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Research Article

University Students' Opinions Concerning Science-Technology-Society Issues

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Abstract

Determining what students think about science, technology, and society (STS) is of great importance. This also provides the basis for scientific literacy. As such, this study was conducted with a total of 102 senior students attending a university located in western Turkey. This study utilized the survey model as a research model and the qualitative data collection method for gathering data. A questionnaire consisting of five open-ended questions was submitted to students who participated in the study. Separate categories were structured for the responses to each question. These categories were analyzed to present student-opinion profiles, and the percentages of student responses were then calculated. According to the results of this study, most students defined both the concepts of science and technology with concrete meanings. In addition, student opinions related to the significance of science and technology for society were collected under seven main categories and presented using a mind map. Separately, students were mostly of the opinion that science comes before technology. Finally, most of the students were found to see the future of science and technology as good.

Keywords

Science • Technology • Society • Mind map • University students

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Comprehending the STS relationship provides a basis for scientific literacy (Vazquez-Alonso, Garcia-Carmona, Manassero-Mas, & Bennassar-Roig, 2013). Therefore, one of the primary aims of science education is to ensure students develop scientifically correct, comprehensive, and consistent attitudes (cognitive models) for the topic of STS (Pekdağ, 2014). In this sense, students' construction of meaningful relationships among STS concepts is a substantial issue of science education. The concentration of recent studies in science education (Constantinou, Hadjilouca, & Papadouris, 2010; Pekdağ, 2014; Scherz & Oren, 2006; Sunar & Geban, 2011; Tairab, 2001; Yalvac, Tekkaya, Cakiroglu, & Kahyaoglu, 2007) on identifying student opinions concerning STS indicates the significance of this issue.

What Does Science Mean?

It is seen that there are various definitions for the concept of science in the literature. According to Çepni (2005) science is defined as the process of comprehension and description of the universe by utilizing and organizing the truth and knowledge with scientific methods. According to Ronan (2005), science is a system which can introduce hypothesis and theories as a result of constructing logical relationships among facts while it is stated as the total of the efforts of humans to comprehend, interpret, and explain the reality by Yeşiloğlu, Demirdöğen, and Köseoğlu (2010). The Turkish Language Institute has defined the concept of science as the "organized body of knowledge which selects various events or parts of the universe as a subject matter and attempts to make inferences by utilizing methods and realities based on experiments" (Türk Dil Kurumu [TDK], 2014a).

Zewail (2002) describes science as an education process that allows the educated and creative minds to question, experiment or observe in an attempt to find answers, and then try to identify a set of unifying principles, concepts, and laws that embraces all phenomena of nature. In addition, science has been explained with a cognitive approach for the discovery of truth and the clarification of the phenomenological world (Yıldırım, 1999).

Bell (2009) indicated that science has three domains. He has graphically demonstrated these domains as well as the relationships among these domains (see Figure 1).

Aslan (2013) listed the characteristics that qualify science as follows: (1) phenomenological, (2) logical, (3) objective, (4) critical, (5) generic, (6) selective, (7) progressive, and (8) based on several fundamental needs.

In light of the aforementioned definitions, science can be concluded as the body of evaluated knowledge that involves definitions, concepts, and phenomena which are systematically organized using several methods.

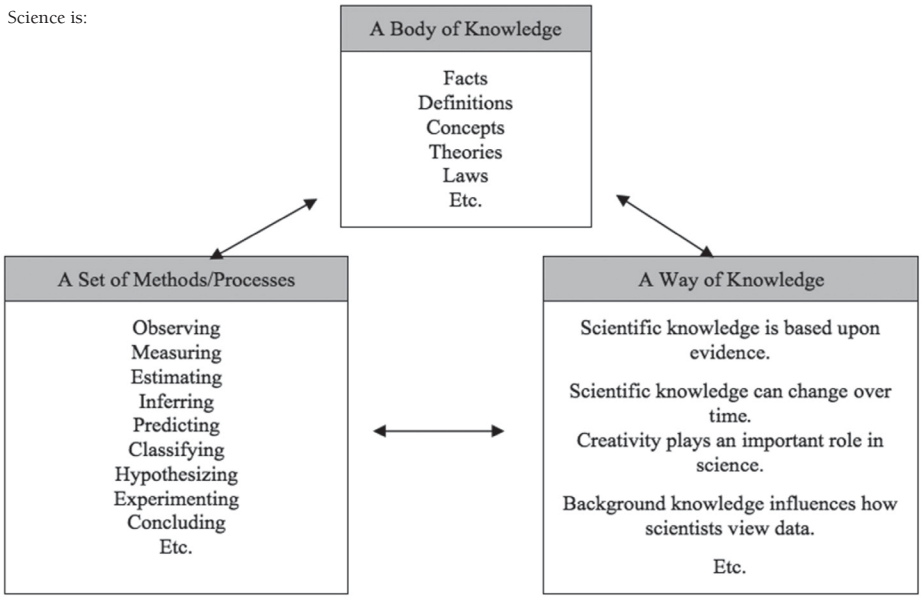

Figure 1. Three domains of science. (Bell, 2009, p. 2).

What Does Technology Mean?

In the literature, a number of definitions have been made for the concept of technology. The Turkish Language Institute has defined the concept of technology as "the application of knowledge that consists of the production methods related to a branch of industry; the equipment, instruments, and tools that are used; and their usage formats" (TDK, 2014b). The concept of technology in the Science and Technology Teaching Program as prepared by the National Ministry of Education is also expressed as:

> Technology is not just technological devices and their various applications as computers. Technology is both a kind of knowledge that utilizes the concepts and skills gained from other disciplines (science, mathematics, culture, etc.) and the submission of this knowledge to the service of humanity for meeting a determined need through the use of materials, energy, and equipment, or for solving a certain problem (Milli Eğitim Bakanlığı, MEB, 2006, p.8).

In his paper, Wonacott (2001, p. 2) reports several researchers' definitions regarding the concept of technology as follows: According to Dugger (2001), technology is the sum of alterations made to the natural environment for people's own purposes (to live longer and more productively, to meet demands and needs). It has been stated that this broad range of definitions involves a wide spectrum from the technology of old (tools made of stone, wheels, levers) to today's high technology (computers, multimedia, and biotechnology). Two important points are necessary for defining technology. The first point is that several authors have defined technology only through computers

and communication technologies (Selfe, 1999), while others have generally defined technology beyond just teaching and communication technologies (Custer, 1999). The second point is that technology has been defined separately from science, despite the fact that science and technology are related to each other (Sanders, 1999).

Naughton (1997, p. 12) defines technology by developing three different points of view. First, technology is a practical activity. Second, technology involves applying not just scientific knowledge but also other types of knowledge. Third, technology also involves people and organizations as well as machines. According to the International Technology Education Association, technology has descriptive and universal processes, knowledge, and content. These processes include human activity in relation to (a) the design and development of technological systems; (b) the determination and control of the behaviors of technological systems; (c) the utilization of technological systems and (d) the evaluation of the impacts and results of these technological systems. These developed systems have been categorized as informative, physical, and biological (International Technology Education Association [ITEA], 1996, p. 16).

In light of these definitions, technology can be concluded as the sum of materials which have been developed to meet people's needs and improve their welfare.

The Relationship among Science, Technology, and Society

It is clear that there is a tight connection among science-technology-society when the aforementioned science and technology definitions are considered. When the literature is examined, scientists assert that science and technology are dependent on each other (Barlex & Pitt, 2002); there is a dynamic information flow between them (Chavez & Moro, 2007) and they are important for the society and they should develop (Sjøberg & Schreiner, 2006). According to the study of Rose and Dugger (2002), about 60% of the American society states that science and technology are basically the same.

Zewail (2002) explains the aim of science is to better understand the universe and gain new knowledge that will enlighten humanity by unveiling mysteries of how nature works by making new discoveries and inventions that change the way we think and/or create new technologies that transform our society. Bybee (2000) explained the relationship of science and technology where science assists society develop a better understanding for the fundamental concepts and processes of technology and adds that there is an integral connection between science and technology where most advances in science are based on technology.

Gardner (1999, pp. 332-333) presented the relationship between science and technology under four headings:

(1) Science precedes technology, i.e. human technological capability depends upon the prior acquisition of scientific knowledge; this position, often called the technology as applied science view, is widely held and influential; it reflects an idealist view of scientific progress, i.e. that the concepts, laws and theories generated by scientists provide the basis for useful technological products.

(2) Science and technology are independent; scientists and technologists are people who have differing goals, use differing methods and produce differing outcomes (the demarcationist view).

(3) Technology precedes science; this materialist view asserts that technology is historically and ontologically prior to science, that human experience with tools, instruments and other artefacts is necessary for conceptual development; the materialist view clearly recognizes that modern science is almost entirely based on interpretations of data generated by instruments made by technologists.

(4) Technology and science engage in two-way interaction; this interactionist view considers scientists and technologists as groups of people who learn from each other in mutually beneficial ways; scientific research may assist in the development of technology, but equally, technological problems may stimulate fresh scientific research, sometimes in unintended ways.

McClellan and Dorn (2006) made this same determination related to the STS relationship:

> The twentieth century witnessed a fateful change in the relationship between science and society…-governments came to believe that theoretical research can produce practical improvements in industry, agriculture, and medicine…. Science became so identified with practical benefits that the dependence of technology on science is commonly assumed to be a timeless relationship and a single enterprise. Science and technology, research and development- these are assumed to be almost inseparable twins (p.1).

In light of the provided explanations, the tight connections of STS stand out. The mind map was constructed in order to present how students comprehend this connection.

Mind maps. Mind maps are graphical materials in which the relationships of different concepts and opinions are categorized through brain storming (Ayas, 2005, p. 79). Like concept maps, the mind map is another mapping strategy based on student interpretation and understanding (D'Antoni, Zipp, & Olson, 2009). However, it is different than concept maps although it is confused with concept mapping (Evrekli, İnel, & Balım, 2012).

Mind Maps organize information via hierarchies and categories flowing out from a central image and major topics or categories associated with the central topic are

captured by branches flowing from this central image (Budd, 2004). They provide a visual representation of not only concepts but also of knowledge and opinions through the transfer of key words and images to paper, connecting them with lines (Evrekli, İnel, & Balım, 2012). Mind mapping is stated to be an effective way of getting information by making remembering information easier (Edwards & Cooper, 2010). They can be used to summarize information, to relate information from various research fields, and to introduce information that demonstrates the overall structure of the topic (Kortelainen & Vanhala, 2004, p. 277). Other functions of mind maps are pointed out as forming, visualizing, conceiving and classifying thoughts in educational fields, organizational activities and problem-solving and decision-making processes (Akınoğlu & Yaşar, 2007).

Student Opinions Concerning the Subject of STS

Student opinions on science. Experimental research that has focused on students' opinions of the concept of science revealed that students explained the concept of science with the following expressions: (a) learning, (b) construction of meaning, (c) body of knowledge, (d) experiment, (e) methodology, (f) human activity, (g) systemic research, (h) discovery process, (i) curiosity, and (j) civilization.

Table 1
Students' Definitions of Science

Definitions	Studies
Learning	Lawson & Renner (1975); Pekdağ (2014)
Construction of Meaning	Lederman (1992); Mellado (1997)
Body of knowledge	Murcia & Schibeci (1999); Tairab (2001)
Experiment	Celik & Bayrakceken (2006); Craven, Hand, & Prain (2002)
Methodology	Scherz & Oren (2006)
Human activity	Constantinou et al. (2010); Nuangchalerm (2009); Pekdağ (2014); Yalvac et al. (2007)
Systemic research	Craven et al. (2002); Mellado (1997)
Discovery process	Sunar & Geban (2011); Yalvac et al. (2007)
Curiosity	Pekdağ (2014)
Civilization	Nuangchalerm (2009)

Pekdağ (2014) conducted a study to discover university students' opinions about the concept of science. As a result of this study, the researcher identified that students had defined the concept of science through the following categories: epistemological, historical, pedagogical, philosophical, psychological, and sociological. This study is significant in terms of proving students' identification of scientific concepts with various viewpoints.

Student opinions on technology. Experimental research that has focused on student opinions on the concept of technology revealed students explained the concept of technology with the following expressions: (a) works, (b) material products, (c) product design, (d) application of science, (e) human activity, (f) discovery, (g) technique, (h) knowledge and (i) ability.

Table 2
Students' Definitions of Technology

Definitions	Studies
Works	Tairab (2001)
Material products	Scherz & Oren (2006); Tairab (2001)
Product design	Constantinou et al. (2010); DiGironimo (2011)
Application of science	Pekdağ (2014)
Human activity	Pekdağ (2014)
Discovery	Sunar & Geban (2011); Yalvac et al. (2007)
Technique	Sunar & Geban (2011)
Knowledge	Pekdağ (2014)
Ability	Pekdağ (2014)

Several studies which examined student opinions about the concept of science and technology found that students had made explanations which did not match the modern definitions of science and technology (DiGironimo, 2011; Lederman, 1992; Pekdağ, 2014; Yalvac et al., 2007). For example, Pekdağ determined that several students had expressed the concept of science as a curiosity, dependency, or satisfaction of the ego. Again in the same study, several students were reported to have described the concept of technology as a skill or as the discovery of new things. The author indicated that the students had had naïve opinions about the concepts of science and technology, and the reason for this was linked to students' insufficient theoretical knowledge regarding these concepts. At the end of his study, the author emphasized that teaching programs were not sufficient for teaching the concepts of science and technology, even at the university level, and he added that university teaching programs should be revised by adding courses such as The History and Philosophy of Science and The History and Philosophy of Technology.

Student opinions about the relationship between science and society. The results of the study conducted by Pekdağ (2014), which focused on the opinions of university level students about the relationship between science and society, revealed that most students (88%) had thought that science was beneficial for society. Meanwhile, these studies indicated that a relatively low percentage of students (10%) had thought that science brings harm to society. Students who held the opinion that science was beneficial for society had expressed that science met the needs of society, solved the problems of society, increased the welfare and peace of society, increased the labor of society, and more. On the other hand, students who held the opinion that science brought harm to society had indicated that science led society to disaster, caused unhappiness among people, made people unsociable, and more.

Student opinions about the relationship between technology and society. The results of studies which focused on the opinions of university level students about the relationship between technology and society indicated that most of the students (77%) had thought that technology was beneficial for society. On the other hand, these studies indicated that various students (21%) had thought technology brings harm to

society. Students with the opinion that technology was beneficial for society expressed that technology had saved both time and money, increased production, raised the quality and standard of living, made life easier, and more. On the other hand, students who felt technology brought harm to society remarked that technology had raised unemployment, brought harm to human life and the environment, killed humanistic sensitivities, made life monotonous, caused cultural corruption, and so forth.

As a consequence, these studies showed that most university level students had had a positive approach towards STS. However, these studies also indicated that several students had had negative approaches. Pekdağ (2014) associated the reason for this negative approach to be a result of the courses of Environmental Chemistry; Environment and People; and Chemistry, People, and Society, which students had taken during their university years and which had taught the societal and environmental effects of scientific and technological applications (atom bomb, nuclear accidents, etc.).

The Purpose of the Study

Science and technology are currently improving rapidly. The discoveries and innovations supplied by these improvements widely influence both individuals and societies in the world. Even the flow of life is organized through these scientific and technological improvements (Akgün, 2001; Okan, 1993). For this reason, determining how students define the concepts of science and technology, how students perceive the relationship between science and technology, how students predict the condition of science and technology in the future, and how students express the STS relationship are all highly important. Additionally, having scientifically correct opinions about the concepts of science and technology, and establishing meaningful relationships in STS create a basis for students' scientific literacy (Vazquez-Alonso et al., 2013). The results obtained from the present study are significant in terms of presenting students' problems, even university seniors' problems, about the subjects of science, technology, and society, as well as for generating solutions to these problems. Also, this study with its aim to investigate the subject of STS over a wide perspective is believed to contribute to the literature and future studies on this subject through its methodological presentation of data analysis when compared to previous studies (Aldan Karademir, 2012; Aslan, Yalçın, & Taşar, 2009; Constantinou et al., 2010; DiGironimo, 2011; Herdem, Aygün, & Çinici, 2014; Kavak, Tufan, & Demirelli, 2006; Scherz & Oren, 2006).

In this context, the following research questions were investigated:

(1) What are the opinions of students on the concepts of science and technology?

(2) What are the opinions of students about the relationship between science and technology?

(3) What are the predictions of students related to the future status of science and technology?

(4) What are the opinions of students about the STS relationship?

Method

Study Model

This study used the survey method because it aimed to describe a current situation. Descriptive studies are studies conducted to shed light on a situation, to evaluate through standards, and to find situational relationships (Çepni, 2007). These studies attempt to describe the subject matter, which can be a situation, individual, or object, through its own situation *as is*; no effort is made to change anything (Karasar, 2008). Survey studies are defined in the literature as studies which are conducted to determine the characteristics of a relatively large sample of participants, such as their interests, abilities, talents, and attitudes related to an object or event (Büyüköztürk, Çakmak, Akgün, Karadeniz, & Demirel, 2010).

Sample

The research was conducted with a total of 102 students studying in their senior (4^{th}) year in biology, physics, and chemistry undergraduate programs in the Science and Art Faculty of a government university situated in the Marmara region of Turkey. Participation in the research was voluntary. The age range of the participants was between 21 and 24 with an average age of 22.1.

Data Gathering Procedure

The qualitative data collection method was utilized in order to discern the opinions of students on the subject of STS. A questionnaire consisting of five open-ended questions was implemented with the students who participated in the study. The first question, "According to you, what is science?" was oriented towards determining student opinion regarding the concept of science. The second question, "According to you, what is technology?" was asked in order to specify the opinions of students on the concept of technology. In the literature, open-ended questions directed to students and teachers in the form of "What is science?" or "According to you, what is technology?" have been encountered (Akerson, Cullen, & Hanson, 2009; DiGironimo, 2011; Pekdağ, 2014). The third question submitted to the students, "How can you explain the relationship between science and technology?" was proposed to detect

the opinions of the students about the relationship between science and technology. The fourth question, "How do you predict the future of science and technology?" was asked to specify the predictions of the students on the status of science and technology in the future. The final question of the questionnaire was "Explain the significance of science and technology for society." With this question, the intention was to understand the opinions of students on the STS relationship. This question is similar to the question directed to students in Pekdağ's (2014) study.

Procedure

First, all of the students were informed orally about the purpose of the study. Then the questionnaires, which consisted of five open-ended questions, were submitted to the students in their classroom environment under the supervision of the researcher. During this process, the students were provided with sufficient time to answer the questions after the questionnaires had been handed out. Students' answering process lasted for about one course hour (45 minutes). Data was gathered from the written responses to the open-ended questions. Data collection occurred over three weeks.

Data Analysis

The written responses of the participant students to the open-ended questions were analyzed qualitatively so as to provide answers to the research questions. The students' answers to each question were analyzed in detail. First, each student's paper was coded with a letter and number (for example, Ö1, Ö2, Ö3, etc.) and examined independently from the other students' responses. As a result of this analysis, the general meaning of students' responses for each question was presented. The response categories were structured by determining similarities among the general meanings of each student response. The categories identified for each question were controlled by examining each student response again for the accuracy of data analysis and to prevent any conflicts. In case of a conflict, the identified category was then modified. These categories were revised by taking the opinions of three experts. Each expert read 16 students' responses that had been randomly selected; they then analyzed them according to the modified categories. Thus, data analysis was conducted by examining each student response a few times through the processes of category formation, justification, and modification. Additionally, categories based on literature that had been conducted on the same subject were structured for each question. The categories formed for each question were utilized to present the profiles of the students' opinions (Abd-El-Khalick & Lederman, 2000; Akerson, Abd-El-Khalick, & Lederman, 2000; Pekdağ, 2014).

The model developed by Pekdağ and Le Maréchal (2007; 2010) was utilized in analyzing the data from the first research question, "What are the opinions of the students on the concepts of science and technology?" These authors indicated that the opinions

of students about a scientific concept could have been categorized through two world models: the perceptual and the restructured world models. According to the authors, the perceptual world is related to the five senses and based on knowledge that is gained by experience, while the restructured world is based on knowledge which requires the learner to go beyond experiences that cannot be perceived directly by the five senses but which requires various cognitive activities (interpretation, synthesis, logical inference, etc.). For instance, the authors determined that the opinions of students on the concept of chemical reactions were limited to just the perceptual world. In other words, these students were determined to have explained the concept of chemical reactions through their knowledge acquired from their five senses. In another study, Pekdağ and Erol (2013) expressed that the perceptual world dealt with concrete ideas whereas the restructured world dealt with abstractions. The authors stated that the meaning of a scientific concept which had occurred in a student's mind could be expressed as a concrete (perceptual world) or abstract (restructured world) idea. Thus, the opinions of the students regarding the concepts of science and technology were analyzed under the categories of *concrete meaning* and *abstract meaning* in the context of the present study in order to find the meanings related to these concepts as had occurred in the minds of the students.

Categories proposed by Gardner (Table 3; 1999) were utilized in analyzing the data gained from the responses to the second question, "What are students' opinions about the relationship between science and technology?" Gardner categorized the relationship between science and technology as (a) science comes before technology, (b) science and technology are independent of each other, (c) technology comes before science, and (d) science and technology have a bidirectional interaction (see pages 3– 4).

Table 3
Analysis of Students' Opinions On the Relationship Between Science and Technology

Categories	Demonstration of the Categories
Science comes before technology	S>T
Science and technology are independent from each other	S∩T
Technology comes before science	T>S
Science and technology have a bidirectional interaction	S↔T

Analysis occurred according to the categories shown in Table 4 for the students' responses to the third research question, "What are your predictions related to the future status of science and technology?" These categories were obtained as a result of the content analysis of students' responses.

Table 4
The Analysis of Students' Predictions About the Future Status of Science and Technology

Categories	Demonstration of the Categories
I see the future of science and technology to be good.	SFG
I see the future of science and technology to be bad.	SFB
I cannot see the future of science and technology.	CSF
There is no future for science and technology.	SNF

A mind map has been constructed in order to answer the fourth research question, "What are the opinions of students about the STS relationship?" In this case, the intent was to visualize the sum of the participating students' mental reflections on this relationship. The following steps were traced in constructing the mind map:

(a) The concept of STS, which is the main point of this study, was taken into a square and placed in the middle of the mind map.

(b) Data which had been obtained as a result of the content analysis of students' answers was collected under seven categories as constructed by the researcher. In the construction of these categories, the processes which were indicated in the first paragraph of the Data Analysis section were traced. The constructed categories were: natural events, education, communication, health, industry and defense. These seven determined categories were placed in a circle around the STS concept which had been located in the center of the mind map.

(c) Student opinions related to each category were placed in a rectangle around the related category.

(d) Both the relationships between STS and the categories and between the categories and students' opinions were indicated with one-directional arrows, as is characteristic of mind maps.

As can be seen in the mind map in Figure 2, the example of *television* was demonstrated under the category of communication. The reason for this was the fact that the students' statement that they had learned about developments and innovations in the world with the help of television. On the other hand, the example of *computer* was given under the category of industry. The reason for this was the fact that no computers had been featured in the students' answers: no sending e-mails or access to social media. Instead of these, the students' answers were related to the production of computers. Therefore, the example of computer was demonstrated under the category of industry, as opposed to communication. Aside from this, the example of machine, which had been placed under the category of industry, involved electronic devices such as dishwashers and washing machines.

Consequently, the participant students' responses to the five open-ended questions were analyzed according to the above-mentioned categories. The percentages of student responses were calculated for each category of analysis. Thusly, the research findings were expressed as percentages for each question.

Validity and Reliability of Data Analysis

To increase the validity and reliability of the data analysis, this study's researcher, along with two other researchers experienced in the current study topic, analyzed

12 students' written responses. Sixteen students' written responses (about 16% of the sample), randomly selected from 102 students' responses, were then analyzed separately by these three researchers; the obtained results were compared. Consistency among the researchers was found to be 85%. Differences among the researchers were revised by examining the 16 students' written responses; any differences were overcome through discussions among the researchers.

The reliability of data was calculated from the formula [agreements / (agreements + disagreements) x 100] (Miles & Huberman, 1994 as cited in Kurt, Ekici, Aksu, & Aktaş, 2013). The main researcher of the study first coded the students' responses for each question according to the previously stated categories. Other researchers then analyzed the responses under these categories. The researchers' analyses were then compared with each other by examining the points on which they had agreed and disagreed. The results of this coding were quantified by providing the frequency and percentage distributions for the analysis of each question. The correlation value among the researchers for the analysis of each question was calculated separately using the agreement formula, and the correlation among researchers was identified by taking the average of five reliability values. In the table below, the details regarding the correlation value from the analysis of each question are shown:

Table 5
Data Reliability Analysis

Question Number	OA	ODA	Correlation Value
1	16	0	100.0
2	14	2	87.5
3	13	3	81.0
4	14	2	87.5
5	11	5	69.0
		Average	85.0

Findings

The findings obtained according to data analysis have been presented in five different sections which are given below.

The Opinions of the Students on the Concept of Science

The findings obtained from students' responses to the question, "According to you, what is science?" are presented in Table 6.

Table 6
The Students' Opinions on the Concept of Science

Categories	Percentage (%)
Concrete Meaning	60
Abstract Meaning	32
No response	8
Total	100

While the concept of science had concrete meaning in several students' minds (60%), an abstract meaning was indicated in some students' minds (32%). However, the percentage of students who had a concrete meaning was nearly twice the percentage of those who had an abstract meaning. Few students did not respond to this question related to the concept of science.

Students who were placed in the category of concrete meaning had expressed the concept of science as: "The sum of research which tries to discover the unknown and which benefits all areas of our lives," "conducting research on a subject by utilizing different methods," "research," "made up of everything perceived by the five senses," "conducting research, observation, and experiments," and "people's investigation into the cause of events in nature." As can be understood from the students' definitions, the concept of science was explained through experiences associated with the five senses, such as research, observation, and experimentation.

The students who were placed in the category of abstract meaning had expressed the concept of science as: "a body of knowledge which grows through connections," "human comprehension of nature and everything around them," "all types of knowledge taught in schools," "new knowledge discovered by scientists," and "scientists' obtainment of new knowledge by examining nature, space, humans and animals, and all living and non-living things."As can be understood from these students' definitions, the concept of science was explained through a number of activities that required several mental activities by moving beyond direct experiences associated with the five senses, such as knowledge, obtaining knowledge, and constructing meaning.

Student Opinions on the Concept of Technology

The findings obtained from students' responses to the question, "According to you, what is technology?" are presented in Table 7.

Table 7
Student Opinions on the Concept of Technology

Categories	Percentage (%)
Concrete Meaning	88
Abstract Meaning	6
No response	6
Total	100

While the concept of technology held concrete meaning in several students' minds (88%), it represented an abstract meaning for some of the students (8%). However, most students had a concrete understanding of the concept of technology. Few students did not respond to this question related to the definition of the concept of technology.

The students who were placed in the category of concrete meaning had understood the concept of technology as: "meaning production," "the machines produced by humans," "the materials which are utilized to make life easier," "the collection of instruments which make life easier," "the practical part of science," "the discovery of more developed tools that provide ease in our daily life," and "saving money and time."As can be understood from these students' definitions, the concept of technology was explained through experiences associated with the five senses, such as production, machines, materials, instruments, and tools.

The students who were placed in the category of abstract meaning had expressed the concept of science as: "chaos," "the final destination of science," and "the construction of a system." As can be understood from these students' definitions, the concept of technology was explained with several activities that required several mental activities which moved beyond the experiences associated with the five senses.

Student Opinions on the Relationship Between Science and Technology

The findings obtained from students' responses to the question, "How do you explain the relationship between science and technology?" are indicated in Table 8.

Table 8
Student Opinions on the Relationship Between Science and Technology

Categories	Percentage (%)
S>T	55
S∩T	0
T>S	5
S↔T	32
No response	8
Total	100

The students' responses regarding the relationship between science and technology were determined to be in the following categories: Science comes before technology (S>T; 55%), technology comes before science (T>S; 5%) and science and technology have a bidirectional interaction (S↔T; 32%). No student responses were found for science and technology being independent of each other (S∩T) in this study. In other words, the student sample in this study thought that science and technology were not independent from each other. However, nearly half of the students possessed the view that science came before technology. Fewer students indicated that technology came before science. As can be understood from this finding, the dominance of science on technology was the prevalent opinion. In addition, nearly one-third of the students had the opinion that science and technology have a bidirectional interaction. Few students gave no respond at all to this question.

The students who thought that science came before technology (S>T) had expressed the following: "Technology would not exist if science did not exist," "Science is the father of technology," "Technology is the child of science," and "Science solves the problems of technology."

The students who believed that technology came before science (T>S) had indicated the following opinions: "Science is dependent on technology," and "Technology is the resource of science."

The students' responses which were placed in the category of science and technology having a bidirectional interaction (S↔T) were as follows: "They are dependent on each other," "They are like two halves of an apple," "They complete each other," and "They are two concepts which intertwine."

Students' Predictions About the Future Status of Science and Technology

The findings obtained from students' responses to the question, "How do you predict the future status of science and technology?" are shown in Table 9.

Table 9
Students' Predictions About the Future Status of Science and Technology

Categories	Percentage (%)
Good (SFG)	60
Bad (SFB)	29
Can't see (CSF)	7
No future (SNF)	4
Total	100

The students' responses about the future status of science and technology were determined to be in these categories: I see the future of science and technology as good (SFG; 60%), I see the future of science and technology as bad (SFB; 29%), I cannot see the future of science and technology (CSF; 7%), and there is no future for science and technology (SNF; 4%). While more than half of the students who had participated in the study stated that they had seen the future of science and technology as good, fewer students held the opinion that there was no future for science and technology. On the other hand, the percentage of students who thought that the future of science and technology was bad constituted nearly one-third of the sample. Few students indicated they couldn't see the future of science and technology. All participating students responded to the question regarding the future status of science and technology.

The students who predicted the future of science and technology as good (SFG) stated expressions such as: "Solutions will be provided for a number of fatal diseases," "Trips will be made to different planets," and "The space age will be experienced."

The students who predicted the future of science and technology as bad (SFB) indicated that "It will bring a mechanical life," "It will make people lazy," "It will end human relationships," "It will damage the ecological balance," and "It will raise unemployment."

The students who predicted that they could not see the future of science and technology (CSF) stated that "The future is like space" and "It is like an endless black hole."

The students who predicted there would be no future for science and technology (SNF) expressed the following opinions: "It will advance up to a point" and "Science and technology will become bogged down in the future."

Student Opinions on the STS Relationship

The findings obtained from students' responses to the question "Explain the significance of science and technology for society" are presented in Table 10.

Table 10
Student Opinions on the STS Relationship

Categories	Percentage (%)
Natural events	1.5
Education	18
Energy	2
Communication	22
Health	23
Industry	29
Defense	4.5
Total	100

The students constructed an STS relationship by relating it to the areas of natural events (1.5%), education (18%), energy (2%), communication (22%), health (23%), industry (29%) and defense (4.5%). Global warming, tsunamis, and solar eclipses took place under *Natural Events*; studying, instruction, and finding resources took place under *Education*; hydrogen energy and nuclear energy took place under *Energy*; radio, television, mobile phones, and the Internet took place under *Communication*; atom bomb, radiation, cancer, medicine, and laser treatments took place under *Health*; machines, cars, planes, robots, computers, and buildings took place under *Industry*; explosives and weapons took place under *Defense*. The area which the students related the STS relationship the most was *Industry*; the least related one was *Natural Events*.

Students expressed the STS relationship under *Natural Events* as: "Science investigates the subject of global warming, which concerns all of society and makes it more conscious," "Being informed about science makes society behave more logically towards events and makes it accept several truths more readily. For example, solar flares are events which science should know," and "Science and technology are significant in

terms of predicting tsunamis, disasters, and so on that are responsible for the deaths of hundreds of thousands of poor people; yet these disasters could not be avoided."

The students signified the STS relationship under *Education* as: "The significance of technological devices can be understood if they are nice and convenient for studying, finding resources, teaching, and treating diseases."

The students described the STS relationship under *Energy* as: "Technology has been presented to society. It is for society. Trade produced by the transformation of science into technology gets ahead of that. Additionally, it becomes a kind of threat to society: nuclear energy, waste which is not refined…,"and "New inventions and the things they bring are important for society. One of these is hydrogen energy."

The students explained the STS relationship under *Communication* as: "I can state that students learn more things today due to the development of various electronics and so on, in addition to the use of the Internet," "Societies make innovations to improve their lives, thanks to technology. However, technology is a common point for all societies. For example, mobile phones, a recent consequence of technology, work for all people," "Technology has a great place inside society. To illustrate, we have no chance of learning what goes around in other parts of the world without TV. We first listened to news from the radio. It then turned to watching TV as a result of the developments in technology," and "Mobile phones were invented thanks to science and technology. Better models were then invented."

The students stated the STS relationship under *Health* as: "Science and technology continue to develop every day; it will continue so that a number of things can be made in people's favor. For example, treatments for cancer, genetic diseases, and so on," "Various diagnoses for diseases have been discovered with the development of scientific techniques. The technological developments in the appropriate drug sector have enhanced disease diagnosis," "With the developments in science, a number of diseases have been provided with cures. For example, cures have been provided for cancers, which are known as the plague of our day, through these developments. As a result of scientific developments, an era has been opened in the treatment of cancer," "Surely, this event is positive as long as it is used for humans' future. Eventually, the atom bomb became a discovery which has dragged humanity near disaster."

The students explained the STS relationship under *Industry* as: "Today, we achieve most of our work thanks to technology. For example, computers have totally changed life. They have brought ease and comfort," "Technology facilitates work by decreasing the time required and the physical effort, such as a washing machine," "Recent discoveries in the area of mathematics have led to improvements in technology as various technological research has results dependent on technology. For example,

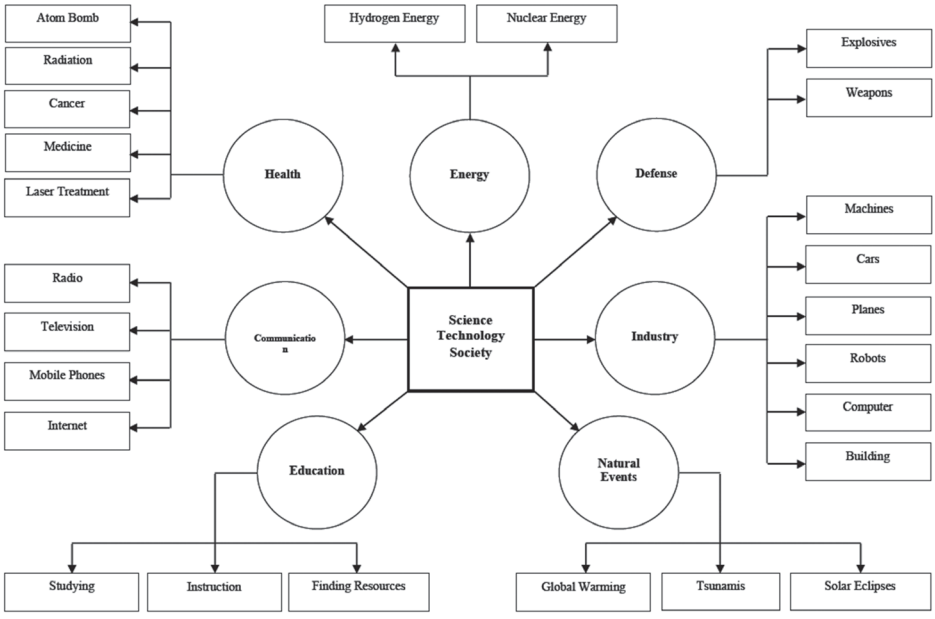

*Figure 2.*The mind map reflecting the students' opinions on STS relationships.

differential equations are utilized in the computers and in the movements of robots and planes," "Science has influenced the improvement of all societies," and "We can deliver science faster with technology. Suppose that you want to build a factory. You can improve production by equipping the factory technologically. When you want to raise a building, you can complete it faster thanks to technology."

The students conceived the STS relationship under *Defense* as: "There might be people who use science and technology with ill will. Chemical weapons, biological weapons, etc.," "People die more quickly and rapidly as technology develops. How? Radiation, recently invented weapons, and food with hormones can be listed," "The weapons which people use to kill each other were invented as a result of technology," and "It is important how technology is used. If technology is used positively, it can be beneficial. For example, explosives are one of the most used products of developed technology today."

The mind map, which demonstrates how students constructed STS relationships in different areas, is shown in Figure 2.

Discussion

One of the most significant aims of science education is for students to correctly define the concepts of science and technology, because comprehending the nature of science and technology makes up the basis of scientific literacy (Vasquez-Alonso et

al., 2013). When the students' definitions were examined in the context of this study, science possessed a concrete meaning in students' minds. These students explained the concept of science by associating it with experiences that could be perceived by the five senses, such as research, observation, and experimentation. On the other hand, this concept also indicated an abstract meaning for several students. When defining this concept, these students explained it with activities that required various mental activities, moving beyond the experiences associated with the five senses. For example, science was defined as "obtaining new knowledge" or as "a body of knowledge" for these students. When the categorization of science by Bell (2009)'s three dimensions was considered, the students who had determined concrete meanings for science were seen to stay in the dimension of a *number of methods and procedures*, whereas the students who had signified an abstract meaning for science limited themselves to the dimension of a *body of knowledge*. Those students who had described science through these two different ways (concrete or abstract) were seen to limit themselves to a single dimension. On the other hand, it was determined that students were not used to describing science through all three dimensions. The reason that science had a concrete meaning in most students' minds might be explained by students having experienced science mainly through the five senses by way of the experiments, observations, and measurements of their science laboratories during their university education. One cause of this determined consequence might be that those students had had no university classes, such as a history of science or philosophy of science class, to facilitate thinking in three dimensions and relating these three dimensions with each other. In this context, placing these courses in undergraduate programs would be beneficial.

Another important consequence gained from this study was that nearly all of the students had possessed a concrete meaning of the concept of technology in their minds. These students explained the concept of technology through experiences, machines, materials, and tools by relating them to their five senses. On the other hand, the concept of technology had an abstract meaning for a few students. Those students explained the concept of technology through activities that required mental activity, thus moving beyond experiences such as system constructions that are associated with the five senses. In the literature, findings exist which have reported that students defined scientific concepts by loading concrete meanings to them. For example, in the study of Pekdağ and Le Maréchal (2010), it was determined that students had described a given scientific concept mostly by using knowledge gained through the five senses, and these students' descriptions had been limited to the perceptual world. The reason why technology had concrete meanings in most students' minds stems from the fact that these individuals were constantly interacting with technological devices like internet, computers, planes, washing machines, and televisions with their daily applications. Students' definitions of technology were consistent with Naughton's (1997, p. 12) definition of technology: "technology is a practical activity…[or]…technology involves applications of all kinds

of knowledge." However, students' definitions were shallow when compared to the definition of technology made by the International Technology Education Association: technology is a process which can be described universally… These processes involve human activities regarding (a) the design, development, and utilization of technological systems; (b) determination and control of the behaviors of technological systems; and (c) evaluation of the influences and consequences of technological systems (ITEA, 1996). The placement of courses, such as a history of technology class for explaining the historical development of technology and its process, in the university teaching programs of those students would facilitate their looking at the concept of technology more broadly.

When the findings related to student opinions about the relationship between science and technology was examined, half of the students' explanations were towards the fact that science came before technology. On the other hand, one-third of the students expressed that science and technology had a bidirectional interaction. Fewer students indicated that technology was more dominant than science. Moreover, no student had the viewpoint that science and technology were independent from each other. These findings indicated that students' viewpoints focused only on two out of the four categories determined by Gardner (1999). This focus of nearly all of student opinions on these two categories showed that students had moved from the opinion that knowledge, which is gained from both scientific experiments and studies conducted in the laboratory, is utilized through its application in the production of technology and technological equipment that occur in daily life. Furthermore, there have been studies in the literature which remarked on the bidirectional interaction between science and technology (Barlex & Pitt, 2002; Bybee, 2000; Chavez & Moro, 2007; McClellan & Dorn, 2006; Rose & Dugger, 2002).

Another important result obtained from the study regarding students' predictions about the future status of science and technology were in the form of (a) seeing the future of science and technology as good, (b) seeing the future of science and technology as bad, (c) being unable to see the future of science and technology, and (d) science and technology's lack of a future. These predictions indicated that students had approached this case from four separate points of view. The reason that students had possessed different opinions related to the future of science and technology might stem from both the positive and negative effects of these on daily life. The most emphasized among the four student viewpoints was seeing the future of science and technology as good. On the contrary, the negligible percentage of students' predictions for seeing the future of science and technology as bad or as non-existent showed that these students had a negative approach towards the future of science and technology. This situation might be evaluated as a reflection of the daily experiences and observations of these future scientist-candidate students. Negative student opinions should be evaluated by science educators and researchers. The natural sciences educators should consider these negative student opinions while planning the content of courses regarding science and technology in the university. Natural science researchers

might contribute to a meaningful teaching of science and technology in the university by developing new teaching approaches and methods. Despite the fact that the reforms which will be implemented in teaching programs on this aspect will contribute to this area, it is probably impossible to purify individuals of their life experiences and opinions related to the negative effects of science and technology on daily life. However, increasing positive opinions of students related to this issue should be among the primary aims of educators.

A mind map was utilized in the presentation of students' complete opinions on STS relationships. When the student opinions on the STS relationship were examined, students were seen to have constructed this relationship in areas such as natural events, education, energy, communication, health, industry, and defense. The reason why students did not limit this STS relationship to only one area can be clarified by the entrance of science and technology to all parts of human life and its in separability from human life. Sometimes students were seen to positively explain the STS relationship (for example, performing rapid and easy communication with the utilization of devices such as internet and cell phones) and sometimes they were seen to negatively explain the STS relationship (for example, the negative influences of the atom bomb and radiation on the environment and on human health). In another words, the students stated that science and technology had been both beneficial and harmful for society. The mind map constructed in this study might guide future research which addresses student opinions on STS issues as it provides benefits for researchers in terms of its complete summaries, relations, and introductions of information for reflecting the structure of the subject.

This study presents important and beneficial knowledge to science educators, science teaching program designers, and researchers in terms of the outcomes of the research. The study was limited to science and art faculty students. Student opinions on STS might be studied from different samples, and the results obtained should be evaluated. Also, the qualitative data obtained from open-ended questions as a result of this study might be enriched through various means such as dual interviews. Thus, collecting more detailed data using qualitative approaches might be possible.

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