

All students assert that there is a plan followed by the scientists. All students who in the sample group think of the opinion that scientific knowledge may change in time.

There is a positive increase between the pre- and post-test in the questionnaire which is evaluated the 'offer rational justification' of the nature of scientific knowledge. The skills which belong the nature of scientific knowledge has been coincide with the results of Ertas, Sen and Parmaksızoglu's (2011) study and it is found that it gets easier in informal environment. Informal learning environments and its contents provide students with unaware and spontaneous learning. Besides, they make easier to learn the contents of the nature of science which is hard to comprehend in traditional learning environment such as school.

It is clear that a different approach instead of to traditional science education should be pursued to achieve the aims of STSE education. Science education given with STSE perspective requires students to be active in the education process and be encouraged to research and problem-solving (Yalaki, 2014).

Informal learning environments are one of the greatest boosters for the science education which tries to explain physical world. Science courses without enough integration with informal environments cannot be achieved with the expected benefits of STSE. The contents of informal environments are not designed to coincide with the content of the science courses and the deficient of guides for explaining contents of informal environments in line of the science course. All these reasons prevented students which come from traditional learning environment such as school to learn deeply. Moreover, as so results of Bozdogan and Yalcın's (2009) study, these environments are not operated in accordance with education-teaching, crowdedness and time constraints are contrary to the principle of individual comprehensive speed.

All these situations prevent informal learning environments from being more effective on the students' understanding of the STSE relations are considered.

The basic function of informal environments, such as science centre, zoo, botanic garden, is education. Therefore, they must be structured and operated in this direction. The research of Dogan (2017) which performed in museums supports the idea.

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4. Recommendations

This study indicated the positive effect of informal learning environments upon the understanding of STSE relations. It should be appropriate to raise awareness on STSE of teachers, principals of informal learning environments, students and parents. In this context, it may be useful to provide the pre-service teachers with the knowledge and skills on how to use the out-of-school environments in education faculties as well as in service training that can be provided for schools and informal environments.

In the previous related studies, teachers were informed that they were refrained from toilsome process of taking a dayoff (Ertas, Sen & Parmaksızoglu, 2011). It was believed that administrators and managers should alleviate bureaucratic obstacles and encourage to the teachers in order to increase the effectiveness of informal environments in educational.

Informal learning environments should be modified as education priority. In these areas, besides being a social area, it is necessary to determine mission and vision about education-teaching. When the curriculum coincides with informal environment contents, it is thought that the effect of these environments will highly increase. It may be an appropriate that the botanic garden, zoo and the municipal recycling centre, which are very important for understanding the relations of the STSE, set a mission for education and provide appropriate guides.

Only the recycling centre is provided guides in this research. Most of the students gave their examples from the recycling centre during the interview. It shows the influence of the guides in these environments. Science centres that are supported by TUBITAK (the scientific and technological research council of Turkey) serving by the municipality, can contribute to the fulfillment of the STSE. However, these centres use like playground today. Therefore, they redesign in line with STSE.

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