Croatian Journal of Education
Vol.16; Sp.Ed.No.3/2014, pages: 11-53
Original research paper
Paper submitted: 3rd July 2013
Paper accepted: 11th March 2014

Prospective Chemists' and Pre-service Chemistry Teachers' Views about Science-Technology-Society (STS) Issues

Bülent Pekdağ
Necatibey Education Faculty, Balıkesir University

Abstract

The present study aims to investigate the views of prospective chemists and pre-service chemistry teachers about science-technology-society (STS) issues, attempting to examine the differences between these views. A questionnaire that included 4 open-ended questions was distributed to 67 senior university students to determine what their views were on STS issues. The data was collected from the students' written responses to the open-ended questions. The data gathered from the two groups of students was analyzed qualitatively from the perspective of responding to the research questions. It was observed that while prospective chemists mostly defined science from epistemological and philosophical perspectives, pre-service chemistry teachers frequently explained science from epistemological and pedagogical perspectives. The results revealed that the meanings of science and technology in the minds of the students in both groups showed some important differences in this sample. Additionally, students in both groups stated that science and technology affected society both negatively and positively.

Key words: *science-technology-society (STS); prospective chemists; pre-service chemistry teachers*

Introduction

A major goal of science education today is to achieve the understanding of the nature of science, the nature of technology, and their interactions within society (AAAS, 1993; NRC, 1996). Understanding relationships between science, technology, and society is essential for attaining basic scientific literacy (Vazquez-Alonso et al., 2012). Scientific literacy generally refers to one's understanding of the concepts, principles, theories, and processes of science, and one's awareness of the complex relationships between science, technology, and society (Abd-El-Khalick et al., 1998). Three respected national and international organizations have spelled out a common set of ideas and skills that form the core of literacy in technology (ITEA, 2006; NAE & NRC, 2002). Understanding science and technology has clear implications for productive citizenship in an information-driven economy (DiGironimo, 2011).

The role of the nature of science and the nature of technology within science education has been given much consideration in recent years. Research has been conducted to investigate the views of students about science and technology (Constantinou et al., 2010; Craven et al., 2002; Lederman et al., 2002; Sunar & Geban, 2011; Tairab, 2001). Researchers in science education found that some students' views are inconsistent with contemporary conceptions of science and technology, and that they have naïve opinions on the subject (DiGironimo, 2011; Kang et al., 2005; Lederman, 1992; Yalvac et al., 2007). For this reason, several attempts have been undertaken to improve the views of students regarding science and technology (Abd-El-Khalick & Lederman, 2000a; Cakmakci, 2012; Leach et al., 2003). Indeed, helping students develop adequate conceptions of science and technology has been a perennial goal of science education, one that can be traced back to the turn of the century (Constantinou et al., 2010; DiGironimo, 2011).

Literature Review

Science

The term "science" is customarily used to refer to the epistemology of science, that is, science as a way of knowing, or the values and beliefs inherent in the development of scientific knowledge (Lederman, 1992). The characterizations in this context, nevertheless, remain fairly general, and philosophers of science, historians of science, and science educators are quick to disagree on a specific definition for science (Bell et al., 2000). Whereas scientists, philosophers, sociologists and economists have developed their own definitions of science, science is simply defined as what scientists do and produce. Scientists and philosophers have defined science by its content (knowledge) and method, economists have defined it as information, and sociologists have defined it by its institutions and practices (Godin, 2007).

Science is a multifaceted activity that may be operationally defined in a number of ways (Gilbert, 1991). Therefore, science is defined in such different ways as a human activity, a way of knowing, a body of knowledge, a process (observation, inference and experimentation) and as systematic thinking (AAAS, 1993; Abd-El-Khalick & Lederman, 2000b; Allchin, 1999; Ibáñez–Orcajo & Martínez–Aznar, 2007; Murcia & Schibeci, 1999; NRC, 1996; Nuangchalerm, 2009). Science has two parts: (1) a body of knowledge that has been accumulated over time and (2) a process–scientific inquiry–that generates knowledge about the natural world (NAE & NRC, 2002). Science is very concerned with what is (what already exists) in the natural world. Many of the courses in schools, colleges, and universities reflect the study of the natural world. These courses deal with biology, chemistry, astronomy, geology, etc. Some of the processes that are used in science to seek out the meaning of the natural world are "inquiry," "discovering what is," "exploring," and using "the scientific method" (Dugger, 2010).

Ziman (1984) developed some broad definitions that try to encompass science's different facets as a human activity. According to Ziman, science is: (i) *a way to solve problems*, if the emphasis is on the instrumental dimension of science as it relates to technology, economics and politics; (ii) *organized knowledge*–when referring to science as the compiler of knowledge, this accumulation of knowledge is a function of technological advances and is studied as a historical process; (iii) *a way of doing things*, from a methodological and philosophical perspective; and (iv) *any discovery carried out by people* with a special talent and vocation for research.

Science is dynamic and ongoing and not a static accumulation of information (Lederman, 1992). The processes of science include observing, classifying, measuring, interpreting data, inferring, communicating, controlling variables, developing models and theories, hypothesizing, predicting and experimenting. Even scientists themselves frequently voice empiricist-inductivist views of science since scientists are not always explicitly conscious of their own research strategies (Gil-Perez et al., 2005).

The constructivist view of science perceives the world differently. The basic beliefs of this view are the following: science is seen as a set of socially negotiated understandings of the universe; knowledge is accepted by the scientific community only if viable; in addition to "scientific method," there are other ways to gain scientific knowledge; scientists are influenced by prior knowledge, social factors and other influences; and scientific knowledge is intuitive (Mansour, 2010). According to the constructivist view, then, science has characteristics that are empirically based, tentative, subjective, creative, unified, and culturally and socially embedded (AAAS, 1993).

Science deals with and seeks the understanding of the natural world (NRC, 1996). The basic aim of science is to give an organized account of whatever knowledge we can obtain about the universe (Purtill, 1970). Science aims to find true answers to a variety of questions–to a variety of *sorts* of questions (van Woudenberg, 2013).

Technology

The term "technology" is customarily used to refer to engineering and computer science, bringing to mind mental constructs such as artifacts, skills, knowledge, organizations, methods, techniques, process of creation or design, or systems (Ankiewicz et al., 2006; Cajas, 2001; De Vries, 2003, 2006; Gil-Perez et al., 2005; Mitcham, 1994). Merriam-Webster's Collegiate Dictionary (2008) defines *technology* as "the practical application of knowledge, especially in a particular area (such as engineering, computer science); or a manner of accomplishing a task, especially using technical processes, methods, or knowledge."

According to modern philosophy, technology is defined as a human activity (Constantinou et al., 2010; De Vries, 2003; Pitt, 2000). Technology as activity is that pivotal event in which knowledge and volition unite to bring artifacts into existence or use (Mitcham, 1994). Technology can also be thought of as techniques referring to the material products of human making (McGinn, 1991). Technology is a focus on the man-made world where designs are aimed at providing observable products that directly affect humans (e.g., air travel, refrigeration, TV, cell phones, transportation, and machines) (Akcay & Yager, 2010). Technology includes material artifacts such as tools, instruments, machines, electronic devices, scientific hardware, or industrial manufacturing systems (Cajas, 2001; İşman, 2012; Mitcham, 1994). These artifacts have the function of extending human capabilities (Franssen et al., 2009). The concept of technology does not only relate to the technology that is embodied in the product, but it is also associated with the knowledge or information of its use, application and the process of developing the product (Bozeman, 2000).

Some researchers define technology as the application of scientific knowledge to the practical aims of human life or to the change and manipulation of the human environment (Soanes & Stevenson, 2008). Technology is very concerned with what can and should be (designed, made, and developed) from natural world materials and substances to satisfy human needs and wants. Some processes used in technology to alter and change the natural world are "invention," "innovation," "practical problem solving" and "design" (Dugger, 2010).

The American Association for the Advancement of Science's (AAAS) *Benchmarks for Science Literacy* defines technology as follows: "In the broadest sense, technology extends our abilities to change the world; to cut, shape, or put together materials; to move things from one place to the other; to reach farther with our hands, voices, and senses" (AAAS, 1993, p. 41). In 2000, in the International Technology Education Association's (ITEA) *Standards for Technological Literacy: Content for the Study of Technology*, technology is defined as "the innovation, change, or modification of the natural environment in order to satisfy perceived human wants and needs" (ITEA, 2000, p. 242). Similar to this definition, *Technically Speaking: Why All Americans Need to Know More about Technology* presents the following: "In its broadest sense, technology is the process by which humans modify nature to meet their needs and wants" (NAE & NRC, 2002, p. 2).

Technology is a product of engineering and science. Science aims to understand the "why" and "how" of nature, engineering seeks to shape the natural world to meet human needs and wants (NAE & NRC, 2002). Technology deals with "what can be" invented, innovated, or designed from the natural world, while science is concerned with "what is" in the natural world (ITEA, 2006). The need to answer questions in the natural world drives the development of technological products; moreover, technological needs can drive scientific research (NRC, 1996).

Technology is developed and applied by people. Its success or failure is usually determined by social acceptance and success in the marketplace. It has helped to satisfy some of the fundamental human needs of hunger, shelter, comfort, health, mobility, and communication (ITEA, 1996). The goal of technology is thus to make modifications in the world to meet human needs (NRC, 1996).

Purpose of the Study

In Turkey, the undergraduate curricula implemented for prospective chemists and pre-service chemistry teachers showed significant differences. The chemistry undergraduate curriculum applied to the prospective chemists participating in this study included compulsory chemistry courses (68%), other compulsory courses (24%) and elective courses (8%). In contrast, the chemistry education undergraduate curriculum implemented for pre-service chemistry teachers participating in this study consisted of compulsory chemistry courses (40%), compulsory education courses (28%), other compulsory courses (26%) and elective courses (6%).

When the two programs are reviewed in terms of science, technology and society, it is observed that prospective chemists take more science courses (theoretical and practical). A large part of these courses are the same (32 courses), but both programs contain some different science courses. For example, the courses on “Quantum Chemistry,” “Industrial Chemistry,” “Polymer Chemistry,” and “Biochemistry Laboratory I and II” are available only in the curriculum applied to prospective chemists. There are more courses that emphasize the chemistry-environment-society connection in the prospective chemists’ program. While the courses on “Environmental Chemistry” and “Chemistry, Human and Society I and II” are only given to prospective chemists, the class on “Environment and Human” is taught to pre-service chemistry teachers. The number of scientific research and technology classes is the same for both. On the other hand, there are differences in the content of these classes. For instance, while prospective chemists take a class in scientific research and start learning how to conduct a scientific study in the field of chemistry (determining the physical and chemical qualities of substances, organic synthesis, etc.), the pre-service chemistry teachers take a course on how to conduct a scientific study in the field of chemistry education (the student’s attitude towards chemistry, the student’s knowledge of chemistry, the teacher’s content knowledge, textbooks, etc.). With regard to technology classes, the course on “Computer” and its content are the same in both programs. On the other hand, courses such as “Computer Applications in Chemistry,” “Textile Technology,” and “Oil Technology” are only offered to prospective chemists. The program for pre-service chemistry teachers includes technology classes such as “Internet Applications,” “Photoshop,” and “Movies in Chemistry Education.” Table 1 shows the number of courses related to science, technology and society in both programs.

Table 1.
Number of Courses related to STS Issues

	Prospective Chemists	Pre-service Chemistry Teachers
Science Courses	48	36
Science, Environment and Society Courses	3	1
Scientific Research Courses	2	2
Technology Courses	4	4

The differences in the number and content of the courses related to STS issues in both programs stem from the nature of the professional field for which the students are being trained and also from their particular needs. The similarities and differences in learning outcomes of courses on STS issues are shown in Table 2.

Table 2.
Program Learning Outcomes related to STS Issues

	Learning Outcomes	Prospective Chemists	Pre-service Chem. Teach.
Theoretical Knowledge	• Understanding theories, models, laws, principles and concepts of chemistry and related sciences (physics, biology)	✓	✓
	• Identifying and learning the characteristics of technological tools used in chemistry laboratories (UV-Visible Spectrophotometer, Fourier Transform InfraRed Spectroscopy, *Conductometer*, *Polarimeter,* pH meter, Muffle furnace, etc.)	✓	✓
	• Learning about environmental pollution (air and water pollution) and the reasons for this pollution (heavy metals, nuclear wastes, etc.)	✓	✓
	• Developments in chemistry (ceramics, coal, textiles, iron & steel, explosives, fertilizers, the petrochemical industry) and understanding the effects of these developments on human beings and society	✓	
	• Learning the Microsoft Word, Microsoft PowerPoint and Microsoft Excel programs	✓	✓
	• Learning about the technological tools used in the chemicals industry (textiles, oils, cleaning agents, etc.)	✓	
	• *Learning the Pascal programming language*	✓	
	• Learning about the design and production of chemistry experiment videos		✓
	• Learning how to prepare a Web page		✓
	• Learning the Photoshop program		✓
	• Learning the steps and techniques used in scientific research in the field of chemistry	✓	
	• Learning the steps and techniques used in scientific research in the field of chemistry education		✓

	Learning Outcomes	Prospective Chemists	Pre-service Chem. Teach.
Field Specific Competence	• The ability to work effectively and safely in a chemistry laboratory	✓	✓
	• The ability to design and carry out chemical experiments	✓	✓
	• The ability to interpret the results of chemical experiments and arrive at a general conclusion	✓	✓
	• The ability to carry out chemical experiments (observations, measurements) in the laboratory using technological tools	✓	✓
	• The ability to use information and communication technologies in one's field of study	✓	✓
	• The ability to carry out scientific research in the field of chemistry	✓	
	• The ability to carry out scientific research in the field of chemistry education		✓
	• The ability to use chemistry knowledge for the benefit of the environment and society	✓	✓
	• The ability to use chemistry knowledge in the chemist's profession	✓	
	• The ability to use chemistry knowledge in the chemistry teaching profession		✓

Because of the differences in these two undergraduate curricula, this study aimed to diagnose the views of prospective chemists and pre-service chemistry teachers about STS issues and to clarify the differences between these views. Literature on science education clearly shows that knowledge of technology is an educational goal but that, however, few studies exploring students' views regarding technology have been published (Constantinou et al., 2010; DiGironimo, 2011; Scherz & Oren, 2006; Tairab, 2001). From another perspective, there seem to be no empirical studies in science education literature that aimed to compare the views on STS issues of prospective chemists and pre-service chemistry teachers, involving two groups of students who are subjected to two different educational processes. Therefore, this study can contribute to the literature by presenting useful information to researchers of chemistry education and chemistry teachers about the views of two groups of students on STS issues.

Research Questions

The study endeavors to answer the following questions:

1. What are the views of prospective chemists and pre-service chemistry teachers regarding science and technology?
2. What is the manner of thinking adopted by prospective chemists and pre-service chemistry teachers about science?
3. How do prospective chemists and pre-service chemistry teachers approach the relationship between science and society?

4. How do prospective chemists and pre-service chemistry teachers approach the relationship between technology and society?

Method

Participants

This study was implemented with a total of 67 senior university students enrolled at the Balıkesir University in Balıkesir. The university is a state university placed in the Aegean region, in the west of Turkey. Of the students, 52% (N=35) were in the School of Science and Arts and 48% (N=32) in the School of Education. The students participating in the research from the School of Science and Arts were studying chemistry. The students participating in the research from the School of Education were studying chemistry education. Students in both groups were invited to volunteer in the study. Their ages ranged from 21 to 25 years, displaying a median of 22.5 years.

Data Collection Method

A qualitative method was used in this study to identify students' views on STS issues. In accordance with the size of the sample, a questionnaire that included 4 open-ended questions was chosen (Marshall & Rossman, 2006). Question 1, "What, in your opinion, is science?" pertained to students' views on science. Question 2, "What, in your opinion, is technology?" focused on students' views on technology. The research studies which direct open ended questions in the form of "What is science?" (Akerson et al., 2009; Akerson et al., 2007) and "What, in your opinion, is technology?" (DiGironimo, 2011) to the students and teachers are encountered in the literature. Question 3, "What is the importance of science for society?" was designed to define students' views about the relationship between science and society. Finally, Question 4, "What is the importance of technology for society?" was meant to diagnose students' views about the relationship between technology and society. These four open-ended questions allow respondents to elucidate their own views regarding STS issues and the reasons that underlie their views (Lederman, 1992).

The questionnaire was administered to the students in their classrooms under the guidance of the researcher. All of the students were informed about the purpose of the study. The students answered the questionnaire in about 30 minutes. In each question, students were required to explain the reason for their answer. In order to obtain more detailed information from the students and to prevent the omission of any question, the researcher was present in the classroom during the administration of the questionnaire. He encouraged the students to answer all questions candidly and with confidence. This approach significantly contributed to the collection of substantial data from the students.

Data Analysis

The data was collected from the prospective chemists' and the pre-service chemistry teachers' written responses to the open-ended questions. The data gathered from both groups of students were analyzed qualitatively with a view to responding to the research questions. The responses of each student were carefully studied to identify and describe the underlying reasoning. All of the student responses were coded in this study using numbers, with students being represented by letters. The coding for the prospective chemists was implemented as C1, C2, C3, etc. while that of the pre-service chemistry teachers was in the form of T1, T2, T3, etc. In data analysis, each student was treated as a separate case. Each open-ended question was used to generate a summary of each student's views of STS issues. This process was repeated for all open-ended questions. After this initial round of analysis, the summaries were searched for categories. These categories were checked against confirmatory or contradictory evidence in the data and were modified accordingly. Several rounds of category generation, confirmation, and modification were conducted to satisfactorily reduce and organize the data. These categories were employed to generate a profile of the students' views of STS issues (Abd-El-Khalick & Lederman, 2000a; Abd-El-Khalick et al., 1998; Akerson et al., 2000).

For responding to research question 2, a classification developed by Ziman (1984) was used to analyze the data. In his definition of science, Ziman distinguished philosophical, historical, psychological, sociological, and epistemological dimensions. Also, McComas and Olson (1998) carried out a rigorous qualitative analysis of documents from many countries on science education standards and identified 30 statements about science, which they grouped into philosophical, sociological, psychological, and historical categories. The classification suggested by Ziman (1984) was adapted in this study and a new category was added from the content analysis of the students' responses. Thus, the manner in which students thought about science was grouped under six categories as the "philosophical dimension," "epistemological dimension," "historical dimension," "sociological dimension," "psychological dimension," and "pedagogical dimension." These categories were used in order to represent the data in a more meaningful way. Table 3 represents the framework of categorizing the students' manner of thinking about science obtained from the student responses.

The descriptors indicated in Table 3 depict that six dimensions used in the categorization of the students' manner of thinking about science are different from each other. For instance, the descriptions of science made by the students who were in the "epistemological dimension" were empiricist perspective related (observation, experiment, measurement, analysis, method, etc.). On the other hand, the descriptions of science made by the students who were in the "pedagogical dimension" were pedagogical perspective related which was constructed on the effort to learn or comprehend. For example, such a student definition of science–"the endeavor to learn about the universe or understand the nature" was categorized under the "pedagogical dimension."

Table 3.
The Framework of Categorizing Students' Manner of Thinking about Science

Categories	Examples of Student Reponses
Philosophical dimension	• Science is the whole body of verifiable and falsifiable knowledge. • Science is the whole body of meaningful and consistent knowledge. Descriptors: provable, demonstrable, verifiable or falsifiable knowledge; meaningful and consistent knowledge; theoretical knowledge; changeable knowledge.
Epistemological dimension	• Science is the explanation of phenomena in the universe through the use of experimentation, observation and measurement. • Science is the attempt to explain the universe through the use of theories and models. Descriptors: observation, experiment, measurement, analysis, method, hypothesis, theory, model, law, principle, paradigm, prediction, assumption, inference, confirmation, interpretation, classification.
Historical dimension	• Science is civilization. • Science is an area of research that, over the course of the history of humanity, tries to shed light on and reveal the facts about scientific phenomena. Descriptors: civilization, becoming civilized, modernization, history of humanity.
Sociological dimension	• Science is a tool used to solve the problems of society. • Science is a phenomenon that raises levels of prosperity and the standard of living in society. Descriptors: problem-solving, level of prosperity, standard of living, societal benefit, quality of life.
Psychological dimension	• Science is curiosity. • Science is the desire to discover new things. Descriptors: interest, desire, curiosity, creativity, ability, dependence.
Pedagogical dimension	• Science is the effort to learn about human beings and the universe that surrounds them. • Science is the attempt to understand nature. Descriptors: becoming acquainted, comprehension, learning, gaining knowledge, gaining awareness.

Finally, student approaches to the relationship between science and society (Question 3) and to that between technology and society (Question 4) were grouped under three categories as "positive approach," "negative approach," and "no answer." In order to respond to research questions 3 and 4, these categories were developed from the content analysis of the students' answers.

Consequently, in this study, an iterative process was used to describe and interpret the data obtained from the students' written responses to the questionnaire with 4 open-ended questions. The percentages of the students' responses for each category were calculated. Later, the results were presented question by question in terms of percentage.

Validity/Reliability

In order to enhance the validity and reliability of the data analysis, firstly, the researcher and two external chemistry education researchers collaborated on the analysis of eight student papers. Then, fifteen randomly-selected papers out of 67 (around 22% of the sample) were independently analyzed by these three researchers, and the ratings were compared. The inter-researcher agreement was found to be 82%, which was considered to be high (Cohen et al., 2007). The researchers sorted out differences by reviewing the students' responses. Discrepancies were resolved through discussions among the researchers.

Results

The results are reported in five separate sections. The first section focuses on students' views on science. The second section explains the students' manner of thinking about science. The third section sets forth students' views on technology. The fourth section presents the students' approaches to the relationship between science and society. The final section reveals the students' approaches to the relationship between technology and society.

Students' Views about Science

The question "What, in your opinion, is science?" determined the students' views about science. The results obtained from this question are presented in Table 4.

Table 4.
Students' Views about Science

Views	Prospective Chemists (%)	Pre-service Chemistry Teachers (%)
Science as a body of knowledge	23	14
Science as a way of learning		19
Science as a way of making sense		5
Science as civilization	2	7
Science as curiosity	5	5
Science as experiment	29	24
Science as human activity	7	14
Science as method	20	7
Science as systematic investigation	7	5
Science as the process of discovery	7	
Total	100	100

Both prospective chemists and pre-service chemistry teachers defined science as associated with different expressions. However, for both student groups, the predominant views used in the definition of science showed some differences. While science was often regarded by prospective chemists as an experiment (29%), a body of knowledge (23%) and a method (20%), pre-service chemistry teachers generally defined science as an experiment (24%), a way of learning (19%), a body of knowledge (14%) and a human activity (14%).

Previous studies have reported that students conceive of science as an experiment, a body of knowledge, a method, or a human activity (Celik & Bayrakçeken, 2006;

Constantinou et al., 2010; Ibáñez–Orcajo & Martínez–Aznar, 2007; Lederman, 1992; Murcia & Schibeci, 1999; Nuangchalerm, 2009; Scherz & Oren, 2006; Tairab, 2001). In this study, some students wrote: "*C12: Science is a body of knowledge, such as concepts, laws and theories*," "*T9: Science is a human activity that seeks answers to questions about the universe*" or "*C3: Science is a method, based on observation and experimentation, that leads to adequate explanations of natural phenomena.*" Only pre-service chemistry teachers defined science as a way of learning. For example, one student wrote: "*T17: "Science is a way of learning about the natural world*."

A small number of students in both groups perceived science as "systematic investigation," "curiosity" and "civilization." For example, one student wrote: "*C24: Science is a systematic investigation for understanding the universe through observation and experiment*." The definition of science by students as "investigation" had also been reported by previous studies (Craven et al., 2002; Mellado, 1997).

Finally, some students explained science as the process of discovery and a way of making sense. For example, some students wrote: "*C6: Science is a process of discovering new things about the world and universe*" or "*T27: Science is a way of making sense of the natural world*." While the definition of science as the process of discovery was made only by prospective chemists, the explanation of science as a way of making sense was made only by pre-service chemistry teachers. The definition of science by students as "the process of discovery" had previously been reported by researchers (Sunar & Geban, 2011; Yalvac et al., 2007).

Students' Manner of Thinking about Science

The results related to the students' manner of thinking about science are presented in Table 5.

Table 5.
Students' Manner of Thinking about Science

Categories	Prospective Chemists (%)	Pre-service Chemistry Teachers (%)
Epistemological dimension	63	36
Historical dimension	2	7
Pedagogical dimension		24
Philosophical dimension	23	14
Psychological dimension	5	5
Sociological dimension	7	14
Total	100	100

The manner of thinking of prospective chemists and pre-service chemistry teachers about science was related to various dimensions. Although students defined science in terms of different dimensions, the predominant dimensions showed some differences in the two student groups. While science was usually defined by prospective chemists in relation to the epistemological dimension (63%) and the philosophical dimension (23%), pre-service chemistry teachers generally thought of science at the epistemological dimension (36%), pedagogical dimension (24%), philosophical dimension (14%) and sociological dimension (14%).

In the epistemological dimension, many students defined science from an empiricist perspective: "*C21: Science is the explanation of phenomena in the universe through the use of experimentation, observation and measurement*." Some students expressed their views on science in the pedagogical dimension. For example, one student wrote: "*T4: Science is the effort to learn about human beings and the universe that surrounds them*." Other students also wrote from a pedagogical perspective: "*T31: Science is the attempt to understand nature*" or "*T2: Science is the attempt to learn about any topic*." Only pre-service chemistry teachers made an explanation of science through the pedagogical dimension. In the philosophical dimension, some students expressed science as: "*C27: Science is the whole body of verifiable and falsifiable knowledge*" or "*T13: Science is the knowledge discovered by the human race using the capabilities of thought and reasoning*." In the sociological dimension, for example, some students explained science as: "*T6: Science is a phenomenon that raises levels of prosperity and the standard of living in society*" or "*C33: Science is a tool used to solve the problems of society*."

A small number of students in both groups defined science in the historical dimension and the psychological dimension. In the historical dimension, for example, some students wrote: "*C10: Science is civilization*" or "*T25: Science is an area of research that, over the course of the history of humanity, tries to shed light on and reveal the facts about scientific phenomena*." In the psychological dimension, for example, some students wrote: "*C14: Science is curiosity*," "*C29: Science is satisfying the ego*" or "*T15: Science is the desire to discover new things*."

Earlier studies revealed that students had different perspectives about science, specifically positivist, empiricist, inductivist or idealistic outlooks (Gallagher, 1991; Hodson, 1985; Lederman, 1992; Mellado, 1997). In this study, the manner of thinking of prospective chemists and pre-service chemistry teachers about science was related to the epistemological, historical, pedagogical, philosophical, psychological and sociological dimensions.

Students' Views about Technology

The question "What, in your opinion, is technology?" determined the students' views about technology. The results obtained with reference to this question are presented in Table 6.

Both prospective chemists and pre-service chemistry teachers defined technology in association with different expressions. However, the predominant views used in the definition of technology showed some differences in the two student groups. While technology was often considered by prospective chemists as invention (26%), material products (21%), artifacts (17%) and a technique (10%), pre-service chemistry teachers generally defined technology as invention (25%), artifacts (20%), knowledge (20%) and a discipline (15%).

Table 6.
Students' Views about Technology

Views	Prospective Chemists (%)	Pre-service Chemistry Teachers (%)
Technology as artifacts	17	20
Technology as design of products	5	5
Technology as discipline	7	15
Technology as human activity	7	5
Technology as invention	26	25
Technology as knowledge	7	20
Technology as material products	21	7
Technology as skill		3
Technology as technique	10	
Total	100	100

For example, some students explained technology as follows: "*T19: Technology is human artifacts such as instruments, machines, devices, hardware*," "*C8: When technology comes to mind, I think of the vehicles we drive, cell phones, computers, the Internet, video games, etc.*," "*T23: Technology is technical knowledge used for the benefit of society*," "*C34: Technology is inventing new things*," "*C2: Technology is an applied science*," "*T29: Technology is the concrete expression of science, its transformation into practical life*" or "*C19: Technology is a technique for solving practical problems*." Additionally, only prospective chemists gave the definition of technology as a technique.

A small number of students in both groups viewed technology as the design of products and a human activity. For example, one student wrote: "*T11: Technology is a design of products to increase standards of living*." Finally, a very small number of students perceived technology as skill. The explanation of technology as skill was offered only by pre-service chemistry teachers.

Previous studies have reported that students explained technology as artifacts, the design of products, a discipline, a human activity, an invention, material products or a technique (Constantinou et al., 2010; DiGironimo, 2011; Scherz & Oren, 2006; Sunar & Geban, 2011; Tairab, 2001; Yalvac et al., 2007). The definition of technology as knowledge and skill was presented in literature related to technology (Ankiewicz et al., 2006; Cajas, 2001; De Vries, 2003; Mitcham, 1994). The conceptualization of technology by students as knowledge and skill was also observed in this study.

Students' Approaches to the Relationship between Science and Society

The question "What is the importance of science for society?" determined the students' approaches to the relationship between science and society. The results obtained from this question are presented in Table 7.

Table 7.
Students' Approaches to the Relationship between Science and Society

Categories	Prospective Chemists (%)	Pre-service Chemistry Teachers (%)
Positive Approach		
Science meets society's needs	38	15
Science solves society's problems	14	11
Science enhances a society's prosperity and peace		7
Science increases society's labor force		2
Science creates awareness in society	21	40
Science socializes a society		4
Science democratizes a society		4
Science insures an impartial perspective on events	3	2
Science fosters acquaintance with the universe	5	7
Science fosters getting to know the human being	3	
Negative Approach		
Science leads society to disaster	7	2
Science makes people unhappy	7	2
Science makes people asocial		2
No Answer	2	2
Total	100	100

Both prospective chemists and pre-service chemistry teachers mostly exhibited a positive approach to the relationship between science and society (84% for prospective chemists; 92% for pre-service chemistry teachers). Most students explained the benefit which science brings society in terms of supplying society's needs (38% for prospective chemists) and in terms of raising awareness (40% for pre-service chemistry teachers). In terms of supplying needs, for example, one student wrote: "*C4: Human beings, as part of their nature, have always tried to find rational answers to events and situations occurring around them. It is at this point that science meets society's needs. Sometimes this need becomes an absolute must*." In terms of raising awareness, for example, some students wrote: "*C25: By making people more aware, science ensures a more sensitive, more tolerant and more understanding society*," "*T20: It's easy to fool the ignorant. Because a society that deals with science will have an accumulation of knowledge, it will always be difficult to fool people in that society*" or "*T32: Science creates social and cultural awareness in people*."

Some students in both groups mentioned the benefit science brings to society in terms of solving problems (14% for prospective chemists; 11% for pre-service chemistry teachers). For example, one student wrote: "*C11: If science didn't exist, people would encounter great problems in everyday life. Science helps people solve these problems*." A small number of students in both groups mentioned the benefit science brings to society in terms of acquaintance with the universe (5% for prospective chemists; 7% for pre-service chemistry teachers). For example, one student wrote: "*T21: Science is vital for a person's getting to know the universe*." A very small number of students in both groups expressed the benefits that science brings society in terms of an unbiased look at events (3% for prospective chemists; 2% for pre-service chemistry teachers). For example, one student wrote: "*C13: Science ensures that people look at events from a more objective viewpoint*."

On the other hand, while only pre-service chemistry teachers explained the benefits of science for society in terms of increasing well-being and peace of mind (7%), increasing the labor force (2%), socialization (4%) and democratization (4%), prospective chemists described the benefit of science in terms of becoming acquainted with human beings (3%). For example, some students wrote: "*T1: Science has the capability of giving people the ability to stand on their own two feet. The more science is advanced in a society, the more there will be prosperity and peace*," "*T30: Science creates new job opportunities and as such, increases a society's labor force*," "*T12: Science improves communication between people and thus socializes a society*," "*T8: The importance of science in a society's democratization cannot be denied*" or "*C17: Science allows a person to get to know his/her own psychological make-up and anatomy*."

Compared to the students with a positive approach, there were fewer students in both groups with a negative approach to the relationship between science and society (14% for prospective chemists; 6% for pre-service chemistry teachers). Some students referred to how science was damaging to society and how it brought on disaster and made people unhappy. For example, one student wrote: "*C35: At one point, straying from the purpose of a human's creation can have detrimental results. The products of science such as atom bombs and chemical weapons are leading mankind into disaster*." Another student wrote: "*T10: It's unfortunate that science can do nothing more for people than make them unhappy and lose hope. In my opinion, people who lived thousands of years ago were happier than we are now*." One student expressed the opinion that science was damaging for society in terms of making people asocial. Such an explanation, however, was offered only by a pre-service chemistry teacher. For example, this student wrote: "*T22: Science creates a world for people where they have to work at a much faster pace. This way, communication and social ties weaken*."

Lastly, a very small number of students did not answer the question "What is the importance of science for society?"

Students' Approaches to the Relationship between Technology and Society

The question "What is the importance of technology for society?" determined the students' approaches to the relationship between technology and society. The results obtained from this question are presented in Table 8.

Both prospective chemists and pre-service chemistry teachers mostly displayed a positive approach to the relationship between technology and society (75% for prospective chemists; 78% for pre-service chemistry teachers). Most students explained the benefits of technology for society in terms of raising the standard and quality of living (42% for prospective chemists) and in terms of facilitating life (36% for pre-service chemistry teachers). In regard to raising the standard and quality of living, for example, one student wrote: "*C25: The standard and quality of life is increasing in society as new technological products are offered to people*." In regard to facilitating life, for example, some students wrote: "*C9: Technology makes people's lives easier. It's easier for people to do things, in terms of transportation, communication, etc.*" or "*T28: Technology makes things easier in every aspect of life. Because of technology, today people in different parts of the world can communicate with each other*."

Table 8.
Students' Approaches to the Relationship between Technology and Society

Categories	Prospective Chemists (%)	Pre-service Chemistry Teachers (%)
Positive Approach		
Technology creates savings in time and energy	10	14
Technology increases production	8	11
Technology raises the standard and quality of life	42	12
Technology makes life easier	10	36
Technology creates awareness in people	5	5
Negative Approach		
Technology increases unemployment		2
Technology damages human life and the environment	8	3
Technology kills human emotions		2
Technology creates dependency		2
Technology makes people lazy	3	2
Technology makes a person's life monotonous	3	
Technology makes a person asocial	5	3
Technology creates a robotic culture	3	2
Technology causes cultural degeneration		2
Technology causes cultural imperialism		2
No Answer	3	2
Total	100	100

Some students in both groups stated the benefits of technology for society in terms of saving time and energy and in terms of increasing production. For example, students in both groups wrote: "*C22: Technology saves time. Before, going from one place to another would take up a lot of time, but now we can go wherever we want in a short time*" or "*T13: Technology saves time and energy. Because of technology, it's possible to finish something in less time and by spending less energy*." Another student wrote: "*T5: Technology increases manufacture and makes society more productive*." A very small number of students in both groups described the benefit of technology for society in terms of raising awareness (5% for students in both groups). For example, one student wrote: "*C18: Technology is one of the most indispensable factors in society. By making use of technology, people become knowledgeable and gain awareness*."

Some students in both groups exhibited a negative approach to the relationship between technology and society (22% for prospective chemists; 20% for pre-service chemistry teachers). Students referred to how technology damages society by causing harm to both human beings and the environment, making people lazy, making people asocial and creating a robotic culture. For example, some students wrote: "*C5: It is a fact that technology spoils the balance of nature. The harmful wastes of factories cause different types of pollution on the earth and this is a hazard to human health*," "*T16: Technological advances especially make people lazy*," "*C28: Technology weakens relationships and dialogs between people. Because social relationships are being overshadowed like this, people are becoming more asocial*" or "*T30: My thoughts on this are unfortunately not very positive because instead of people ruling over technology, technology is ruling over human beings and actually turning them into robots. A robotic culture is developing in society*."

On the other hand, while only pre-service chemistry teachers explained how technology damaged society by killing humanistic emotions (2%), increasing unemployment (%2), creating addiction (2%), causing cultural degeneration (2%) and cultural imperialism (2%), prospective chemists described the damage wrought by technology in society in terms of causing people to lead monotonous lives (3%). For example, some students wrote: "*T8: Technological equipment is taking the place of human beings in factories. The number of people working is decreasing with each passing day. This gives rise to an increasing unemployment rate in a society*," "*T12: People are fast becoming mechanized and as a result, human emotions are dying*," "*T18: High-tech products cause addiction*," "*T26: Technology turns everyone into prototypes and culture begins to degenerate in society. This is why society must protect its basic values and stand by them*," "*T31: Technology is very important for the development of society. Societies that do not produce technology must resign themselves to bowing down to cultural imperialism and becoming a colonized state. There are many examples of this all over the world*" or "*C32: Technological tools and equipment make life monotonous for people. Instead of playing outdoors and getting to know nature, children spend time playing computer games and grow up in this monotony*."

Finally, a very small number of students did not answer the question "What is the importance of technology for society?"

Discussion and Conclusions

Literature on science education clearly shows that knowledge of science and technology is an educational goal (DiGironimo, 2011; Solbes & Vilches, 1997). Thus, research has been conducted to investigate students' views on science and technology. It was observed in this study that some students' views on science and technology were similar to results revealed by previous studies. The explanations students gave for science as an experiment, a body of knowledge, a method or a human activity could be cited as examples reported in literature (Celik & Bayrakçeken, 2006; Constantinou et al., 2010; Craven et al., 2002; Lederman, 1992; Mellado, 1997; Murcia & Schibeci, 1999; Nuangchalerm, 2009; Scherz & Oren, 2006; Tairab, 2001). There are examples of explanations of technology by students as artifacts, a design of products, a discipline, a human activity, an invention, material products or a technique reported in the literature (Constantinou et al., 2010; DiGironimo, 2011; Scherz & Oren, 2006; Sunar & Geban, 2011; Tairab, 2001; Yalvac et al., 2007).

A significant finding of the present study was that there were differences observed in the descriptions of science and technology made by the two groups of students. For example, only pre-service chemistry teachers defined science as a way of learning or a way of making sense. On the other hand, while the definition of technology as knowledge was generally observed in the case of pre-service chemistry teachers, the explanation of technology as material products was frequently made by prospective chemists.

Previous studies reported that students had different perspectives concerning science, explaining science, for example, from positivist, empiricist, inductivist or idealistic viewpoints (Gallagher, 1991; Hodson, 1985; Lederman, 1992; Mellado, 1997). In this study, students in both groups explained science from an epistemological, historical, pedagogical, philosophical, psychological or sociological perspective, and many students had empiricist conceptions of science. These conceptions are coherent with traditional classroom practices (Lederman, 1992; Tsai, 2002). In addition, while prospective chemists mostly defined science from epistemological and philosophical perspectives, pre-service chemistry teachers frequently explained science from epistemological and pedagogical perspectives. This result indicates that there are conspicuous differences in the manner of thinking about science between the two groups of students.

The fact that it was only pre-service chemistry teachers who formulated their definition of science from a pedagogical perspective (e.g., science as a way of learning or a way of making sense) is a reflection of the curriculum based on the fact that 28% of the courses in the pre-service teacher curriculum are compulsory education courses. It is for this reason that chemistry pre-teachers exhibit pedagogical terms in their definitions of science. Since courses on education are not part of the prospective chemists' program, such a perspective was not seen in their definitions of science. Moreover, that there were more definitions of science from an epistemological perspective rendered by prospective chemists compared to pre-service chemistry teachers can also be traced to the undergraduate program. Prospective chemists are more exposed to theoretical and practical science courses than pre-service chemistry teachers. Because prospective chemists perform more experiments in the laboratory (have more interaction with experimental work), they are more able to identify the concept of science through epistemological terms such as observation, measurement, experiment and method compared to pre-service chemistry teachers.

In this study, students in both groups stated that science and technology affected society both negatively and positively. They generally had a positive approach, however, to the relationship between science and society, and between technology and society. Some students in both groups exhibited a negative approach to the relationship between science and society, and between technology and society. This negative perspective stemmed from the knowledge of the detrimental effects of heavy metals, nuclear wastes, nuclear accidents and other adversities on human health and the environment. The curriculum for both of the student groups contain courses such as "Environmental Chemistry," "Environment and Human" or "Chemistry, Human and Society," which are designed to teach students the negative aspects of scientific and technological applications (the atom bomb, nuclear accidents, factory chimney emissions that have not been adequately filtered, etc.) and their effects on the environment and society. Such information leads students to develop a negative perspective on the relationship between science, technology and society. Students thus referred to science and technology from a negative point of view, a situation that may make meaningful learning more difficult (Gil-Perez et al., 2005; Mansour, 2010). Therefore, it would be useful for educators and social scientists to evaluate the negative views held by students.

On the other hand, the present study also indicated that some students had naïve views concerning science and technology and they generally did not adequately understand science and technology. For example, some students defined science by saying, "*Science is curiosity,*" "*Science is dependence*" or "*Science is satisfying the ego.*" Some students also explained technology as "*Technology is skill*" or "*Technology is inventing new things.*" The statements offered by some students in both groups pointed to the fact that they have naïve views on the subject. The naïve views students harbor with respect to science and technology may be attributed to a lack of knowledge about science and technology (Abd-El-Khalick & Lederman, 2000b; DiGironimo, 2011). Some studies have revealed that science curricula are still unsuccessful in imparting such knowledge (Hanuscin et al., 2006; Mansour, 2010; Pekdağ & Erol, 2013; Rowell et al., 1999) whereas it is known that science curricula, textbooks and teaching methods are important factors in developing an adequate and prevailing understanding of science and technology in the minds of the students (Gil-Perez et al., 2005; Lederman, 2007; McDonald, 2010). In time, these factors should be reviewed and revised from a rationalist and realistic standpoint.

In order to improve students' conceptual understanding of science and technology, both undergraduate curricula must be revised, new courses should be added, and a new pedagogical approach and effective teaching methods must be developed. For example, courses on the history and philosophy of science, on the history of chemistry, on the history and philosophy of technology, and on chemical laboratory technology may be added to the curriculum of both pre-service chemistry teachers and prospective chemists. In addition, courses on computer software (e.g., *Avogadro*, *ChemSketch*, *HyperChem*) may also be part of the teaching program for prospective chemists and pre-service chemistry teachers. In Turkey, courses on science, technology and society (outside of laboratory courses) are customarily part of the curriculum for students in the School of Science and Arts and these are usually taught using the traditional approach (teacher-centered instruction). Students in the School of Education, however, are given these courses using both traditional and constructivist approaches (teacher- and student-centered instruction). In both programs, courses on science, technology and society using constructivist/social constructivist approach (student-centered instruction) should be offered to both prospective chemists and pre-service chemistry teachers.

Chemistry education should help students develop an adequate understanding about science and technology, and the relationships between science, technology and society (AAAS, 1993; ITEA, 2006; NAE & NRC, 2002; NRC, 1996). Simply engaging in inquiry-based activities, i.e. the implicit approach, is not enough to enhance students' conceptual understanding about science and technology. To the contrary, using an explicit approach that focuses on the history and philosophy of science and technology and discussions on these issues in the instructional process in addition to inquiry-based activities, must be adopted (Abd-El-Khalick & Lederman, 2000b). Such an approach can include watching videos about scientists' lives, visiting science and technology centers and museums, reading and discussing papers related to science and technology, designing and conducting a research project, writing a research report, etc. (Cakmakci, 2012; Schwartz et al., 2004; Solomon, 2002).

The results of this study revealed that the meanings of science and technology in the minds of the students in both groups showed some important differences in this sample. In other words, the results of this study indicated a number of important differences between the views of students who do science and who teach science about STS issues. This can be explained by the differences in the curricula put into practice for prospective chemists and pre-service chemistry teachers. In other words, conceptual learning of science and technology is related to course content and behind the difference in the viewpoints of the two student groups might indeed be a product of the students' chemistry learning experience. It is hoped that this study will assist chemistry educators to be informed about the views of students subjected to two different types of training, and will contribute to them in developing more effective pedagogical strategies and a curricular framework that will lead to the improvement of the understanding of science and technology by pre-service chemistry teachers and prospective chemists.

Also, this study will contribute to the education researchers who aim to compare the views of prospective scientists and science teacher candidates in the fields of physics and biology related to STS issues in terms of research methodology aspects (the type of the comparison of undergraduate curricula, the type of data analysis) and empirical aspects (research results). However, this study has the limitation with respect to its generalization because of a small amount of sample of the participants. Science education researchers can conduct this study on different samples (for example in the fields of physics or biology) or chemistry education researchers can study on larger samples.

References

AAAS (American Association for the Advancement of Science). (1993). *Benchmarks for science literacy*. New York: Oxford University Press.

Abd-El-Khalick, F., & Lederman, N. G. (2000a). The influence of history of science courses on students' views of nature of science. *Journal of Research in Science Teaching*, 37(10), 1057-1095.

Abd-El-Khalick, F., & Lederman, N. G. (2000b). Improving science teachers' conceptions of nature of science: A critical review of the literature. *International Journal of Science Education*, 22(7), 665-701.

Abd-El-Khalick, F., Bell, R. L., & Lederman, N. G. (1998). The nature of science and instructional practice: Making the unnatural natural. *Science Education*, 82(4), 417-436.

Akcay, H., & Yager, R. E. (2010). The impact of a science/technology/society teaching approach on student learning in five domains. *Journal of Science Education and Technology*, 19(6), 602-611.

Akerson, V. L., Abd-El-Khalick, F., & Lederman, N. G. (2000). Influence of a reflective explicit activity-based approach on elementary teachers' conceptions of nature of science. *Journal of Research in Science Teaching*, 37(4), 295-317.

Akerson, V. L., Cullen, T. A., & Hanson, D. L. (2009). Fostering a community of practice through a professional development program to improve elementary teachers' views of nature of science and teaching practice. *Journal of Research in Science Teaching*, 46(10), 1090-1113.

Akerson, V. L., Hanson, D. L., & Cullen, T. A. (2007). The influence of guided inquiry and explicit instruction on K-6 teachers' views of nature of science. *Journal of Science Teacher Education*, 18(5), 751-772.

Allchin, D. (1999). Values in science: An educational perspective. *Science* & *Education*, 8(1), 1-12.

Ankiewicz, P., De Swardt, E., & De Vries, M. (2006). Some implications of the philosophy of technology for science, technology and society (STS) studies. *International Journal of Technology and Design Education*, 16(2), 117-141.

Bell, R. L., Lederman, N. G., & Abd-El-Khalick, F. (2000). Developing and acting upon one's conception of the nature of science: A follow-up study. *Journal of Research in Science Teaching*, 37(6), 563-581.

Bozeman, B. (2000). Technology transfer and public policy: A review of research and theory. *Research Policy*, 29(4-5), 627-655.

Cajas, F. (2001). The science/technology interaction: Implications for science literacy. *Journal of Research in Science Teaching*, 38(7), 715-729.

Cakmakci, G. (2012). Promoting pre-service teachers' ideas about nature of science through educational research apprenticeship. *Australian Journal of Teacher Education*, 37(2), 113-135.

Celik, S., & Bayrakçeken, S. (2006). The effect of a 'science, technology and society' course on prospective teachers' conceptions of the nature of science. *Research in Science* & *Technological Education*, 24(2), 255-273.

Cohen, L., Manion, L., & Morrison, K. (2007). *Research methods in education* (6th edition). New York: Routledge.

Constantinou, C., Hadjilouca, R., & Papadouris, N. (2010). Students' epistemological awareness concerning the distinction between science and technology. *International Journal of Science Education*, 32(2), 143-172.

Craven, J. A., Hand, B., & Prain, V. (2002). Assessing explicit and tacit conceptions of the nature of science among preservice elementary teachers. *International Journal of Science Education*, 24(8), 785-802.

De Vries, M. J. (2003). The nature of technological knowledge: Extending empirically informed studies into what engineers know. *Techné: Research in Philosophy and Technology*, 6(3), 1-21.

De Vries, M. J. (2006). Two decades of technology education in retrospect. In M. J. De Vries, & I. Mottier (Eds.), *International Handbook of Technology Education: Reviewing the Past Twenty Years* (pp. 3-11). Rotterdam: Sense Publishers.

DiGironimo, N. (2011). What is technology? Investigating student conceptions about the nature of technology. *International Journal of Science Education*, 33(10), 1337-1352.

Dugger, W. E. (2010). Evolution of STEM in the United States. *Paper presented at the 6th Biennial International Conference on Technology Education Research*, December 8-11, 2010 in Australia. Retrieved on 21 May 2013 from http://www.iteaconnect.org/mbrsonly/Library/Library.htm.

Franssen, M., Lokhorst, G.-J., & van de Poel, I. (2009). *Philosophy of technology*. Retrieved on 11 May 2012 from http://plato.stanford.edu/entries/technology.

Gallagher, J. J. (1991). Prospective and practicing secondary school science teachers' knowledge and beliefs about the philosophy of science. *Science Education*, 75(1), 121-133.

Gilbert, S. W. (1991). Model building and a definition of science. *Journal of Research in Science Teaching*, 28(1), 73-79.

Gil-Perez, D., Vilches, A., Fernandez, I., Cachapuz, A., Praia, J., Valdes, P., & Salinas, J. (2005). Technology as 'Applied Science'. *Science & Education*, 14(3-5), 309-320.

Godin, B. (2007). *What is science? Defining science by the numbers, 1920-2000*. Retrieved on 30 May 2013 from http://www.csiic.ca/PDF/Godin_35.pdf.

Hanuscin, D. L., Akerson, V. L., & Phillipson-Mower, T. (2006). Integrating nature of science instruction into a physical science content course for preservice elementary teachers: NOS views of teaching assistants. *Science Education*, 90(5), 912-935.

Hodson, D. (1985). Philosophy of science, science and science education. *Studies in Science Education*, 12(1), 25-57.

Ibáñez–Orcajo, M. T., & Martínez–Aznar, M. M. (2007). Solving problems in genetics, Part III: Change in the view of the nature of science. *International Journal of Science Education*, 29(6), 747-769.

ITEA (International Technology Education Association). (1996). *Technology for all Americans: A rationale and structure for the study of technology*. Reston, VA: ITEA.

ITEA (International Technology Education Association). (2000). *Standards for technological literacy: Content for the study of technology*. Reston, VA: ITEA.

ITEA (International Technology Education Association). (2006). *Technological literacy for all: A rationale and structure for the study of technology*. Reston, VA: ITEA.

İşman, A. (2012). Technology and technique: An educational perspective. *The Turkish Online Journal of Educational Technology*, 11(2), 207-213.

Kang, S., Scharmann, L. C., & Noh, T. (2005). Examining students' views on the nature of science: Results from Korean 6th, 8th, and 10th graders. *Science Education*, 89(2), 314-334.

Leach, J., Hind, A., & Ryder, J. (2003). Designing and evaluating short teaching interventions about the epistemology of science in high school classrooms. *Science Education*, 87(6), 831-848.

Lederman, N. G. (1992). Students' and teachers' conceptions of the nature of science: A review of the research. *Journal of Research in Science Teaching*, 29(4), 331-359.

Lederman, N. G. (2007). Nature of science: Past, present, and future. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 831-880). Mahwah, NJ: Lawrence Erlbaum Associates.

Lederman, N. G., Abd-El-Khalick, F., Bell, R. L., & Schwartz, R. S. (2002). Views of nature of science questionnaire: Toward valid and meaningful assessment of learners' conceptions of nature of science. *Journal of Research in Science Teaching*, 39(6), 497-521.

Mansour, N. (2010). Science teachers' perspectives on science-technology-society (STS) in science education. *Eurasian Journal of Physics and Chemistry Education*, 2(2), 123-157.

Marshall, C., & Rossman, G. B. (2006). *Designing qualitative research* (4th edition). London: Sage.

McComas, W. F., & Olson, J. K. (1998). The nature of science in international science education standards documents. In W. F. McComas (Ed.), *The nature of science in science education: Rationales and strategies* (pp. 41-52). Dordrecht: Kluwer Academic Publishers.

McDonald, C. V. (2010). The influence of explicit nature of science and argumentation instruction on preservice primary teachers' views of nature of science. *Journal of Research in Science Teaching*, 47(9), 1137-1164.

McGinn, R. E. (1991). *Science, technology, and society*. Englewood Cliffs, NJ: Prentice Hall.

Mellado, V. (1997). Preservice teachers' classroom practice and their conceptions of the nature of science. *Science & Education*, 6(4), 331-354.

Merriam-Webster (2008). *Merriam-Webster's collegiate dictionary* (11th edition). Springfield: Merriam-Webster Inc.

Mitcham, C. (1994). *Thinking through technology: The path between engineering and philosophy*. Chicago: The University of Chicago Press.

Murcia, K., & Schibeci, R. (1999). Primary student teachers' conceptions of the nature of science. *International Journal of Science Education*, 21(11), 1123-1140.

NAE & NRC (National Academy of Engineering and National Research Council). (2002). *Technically speaking: Why all Americans need to know more about technology*. Washington, DC: National Academy Press.

NRC (National Research Council). (1996). *National science education standards*. Washington, DC: National Academy Press.

Nuangchalerm, P. (2009). Preservice teachers' perception about nature of science. *The Social Sciences*, 4(5), 463-467.

Pekdağ, B., & Erol, H. (2013). The examination of secondary education chemistry curricula published between 1957-2007 in terms of the dimensions of rationale, goals, and subject-matter. *Educational Sciences: Theory & Practice*, 13(1), 631-659.

Pitt, J. C. (2000). *Thinking about technology: Foundations of the philosophy of technology*. New York: Seven Bridges Press.

Purtill, P. (1970). The purpose of science. *Philosophy of Science*, 37(2), 301-306.

Rowell, P. M., Gustafson, B. J., & Guilbert, S. M. (1999). Characterization of technology within an elementary science program. *International Journal of Technology and Design Education*, 9(1), 37-55.

Scherz, Z., & Oren, M. (2006). How to change students' images of science and technology. *Science Education*, 90(6), 965-985.

Schwartz, R. S., Lederman, N. G., & Crawford, B. A. (2004). Developing views of nature of science in an authentic context: An explicit approach to bridging the gap between nature of science and scientific inquiry. *Science Education*, 88(4), 610-645.

Soanes, C., & Stevenson, A. (Eds.) (2008). *Concise Oxford English dictionary* (11th edition). Oxford: Oxford University Press.

Solbes, J., & Vilches, A. (1997). STS interactions and the teaching of physics and chemistry. *Science Education*, 81(4), 377-386.

Solomon, J. (2002). Science stories and science texts: What can they do for our students?. *Studies in Science Education*, 37(1), 85-105.

Sunar, S., & Geban, Ö. (2011). Turkish pre-service science teachers' views on science-technology-society issues. *Eurasian Journal of Physics and Chemistry Education*, Jan(Special Issue), 9-24.

Tairab, H. H. (2001). How do pre-service and in-service science teachers view the nature of science and technology?. *Research in Science* & *Technological Education*, 19(2), 235-250.

Tsai, C.-C. (2002). Nested epistemologies: Science teachers' beliefs of teaching, learning and science. *International Journal of Science Education*, 24(8), 771-783.

van Woudenberg, R. (2013). *Truth, the goal of science*. Retrieved on 29 May 2013 from http://www.allofliferedeemed.co.uk/vanwoudenberg.htm.

Vazquez-Alonso, A., Garcia-Carmona, A., Manassero-Mas, M. A., & Bennassar-Roig, A. (2012). Spanish secondary-school science teachers' beliefs about science-technology-society (STS) issues. *Science* & *Education*, DOI 10.1007/s11191-012-9440-1.

Yalvac, B., Tekkaya, C., Cakiroglu, J., & Kahyaoglu, E. (2007). Turkish pre–service science teachers' views on science-technology-society issues. *International Journal of Science Education*, 29(3), 331-348.

Ziman, J. (1984). *An introduction to science studies: The philosophical and social aspect of science and technology*. Cambridge: Cambridge University Press.

Bülent Pekdağ
Necatibey Education Faculty, Balıkesir University
Balıkesir 10100, Turkey
pekdag@balikesir.edu.tr

Stavovi budućih kemičara i budućih nastavnika kemije o problemima znanstveno-tehnološkog društva (ZTD)

Sažetak

Cilj ovoga rada bio je istražiti stajališta budućih kemičara i budućih nastavnika kemije o problemima znanstveno-tehnološkog društva (ZTD), s pokušajem razmatranja razlika u njihovim stajalištima. Upitnik koji se sastojao od 4 pitanja otvorenoga tipa podijeljen je skupini od 67 studenata u višim godinama studija kako bi se odredila njihova stajališta o problemima ZTD-a. Podatci su prikupljeni iz odgovora studenata na pitanja otvorenoga tipa. Podatci koji su prikupljeni od dviju skupina studenata analizirani su kvantitativno iz perspektive odgovora na zadana pitanja. Uočeno je da budući kemičari uglavnom definiraju znanost iz epistemološke i filozofske perspektive, a budući nastavnici kemije učestalo objašnjavaju znanost iz epistemološke i pedagoške perspektive. Rezultati su otkrili da se značenje znanosti i tehnologije kod studenata iz obje skupine u proučenom uzorku bitno razlikuju. Nadalje, studenti u obje skupine ustvrdili su da znanost i tehnologija utječu na društvo na negativan i pozitivan način.

Ključne riječi: *znanstveno-tehnološko društvo (ZTD); budući kemičari; budući nastavnici kemije*

Uvod

Jedan od glavnih ciljeva prirodoslovnog/znanstvenog odgoja danas jest razumjeti prirodu znanosti i prirodu tehnologije, kao i njihovu interakciju unutar društva (AAAS, 1993; NRC, 1996). Razumjeti odnos između znanosti, tehnologije i društva presudno je za usvajanje osnovne znanstvene pismenosti (Vazquez-Alonso i sur., 2012). Znanstvena pismenost uglavnom podrazumijeva shvaćanje termina, principa, teorija i procesa u znanosti, kao i osviještenost o složenim odnosima između znanosti, tehnologije i društva (Abd-El-Khalick i sur., 1998). Tri ugledne nacionalne i međunarodne organizacije iznijele su zajednički korpus ideja i vještina koje tvore jezgru tehnološke pismenosti (ITEA, 2006; NAE i NRC, 2002). Razumijevanje znanosti i tehnologije ima jasne implikacije na produktivno građanstvo u informacijski vođenom gospodarstvu (DiGironimo, 2011).

Posljednjih se nekoliko godina uloga prirode znanosti i tehnologije unutar prirodoslovnog obrazovanja pobliže sagledava. Istraživanja su provedena kako bi se istražili stavovi studenata vezanih uz znanost i tehnologiju (Constantinou i sur., 2010; Craven i sur., 2002; Lederman i sur., 2002; Sunar i Geban, 2011; Tairab, 2001). Istraživači prirodoslovnog obrazovanja uvidjeli su da pogledi nekih studenata nisu usklađeni s modernim pojmovima znanosti i tehnologije i da su njihova mišljenja o tom predmetu naivna (DiGironimo, 2011; Kang i sur., 2005; Lederman, 1992; Yalvac i sur., 2007). Zbog toga se u nekoliko navrata pokušalo promijeniti stavove studenata vezane uz znanost i tehnologiju (Abd-El-Khalick i Lederman, 2000a; Cakmakci, 2012; Leach i sur., 2003). Štoviše, pomoć studentima u razvijanju primjerenog poimanja znanosti i tehnologije bio je trajan cilj prirodoslovnog obrazovanja još od početka stoljeća (Constantinou i sur., 2010; DiGironimo, 2011).

Pregled literature

Znanost

Pojam "znanost" uglavnom se koristi kada se pozivamo na epistemologiju znanosti, odnosno na znanost kao način znanja ili vrijednosti i vjerovanja sadržana u razvoju znanja o znanosti (Lederman, 1992). Karakterizacija u tome kontekstu ostaje općenita, a znanstveni filozofi, znanstveni povjesničari i znanstveni učitelji prilično brzo nailaze na nesuglasje kada je riječ o specifičnom definiranju znanosti (Bell i sur., 2000). Dok znanstvenici, filozofi, sociolozi i ekonomisti imaju vlastite definicije znanosti, znanost se jednostavno definira kao ono što znanstvenici rade i proizvode. Znanstvenici i filozofi definirali su znanost prema njezinu sadržaju (znanje) i metodi, ekonomisti kao informaciju, a sociolozi prema institucijama i praksi (Godin, 2007).

Znanost je višestrana aktivnost koja se operativno može definirati na nekoliko načina (Gilbert, 1991). Prema tome, znanost se definira kao ljudska aktivnost, način na koji nešto znamo, korpus znanja, proces (promatranje, zaključivanje i eksperimentiranje), zatim sustavno razmišljanje (AAAS, 1993; Abd-El-Khalick i Lederman, 2000b; Allchin, 1999; Ibáñez–Orcajo i Martínez–Aznar, 2007; Murcia i Schibeci, 1999; NRC, 1996; Nuangchalerm, 2009). Znanost se sastoji od dva dijela: (1) korpus znanja koje je akumulirano tijekom vremena i (2) proces – znanstvena ispitivanja – koja generiraju znanje o prirodi svijeta (NAE i NRC, 2002). Znanost se bavi onim što je (što postoji) u prirodi. Mnoštvo predmeta u školama, na fakultetima i sveučilištima sadrži proučavanje prirode. Ti se predmeti bave biologijom, kemijom, astronomijom, geologijom itd. Neki od procesa koji se koriste u znanosti kako bi se istražilo značenje prirodnog jesu „ispitivanje", „otkrivanje onoga što jest", „istraživanje", primjena „znanstvene metode" (Dugger, 2010).

Ziman (1984) je razvio neke općenite definicije koje pokušavaju obuhvatiti različite aspekte znanosti kao ljudske aktivnosti. Prema Zimanu, znanost je: (i) *način rješavanja problema*, ako je naglasak na instrumentalnoj dimenziji znanosti koja se dovodi u vezu s tehnologijom, gospodarstvom i politikom; (ii) *organizirano znanje* – kada govorimo o znanosti kao skupljaču znanja ta akumulacija znanja rezultat je tehnološkog napretka i proučava se kao povijesni proces; (iii) *način na koji nešto radimo*, iz perspektiva metodologije i filozofije; i (iv) *bilo koje otkriće ljudi* koji imaju poseban talent i poziv za istraživanja.

Znanost je dinamično i neprekidno, a ne statično, akumuliranje informacija (Lederman, 1992). Znanstveni procesi uključuju: praćenje, klasificiranje, mjerenje, interpretaciju podataka, zaključivanje, komuniciranje, kontroliranje varijabli, razvijanje modela i teorija, hipoteze, predviđanja i eksperimentiranje. Čak i sami znanstvenici često zagovaraju empirijsko-induktivne poglede na znanost jer i sami nisu uvijek eksplicitno svjesni svojih strategija istraživanja (Gil-Perez i sur., 2005).

Konstruktivistički pogled na znanost svijet poima drukčije. Osnovna vjerovanja u tom pogledu jesu sljedeća: znanost je skup društveno dogovorenih poimanja svemira; znanje je prihvaćeno od znanstvene zajednice samo ako je održivo; uz "znanstvenu metodu" postoje i drugi načini dobivanja znanja iz znanosti; znanstvenici su pod utjecajem prijašnjeg znanja, društvenih čimbenika i ostalih utjecaja; znanje o znanosti je intuitivno (Mansoura, 2010). Prema konstruktivističkom poimanju, znanost sadrži karakteristike koje su empirijske osnove, provizorne, subjektivne, kreativne, nedefinirane i koje su ugrađene u kulturu i društvo (AAAS, 1993).

Znanost se bavi razumijevanjem prirodnog svijeta (NRC, 1996). Osnovni cilj znanosti jest dati organiziranu obavijest o bilo kojem znanju koje možemo dobiti a tiče se svemira (Purtill, 1970). Znanost teži pronalasku istinitih odgovora na različita pitanja – na različite vrste pitanja (van Woudenberg, 2013).

Tehnologija

Pojam »tehnologija« obično se koristi kada se govori o inženjerstvu i računalnoj znanosti (eng. *computer science*). Pritom se misli na mentalne konstrukte poput rukotvorina, vještina, znanja, organizacije, metoda, tehnika, procesa razvoja ili dizajna, sustava (Ankiewicz *i sur.,* 2006; Cajas, 2001; De Vries, 2003, 2006; Gil-Perez *i sur.,* 2005; Mitcham, 1994). Rječnik Merriam-Webster's Collegiate Dictionary (2008) navodi da je tehnologija: "praktična primjena znanja, osobito u određenim područjima (npr. inženjerstvo, informatika); ili način na koji realiziramo zadatak, posebno koristeći se tehničkim procesima, metodama ili znanjima."

Prema modernoj filozofiji, tehnologija se definira kao ljudska aktivnost (Constantinou i sur., 2010; De Vries, 2003; Pitt, 2000). Tehnologija kao aktivnost jest onaj ključni događaj u kojem se ujedinjuju znanje i volja kako bi se tvorevine (Eng. *artifacts*) održale i koristile (Mitcham, 1994). Tehnologiju također možemo poimati kao tehnike misleći pri tome na materijalne proizvode ljudskog rada (McGinn, 1991). Tehnologija je usredotočenost na sintetički svijet u kojem su kreacije ciljane na osiguranje vidljivih proizvoda koje izravno utječu na ljude (npr. putovanja zrakom, zamrzavanje, TV., mobilni telefoni, transport, strojevi) (Akcay i Yager, 2010). Tehnologija podrazumijeva materijalne tvorevine poput alata, instrumenata, strojeva, elektroničkih uređaja, znanstvenog hardvera ili sustava industrijske proizvodnje (Cajas, 2001; İşman, 2012; Mitcham, 1994). Te tvorevine imaju ulogu proširivanja ljudskih potencijala (Franssen i sur., 2009). Pojam tehnologije ne samo da je vezan uz tehnologiju koja je sadržana u proizvodu, već je također povezana sa znanjem ili informacijama o njihovoj upotrebi i razvoju proizvoda (Bozeman, 2000).

Neki istraživači definiraju tehnologiju kao primjenu znanstvenog znanja na praktične ciljeve ljudskog života ili na promjene i manipulaciju ljudske okoline (Soanes i Stevenson, 2008). Tehnologija se brine za ono što može i treba biti (dizajnirano, napravljeno i razvijeno) iz materijala i sadržaja iz prirodnog svijeta kako bi se zadovoljile ljudske potrebe i želje. Neki procesi u tehnologiji kako bi se mijenjao ili promijenio prirodni svijet su "otkriće," "izum," "praktično rješavanje problema" i "dizajn" (Dugger, 2010).

Američka udruga za napredak znanosti (AAAS) u dokumentu *Benchmarks for Science Literacy* definira tehnologije na ovaj način: "U najširem smislu, tehnologija proširuje naše mogućnosti za mijenjanjem svijeta; rezanjem, modeliranjem ili združivanjem materijala; premještanjem stvari iz jednog mjesta na drugo; daljnjim dosezanjem uz pomoć ruku, glasova i osjetila" (AAAS, 1993, str. 41). Međunarodna Asocijacija tehnološkog obrazovanja (ITEA) u dokumentu *Standards for Technological Literacy: Content for the Study of Technology* tehnologiju definira kao "inovaciju, promjenu, modifikaciju prirodnog okruženja kako bi se zadovoljile zamijećene ljudske želje i potrebe" (ITEA, 2000, str. 242). Slično toj definiciji *Technically Speaking: Why All Americans Need to Know More about Technology* iznosi sljedeće: "U najširem smislu, tehnologija je proces kojim ljudi modificiraju prirodu kako bi zadovoljili svoje potrebe i želje" (NAE i NRC, 2002, str. 2).

Tehnologija je proizvod inženjerstva i znanosti. Znanost teži razumijevanju "zašto" i "kako" u prirodi, a inženjerstvo teži oblikovanju prirodnog svijeta kako bi se zadovoljile ljudske potrebe i želje (NAE i NRC, 2002). Tehnologija se bavi onim "što može biti" izumljeno, otkriveno ili dizajnirano iz prirodnog svijeta, a znanost onim "što jest" u prirodnom svijetu (ITEA, 2006). Potreba za pronalaženjem odgovora na pitanja u prirodnom svijetu pokreće razvoj tehnoloških proizvoda. Štoviše, tehnološke potrebe mogu pokrenuti znanstvena istraživanja (NRC, 1996).

Tehnologiju razvijaju i primjenjuju ljudi. Njezin uspjeh ili neuspjeh obično je određen društvenim prihvaćanjem i uspjehom na tržištu. Pomogla je kako bi se zadovoljile neke osnovne ljudske potrebe poput hrane, skrovišta, udobnosti, zdravlja, mobilnosti i komunikacije (ITEA, 1996). Cilj tehnologije prema tome jest raditi preinake u svijetu kako bi se zadovoljile ljudske potrebe (NRC, 1996).

Svrha istraživanja

U Turskoj se preddiplomski kurikuli za buduće kemičare i nastavnike kemije znatno razlikuju. Preddiplomski kurikulum iz kemije namijenjen budućim kemičarima koji su sudjelovali u ovome istraživanju sastoji se od obveznih kolegija iz kemije (68%), ostalih obveznih kolegija (24%) i izbornih kolegija (8%). Za razliku od toga, preddiplomski studij nastavnika kemije u svom kurikulu sastoji se od obveznih kolegija iz kemije (40%), obveznih obrazovnih kolegija (28%), ostalih obveznih kolegija (26%) i izbornih kolegija (6%).

Kada se ta dva programa sagledaju iz perspektive znanosti, tehnologije i društva, vidljivo je da budući kemičari imaju više znanstvenih kolegija (teorijskih i praktičnih). Velika većina tih kolegija je identična (32 kolegija), ali oba programa sadrže različite znanstvene kolegije. Na primjer, kolegij "Kvantna kemija," "Industrijska kemija," "Polimerna kemija" i "Biokemija Laboratorij I i II" dostupni su u kurikulu za buduće kemičare. U istom je programu i više kolegija koji naglašavaju vezu kemija-okoliš-društvo, a dostupni su u kurikulu koji prate budući kemičari. Kolegiji "Kemija okoliša" i "Kemija", Čovjek i društvo I i II" dostupni su samo budućim kemičarima, a kolegij "Okoliš i čovjek" dostupan je budućim nastavnicima kemije. Broj kolegija vezanih uz znanstvena istraživanja i tehnologiju jednak je za obje skupine. S druge strane, postoje razlike u sadržaju kolegija. Primjerice, dok budući kemičari imaju kolegij o znanstvenom istraživanju i počinju učiti o provođenju istraživanja u području kemije (određujući fizičke i kemijske kvalitete supstanci, organske sinteze itd.), budući nastavnici kemije slušaju kolegij o načinima provođenja znanstvenih istraživanja u području nastave kemije (stavovi studenata prema kemiji, učeničko znanje iz područja kemije, nastavnici i poznavanje sadržaja, udžbenici itd.). U vezi s tehnologijom kolegij "Računalo" i njegov sadržaj isti su u oba programa. Međutim, kolegiji "Računalne aplikacije u kemiji," "Tekstilna tehnologija" i "Naftna tehnologija" ponuđeni su isključivo budućim kemičarima. Program za obrazovanje budućih nastavnika kemije nudi kolegije vezane uz tehnologiju, poput "Mrežne aplikacije," "Photoshop," i "Filmovi u nastavi kemije." Tablica 1 prikazuje broj kolegija vezanih uz znanost, tehnologiju i društvo u oba programa.

Tablica 1.

Razlike u broju i sadržaju kolegija vezanih uz ZTD u oba programa posljedica su prirode profesionalnog područja za koje se studenti obrazuju i njihovih potreba. Sličnosti i razlike u ishodima učenja vezanih uz ZTD prikazani su u Tablici 2.

Upravo zbog razlika u kurikulima dva preddiplomska studija ovim istraživanjem nastojimo dijagnosticirati stajališta budućih kemičara i budućih nastavnika kemije o problematikama ZTD-a i pojasniti razlike u njihovim stajalištima. Literatura o prirodoslovnom/znanstvenom obrazovanju jasno pokazuje da je znanje o tehnologiji obrazovni cilj. Međutim, objavljeno je svega nekoliko studija koje istražuju poglede studenata na tehnologiju (Constantinou i sur., 2010; DiGironimo, 2011; Scherz i Oren, 2006; Tairab, 2001). Iz druge perspektive, čini se da ne postoje empirijska istraživanja u literaturi o prirodoslovnom/znanstvenom obrazovanju koja su kao cilj imala usporedbu pogleda na ZTD od budućih kemičara, budućih nastavnika kemije, odnosno dviju skupina studenata koje su podvrgnute dvama obrazovnim procesima.

Iz toga slijedi da ovo istraživanje doprinosi literaturi jer donosi korisne informacije za znanstvenike u području prirodoslovnog/znanstvenog obrazovanja i nastavnike kemije o pogledima dviju skupina studenata na problematiku ZTD-a.

Tablica 2.

Ishodi učenja vezanih uz ZTD problematiku na razini programa

	Ishodi učenja	Budući kemičari	Budući nastavnici kemije
Teorijsko znanje	• Razumijevanje teorija, modela, zakona, principa i pojmova u kemiji i srodnim znanostima (fizika, biologija)	✓	✓
	• Prepoznavanje i učenje karakteristika tehnoloških alata koji se koriste u kemijskim laboratorijima (UV-Visible Spectrophotometer, Fourier Transform InfraRed Spectroscopy, *Conductometer*, *Polarimeter,* pH meter, Muffle furnace itd.)	✓	✓
	• Učenje o onečišćenju okoliša (zrak i voda), razlozi onečišćenja (teški metali, nuklearni otpad itd.)	✓	✓
	• Razvoj kemije (keramika, ugljen, tekstil, željezo & čelik, eksplozivi, umjetno gnojivo, petrokemijska industrija), razumijevanja učinaka koje takav razvoj ima na ljude i društvo	✓	
	• Učenje programa Microsoft Word, Microsoft PowerPoint i Microsoft Excel	✓	✓
	• Učenje o tehnologijskim alatima koji se koriste u kemijskoj industriji (tekstili, ulja, sredstva za čišćenje, itd.)	✓	
	• Učenje programskog jezika *Pascal*	✓	
	• Učenje o dizajniranju i proizvodnji videa o kemijskim eksperimentima		✓
	• Učiti kako stvoriti Web stranicu		✓
	• Učiti kako raditi u Photoshop programu		✓
	• Učenje postupaka i tehnika koje se koriste u znanstvenom istraživanju u području kemije	✓	
	• Učenje o postupcima i tehnikama koje se koriste za znanstvena istraživanja u području nastave kemije		✓
Kompetencije specifičnog područja	• Sposobnost učinkovitog i sigurnog rada u kemijskom laboratoriju	✓	✓
	• Sposobnost dizajniranja i realizacije kemijskih eksperimenata	✓	✓
	• Sposobnost interpretacije rezultata kemijskih eksperimenata i sposobnost općenitog zaključivanja	✓	✓
	• Sposobnost realizacije kemijskih eksperimenata (promatranje, mjerenje) u laboratoriju uz pomoć tehnologije kao alata	✓	✓
	• Sposobnost služenja informacijskom i komunikacijskom tehnologijom u području učenja	✓	✓
	• Sposobnost provođenja znanstvenog istraživanja u području kemije	✓	
	• Sposobnost provođenja znanstvenog istraživanja u području nastave kemije		✓
	• Sposobnost korištenja znanja o kemiji za dobrobit okoliša i društva	✓	✓
	• Sposobnost korištenja znanja o kemiji u kemijskoj profesiji	✓	
	• Sposobnost primjene znanja o kemiji u nastavi kemije kao profesiji		✓

Istraživačka pitanja

Ovim istraživanjem nastoji se pronaći odgovore na sljedeća pitanja:

1. Koja su stajališta budućih kemičara i nastavnika kemije na znanost i tehnologiju?
2. Koji su načini razmišljanja u vezi sa znanošću usvojeni kod budućih kemičara i nastavnika kemije?
3. Kako budući kemičari i budući nastavnici kemije pristupaju odnosu znanosti i društva?
4. Kako budući kemičari i budući nastavnici kemije pristupaju odnosu tehnologije i društva?

Metodologija

Uzorak

Ovo istraživanje provedeno je na ukupno 67 studenata viših godina studija na sveučilištu Balıkesir u Balıkesiru. To je državno sveučilište smješteno u egejskom području na zapadu Turske. Od ukupnog broja studenata 52% (N=35) je upisano na Fakultet za znanost i umjetnost, njih 48% (N=32) na Fakultet za obrazovanje. Studenti koji su sudjelovali u istraživanju iz Fakulteta za znanost i umjetnost studirali su kemiju. Studenti koji su sudjelovali u istraživanju iz Fakulteta za obrazovanje studirali su kemiju – nastavni smjer. Studenti u obje skupine pozvani su na volontiranje u istraživanju. Njihova je dob između 21 i 25 godina, što čini srednju vrijednost od 22,5 godine.

Metoda prikupljanja podataka

Kvalitativna metoda korištena je u ovome istraživanju kako bi se istražili stavovi studenata o problematici ZTDa. U skladu s brojem ispitanika u uzorku odabran je upitnik koji se sastojao od 4 pitanja otvorenoga tipa (Marshall i Rossman, 2006). Pitanje 1, "Što je, prema tvom mišljenju, znanost?" odnosi se na poglede studenata na znanost. Pitanje 2, "Što je, prema tvom mišljenju, tehnologija?", usmjereno je na poglede studenata na tehnologiju. Istraživanja koja u sebi sadrže tip otvorenog pitanja poput „Što je znanost?" (Akerson i sur., 2009; Akerson i sur., 2007) i "Što je, prema tvom mišljenju, tehnologija?" (DiGironimo, 2011) za studente i nastavnike nalazimo i u literaturi. Pitanje 3, "Zbog čega je znanost važna za društvo?" definira stajališta studenata o odnosu znanosti i društva. Konačno, pitanje broj 4, "Zbog čega je tehnologija važna za društvo" oblikovano je kako bi dijagnosticiralo stajališta studenata o odnosu tehnologije i društva. Ta četiri pitanja otvorenoga tipa omogućuju ispitanicima da pojasne svoje poglede na pitanja ZTD-a i razloge koji su u osnovi njihovih stavova (Lederman, 1992).

Upitnik je distribuiran studentima u vrijeme nastave pod vodstvom istraživača. Svi studenti informirani su o svrsi istraživanja. Studenti su odgovorili na pitanja u 30 minuta. Za svako pitanje studenti su morali pojasniti odgovor. Kako bismo dobili detaljnije informacije od studenata i spriječili izostavljanje odgovora, istraživač je bio prisutan u razredu za vrijeme ispunjavanja upitnika. Njegova je uloga bila motivirati studente da odgovore na sva pitanja iskreno i sa samopouzdanjem. Takav je pristup doprinio prikupljanju značajnog broja podataka.

Analiza podataka

Podatci su prikupljeni iz pisanih odgovora na pitanja budućih kemičara i budućih nastavnika kemije. Podatci obje skupine studenata analizirani su kvalitativno s ciljem odgovora na svako postavljeno pitanje u istraživanju. Odgovori studenata pažljivo su proučavani kako bi se identificirala i opisala temeljna zaključivanja. Svi odgovori studenata šifrirani su numerički, a studenti su bili šifrirani abecedno. Šifriranje za buduće kemičare bilo je sljedeće C1, C2, C3 itd., a za buduće nastavnike kemije T1, T2, T3, itd. Kod analize podataka svaki je student bio obrađivan kao zaseban slučaj. Svako pitanje otvorenoga tipa iskorišteno je kako bi se generirao sažetak stajališta na ZTD za svakog studenta. Taj proces ponavljan je za sva pitanja otvorenoga tipa. Nakon prvog kruga analize sažetci su kategorizirani. Te su kategorije pregledane kako ne bi došlo do potvrdnih ili kontradiktornih dokaza kod podataka pa su primjereno modificirani. Nekoliko krugova kategorizacija, potvrđivanja i modifikacija primijenjeno je kako bi se podatci dovoljno reducirali i organizirali. Te kategorije nastale su kako bi se generirao profil stajališta studenata na problematiku ZTD-a (Abd-El-Khalick i Lederman, 2000a; Abd-El-Khalick i sur., 1998; Akerson i sur., 2000).

Kako bi se analizirali podatci za odgovore na pitanje broj dva korištena je klasifikacija prema Zimanu (1984). U svojoj definiciji znanosti Ziman razlikuje filozofsku, povijesnu, psihološku, sociološku i epistemološku dimenziju. McComas i Olson (1998) također su proveli jaku kvalitativnu analizu dokumenata iz mnogih zemalja na standarde znanstvenog/prirodoslovnog obrazovanja pa su identificirali 30 izjava o znanosti koje su grupirali u filozofske, sociološke, psihološke i povijesne kategorije. Klasifikaciju koju predlaže Ziman (1984) preradili smo i u ovome istraživanju dodali novu kategoriju u analizi podataka dobivenih od studenata. Način na koji studenti poimaju znanost grupirana je u šest kategorija"filozofska dimenzija," "epistemološka dimenzija," "povijesna dimenzija," "sociološka dimenzija," "psihološka dimenzija" i "pedagoška dimenzija." Te kategorije iskorištene su kako bi se podatci prikazali što jasnije. Tablica 3 prikazuje okvir za kategorizaciju poimanja znanosti dobivenih iz odgovora studenata.

Deskriptori prikazani u Tablici 3 ukazuju na različitost šest dimenzija koje su korištene u kategorizaciji odgovora studenata o poimanju znanosti. Primjerice, deskriptori znanosti koje su iskazali studenti kroz „epistemološku dimenziju" povezani su s empirijskom perspektivom (praćenje, eksperiment, mjerenje, analiza, metoda, itd.). Deskriptori koje su iznijeli studenti koji su se uvrstili u „pedagošku dimenziju" povezani su s pedagoškom perspektivom koja ja utemeljena na trudu uloženom u učenje ili razumijevanje. Primjerice, takva definicija znanosti – „pokušaj učenja o svijetu i razumijevanju prirode" kategorizacijom se ubraja u „pedagošku dimenziju."

Konačno, pristupi kojima se studenti koriste u vezi s odnosom između znanosti i društva (Pitanje 3), zatim između tehnologije i društva (Pitanje 4) grupirani su u tri kategorije kao „pozitivan pristup", „negativan pristup" i „bez odgovora". Kako bi se dobili odgovori na pitanja 3 i 4, te su kategorije razrađene iz analize studentskih odgovora.

Tablica 3.
Okvir za kategorizaciju studentskih poimanja znanosti

Kategorije	Primjeri odgovora studenata
Filozofska dimenzija	• Znanost je cijeli skup znanja koje se može dokazati ili pobiti. • Znanosti je cijeli skup suvislog i dosljednog znanja. Deskriptori: dokazno, prikazano, potvrđeno, pobijeno znanje; suvislo i dosljedno znanje; teorijsko znanje; promjenjivo znanje.
Epistemološka dimenzija	• Znanost je objašnjenje fenomena u svemiru uz pomoć eksperimenata, promatranja i mjerenja. • Znanost je pokušaj pronalazaka objašnjenja svemira primjenom teorija i modela. Deskriptori: promatranje, eksperiment, mjerenje, analiza, metoda, hipoteza, teorija, model, zakon, princip, paradigma, predviđanje, pretpostavka, zaključivanje, potvrda, interpretacija, klasifikacija.
Povijesna dimenzija	• Znanost je civilizacija. • Znanost je područje istraživanja koje, tijekom povijesti čovječanstva, pokušava osvijetliti i otkriti činjenice o znanstvenim fenomenima. Deskriptori: civilizacija, civiliziranost, modernizacija, povijest čovječanstva.
Sociološka dimenzija	• Znanost je alat koji se koristi kako bi se riješili društveni problemi. • Znanost je fenomen koji podiže razine prosperiteta i životnog standarda. Deskriptori: rješavanje problema, razina prosperiteta, životni standard, društvena dobrobit, kvaliteta života.
Psihološka dimenzija	• Znanost je radoznalost. • Znanost je želja za otkrivanjem novih stvari. Deskriptori: interes, želja, radoznalost, kreativnost, mogućnost, ovisnost.
Pedagoška dimenzija	• Znanost je trud uložen u učenje o ljudskoj vrsti i svemiru koji ga okružuje. • Znanost je pokušaj razumijevanja prirode. Deskriptori: upoznati se, razumijevanje, učenje, usvajanje znanja, usvajanje osviještenosti.

Posljedica je da se u ovom istraživanju koristio proces ponavljanja kako bi se opisali i interpretirali podaci dobiveni iz studentskih odgovora u upitniku s četiri pitanja otvorenoga tipa. Izračunat je postotak odgovora studenata za svaku kategoriju. Naposljetku, rezultati su iskazani zasebnim postotcima za svako pitanje.

Valjanost/Pouzdanost

Kako bi se poboljšala valjanost i pouzdanost analize podataka, istraživač i dva vanjska istraživača nastave kemije surađivali su u analizi odgovora za osam studenata. Nakon toga je nasumično odabrano petnaest studentskih upitnika od ukupno 67 (otprilike 22% uzorka) koje su samostalno analizirala tri spomenuta istraživača i nakon toga su njihovi rezultati uspoređivani. Slaganje istraživača bilo je na razini 82%, što se smatra visokim slaganjem (Cohen *i sur.*, 2007). Istraživači su sagledali razlike u analizi ponovno procjenjujući odgovore studenata. Razlike su riješene u raspravi u kojoj su sudjelovala sva tri istraživača.

Rezultati

Rezultati su prikazani u pet različitih dijelova. Prvi dio bavi se pogledima studenata na znanost. Drugi dio objašnjava načine na koji studenti poimaju znanost. Treći dio prikazuje poglede studenata na tehnologiju. Četvrti dio prikazuje načine na koji studenti pristupaju vezi između znanosti i društva. Posljednji dio odnosi se na stavove koje studenti imaju u razumijevanju veze između tehnologije i društva.

Pogledi studenata na znanost

Pitanje „Što je, po tvom mišljenju, znanost?" otkrilo je stajališta studenata o znanosti. Rezultati dobiveni iz tog pitanja prikazani su u Tablici 4.

Tablica 4.

I budući kemičari i budući nastavnici kemije definiraju znanost povezujući je s različitim izrazima. Međutim, za obje skupine studenata dominantna poimanja znanosti ipak se razlikuju. Dok je znanost često viđena kao eksperiment (29%), skup znanja (23%) i metoda (20%), budući nastavnici kemije općenito definiraju znanost kao eksperiment (24%), način učenja (19%), skup znanja (14%) i ljudske aktivnosti (14%).

Prijašnja istraživanja iznose da studenti doživljavaju znanost kao eksperiment, skup znanja, metodu ili kao ljudsku aktivnost (Celik i Bayrakçeken, 2006; Constantinou i sur., 2010; Ibáñez–Orcajo i Martínez–Aznar, 2007; Lederman, 1992; Murcia i Schibeci, 1999; Nuangchalerm, 2009; Scherz i Oren, 2006; Tairab, 2001). U ovome istraživanju, nekolicina studenata izjavila je sljedeće: "*C12: Znanost je korpus znanja, poput termina, zakonitosti i teorija*," "*T9: Znanost je ljudska aktivnost koja traži odgovore na pitanja o svijetu*" ili "*C3: Znanost je metoda, zasnovana na promatranju i eksperimentu koja dovodi do odgovarajućih objašnjenja prirodnih fenomena.*" Samo su budući nastavnici kemije definirali znanost kao način učenja. Primjerice, jedan je student napisao: "*T17: "Znanost je način učenja o prirodnom svijetu.*"

Malen broj studenata iz obje skupine doživljava znanost kao „sustavno istraživanje," „znatiželju" i „civilizaciju". Primjerice, jedan je student napisao: "*C24: Znanost je sistematično istraživanje za razumijevanje svijeta kroz promatranje i eksperimentiranje.*" Da studenti znanost definiraju kao „istraživanje" potvrđeno je i u prethodnim istraživanjima (Craven i sur., 2002; Mellado, 1997).

Na kraju, neki studenti znanost su definirali kao proces otkrivanja i davanja smisla. Primjerice, neki su studenti napisali: "*C6: Znanost je proces otkrivanja novih stvari o svijetu i svemiru*" ili "*T27: Znanost je proces davanja smisla o prirodnome svijetu.*" Dok znanost kao proces otkrivanja definiraju samo budući kemičari, budući nastavnici kemije znanost definiraju kao proces davanja smisla. Definiranje znanosti kao „procesa otkrivanja" potvrđeno je i u prijašnjim istraživanjima (Sunar i Geban, 2011; Yalvac i sur., 2007).

Studenti i njihov način razmišljanja o znanosti

Rezultati vezani uz studente i njihov način razmišljanja o znanosti prikazani su u Tablici 5.

Tablica 5.

Način razmišljanja budućih kemičara i budućih nastavnika kemije o znanosti povezuje se različitim dimenzijama. Iako studenti definiraju znanost kroz četiri dimenzije, postoje razlike kod dominantnih dimenzija za dvije skupine. Dok budući kemičari znanost uglavnom definiraju u odnosu na epistemološku dimenziju (63%) i filozofsku dimenziju (23%), budući nastavnici kemije uglavnom poimaju znanost u odnosu na epistemološku dimenziju (36%), pedagošku dimenziju (24%), filozofsku dimenziju (14%) i sociološku dimenziju (14%).

Iz epistemološke dimenzije, mnogo studenata definira znanost iz empirijske perspektive: "*C21: Znanost je objašnjenje fenomena u svijetu korištenjem eksperimenta, promatranjem i mjerenjem*." Neki studenti iznijeli su svoje viđenje znanosti kroz pedagošku dimenziju. Primjerice, jedan je student napisao:"*T4: Znanost je trud uložen u učenje o ljudskoj vrsti i svijetu koji ju okružuje.*" Ostali studenti također su se izrazili iz pedagoške perspektive: "*T31: Znanost je pokušaj razumijevanja prirode*" ili "*T2: Znanost je pokušaj učenja o bilo kojoj temi*." Samo budući nastavnici kemije objasnili su znanost preko pedagoške dimenzije. Promatrajući filozofsku dimenziju, neki studenti objasnili su znanost kao: "*C27: Znanost je cijeli skup znanja koje se može dokazati ili pobiti*" ili "*T13: Znanost je znanje koje otkriva ljudska vrsta koristeći mogućnosti mišljenja i zaključivanja.*" U sociološkoj dimenziji nekoliko je studenata objasnilo znanost kao:"*T6: Znanost je fenomen koji povećava razine prosperiteta i životnog standarda društva*" ili "*C33: Znanost je alat korišten kako bi se riješili problemi u društvu.*"

Malen broj studenata iz obje skupine definirao je znanost u povijesnoj i psihološkoj dimenziji. U povijesnoj dimenziji nekoliko je studenata napisalo:"*C10: Znanost je civilizacija*" ili "*T25: Znanost je područje istraživanja koje, tijekom razvoja čovječanstva, pokušava osvijetliti ili razotkriti činjenice o znanstvenim fenomenima.*" Kroz psihološku dimenziju, neki su studenti napisali: "*C14: Znanost je znatiželja,*" "*C29: Znanost je zadovoljavanje ega*" ili "*T15: Znanost je želja za otkrivanjem novoga.*"

Prijašnja istraživanja otkrila su da studenti imaju različite poglede na znanost, posebno pozitivističke, empirijske, induktivne ili idealističke poglede (Gallagher, 1991; Hodson, 1985; Lederman, 1992; Mellado, 1997). U ovome istraživanju, način razmišljanja o znanosti kada je riječ o budućim kemičarima i budućim nastavnicima kemije povezuje se s epistemološkom, povijesnom, pedagoškom, filozofskom, psihološkom i sociološkom dimenzijom.

Mišljenje studenata o tehnologiji

Pitanje „Što je, po tvom mišljenju, tehnologija?" odredilo je poglede studenata na tehnologiju. Rezultati dobiveni iz toga pitanja prikazani su u Tablici 6.

Tablica 6.

Obje skupine studenata, budući kemičari i budući nastavnici kemije, definiraju tehnologiju kroz različite izraze. Međutim, dominantna stajališta u definiranju tehnologije ukazuju na različitosti za te dvije skupine studenata. Dok budući kemičari tehnologiju doživljavaju kao izum (26%), materijalne proizvode (21%), tvorevine (17%) i tehniku (10%), budući nastavnici kemije uglavnom ju definiraju kao izum (25%), tvorevine (20%), znanje (20%) i disciplinu (15%).

Primjerice, neki studenti objašnjavaju tehnologiju kao:"*T19: Tehnologiju čine ljudski proizvodi poput instrumenata, strojeva, naprava, sklopovlja,*" "*C8: Kada pomislim na tehnologiju, pomislim na vozila kojima se služimo, mobilne telefone, računala, Internet, video igrice, itd.,*" "*T23: Tehnologija je tehničko znanje koje se koristi za dobrobit društva,*" "*C34: Tehnologija je izumljivanje novoga,*" "*C2: Tehnologija je primijenjena znanost,*" "*T29: Tehnologija je opipljiv izraz znanosti, transformacija znanosti u praktičnom životu*" ili "*C19: Tehnologija je tehnika rješavanja praktičnih problema.*" Nadalje, samo su budući kemičari definirali tehnologiju kao tehniku.

Malen broj studenata iz obje skupine tehnologiju doživljava kao dizajn proizvoda ili kao ljudsku aktivnost. Primjerice, jedan je student napisao: "*T11: Tehnologija je dizajniranje proizvoda kako bi se poboljšao životni standard*." Konačno, vrlo mali broj studenata tehnologiju vidi kao vještinu. Doživljavanje tehnologije kao vještine iznijeli su samo budući nastavnici kemije.

Prijašnja istraživanja ukazala su na to da studenti doživljavaju tehnologiju kao tvorevine, dizajn proizvoda, kao disciplinu, ljudsku aktivnost, materijalne proizvode ili kao tehniku (Constantinou i sur., 2010; DiGironimo, 2011; Scherz i Oren, 2006; Sunar i Geban, 2011; Tairab, 2001; Yalvac i sur.,2007). Definiciju tehnologije kao znanje i vještinu nalazimo u literaturi vezanoj uz tehnologiju (Ankiewicz i sur., 2006; Cajas, 2001; De Vries, 2003; Mitcham, 1994). Poimanje tehnologije kao znanja i vještine također je zabilježeno i u ovome istraživanju.

Stavovi studenata o odnosu znanosti i društva

Pitanje "Koja je važnost znanosti za društvo?" ukazalo je na pristupe koji studenti imaju prema odnosu znanosti i društva. Rezultati dobiveni iz odgovora na to pitanje prikazani su u Tablici 7.

Tablica 7.

Budući kemičari kao i budući nastavnici kemije uglavnom su iskazali pozitivan stav prema odnosu znanosti i društva (84% budući kemičari; 92% budući nastavnici kemije). Većina studenata iskazala je korist koju znanost donosi za društvo u smislu zadovoljavanja ljudskih potreba (38% za buduće kemičare) i u smislu osvještavanja (40% za buduće nastavnike kemije). Vezano uz zadovoljavanje potreba, primjerice, jedan student je napisao:"*C4: Ljudska bića, po prirodi, uvijek traže racionalne odgovore na događaje i situacije koje ih okružuju. U ovome smislu, znanost zadovoljava ljudske potrebe. Ponekad ova potreba postaje apsolutna.*" Vezano uz osvještavanje, jedan student piše:"*C25: Osvještavanjem ljudi, znanost osigurava osjećajnije i tolerantnije društvo, puno razumijevanja.*" "*T20: Lako je zavarati onoga koji ne zna. Upravo jer društvo koje se bavi znanošću posjeduje znanje, bit će teško zavarati ljude u takvome društvu.*" ili "*T32: Znanost stvara društvenu i kulturološku osviještenost kod ljudi.*"

U obje skupine studenti su naveli koristi koje društvo ima od znanosti u vidu rješavanja problema (14% budući kemičari; 11% budući nastavnici kemije). Primjerice, jedan je student napisao: "*C11: Da znanost ne postoji, ljudi bi se suočili s velikim problemima u svakodnevnom životu. Znanost nam pomaže riješiti te probleme.*" Mali broje studenata iz obje skupine spomenuo je korist koje društvo ima od znanosti u smislu upoznavanja sa svijetom (5% budućih kemičara; 7% budućih nastavnika kemije). Primjerice, jedan student je napisao: "*T21: Znanost je ključna za upoznavanje pojedinca sa svijetom.*" Vrlo malen broj studenata iz obje skupine naveo je korist koju znanost ima za društvo u vidu pogleda na događanja bez predrasuda (3% budućih kemičara; 2% budućih nastavnika kemije). Primjerice, jedan je student izjavio: "*C13: Znanost omogućuje ljudima da događaje promatraju objektivnije.*"

S druge strane, dok su isključivo budući nastavnici kemije objasnili korist koju znanost ima za društvo u vidu povećane dobrobiti i bezbrižnosti (7%), povećanje radne snage (2%), socijalizacije (4%) i demokratičnosti (4%), budući kemičari opisali su korist koju društvo ima od znanosti u vidu upoznavanja ljudske vrste (3%). Primjerice, neki su studenti napisali "*T1: Znanost ima sposobnost davanja ljudima mogućnost da se oslone na vlastite noge. Što znanost više napreduje u društvu, to je veći prosperitet i mir,*" "*T30: Znanost stvara nove mogućnosti za zaposlenje i kao takva povećava radnu snagu društva*" "*T12: Znanost poboljšava komunikaciju među ljudima i na taj način socijalizira društvo,*" "*T8: Važnost znanosti u demokratičnosti društva ne može se negirati*" ili "*C17: Znanost omogućuje osobi da bolje upozna vlastitu psihološku sliku i anatomiju.*"

U odnosu na studente s pozitivnim stavom, postoji i nekolicina studenata u obje skupine koji su iskazali negativan stav vezano uz odnos znanosti i društva (14% budućih kemičara; 6% budućih nastavnika kemije). Neki studenti napomenuli su kako je znanost štetna za društvo, kako je donijela nepogode i ljude učinila nesretnima. Primjerice, jedan je student napisao: "*C35: U jednom trenutku, odlutati od same svrhe ljudskog postanka može imati štetne posljedice. Produkti znanosti poput atomske bombe i kemijskog oružja dovode ljudsku vrstu do katastrofe.*" Drugi je student napisao: "*T10: Žalosno je što znanost ne može učiniti više za ljude od toga da ih čini nesretnima i da gube nadu. Mišljenja sam da su ljudi koji su živjeli prije nekoliko tisuća godina bili sretniji nego ljudi danas.*" Jedan student izrekao je mišljenje da je znanost štetna za društvo jer ih čini nedruštvenima. Takav je stav izrečen samo kod budućih nastavnika kemije.

Primjerice, jedan student je napisao: "*T22: Znanost stvara svijet u kojemu ljudi moraju raditi puno bržim tempom. Na taj način oslabljuju se komunikacijske i društvene veze.*"

Na kraju, vrlo malen broj studenata nije ponudio odgovor na pitanje: "Zašto je znanost važna za društvo?"

Stavovi studenata o odnosu tehnologije i društva

Odgovori na pitanje "Zašto je tehnologija važna za društvo?" odredilo je stavove studenata u vezi s tehnologijom i društvom. Odgovori na to pitanje prikazani su u Tablici 8.

Tablica 8.

Budući kemičari kao i budući nastavnici kemije uglavnom su iskazali pozitivan stav u vezi s odnosom odnos tehnologije i društva (75% budućih kemičara; 78% budućih nastavnika kemije). Većina studenata objasnila je koristi koje društvo ima od tehnologije u vidu poboljšanja standarda i kvalitete življenja (42% budućih kemičara) i u vidu olakšavanja života (36% budućih nastavnika kemije). Vezano uz poboljšanje standarda i kvalitete življenja, jedan je student napisao: "*C25: Standard i kvaliteta života u društvu raste jer su novi tehnološki proizvodi ponuđeni ljudima*" Vezano uz životne olakšice neki su studenti napisali: "*C9: Tehnologija olakšava ljudima život. Ljudima je puno lakše nešto napraviti, u vidu transporta, komunikacije, itd..*" ili "*T28: Tehnologija olakšava život u mnogim njegovim aspektima. Zbog tehnologije danas ljudi žive u različitim dijelovima svijeta i mogu komunicirati jedni s drugima.*"

Neki studenti iz obje skupine iskazali su koristi koje društvo ima od tehnologije u vidu uštede vremena i energije, zatim u vidu povećanja produktivnosti. Primjerice, studenti iz obje skupine napisali su: "*C22: Tehnologija štedi vrijeme. Prije je odlazak iz jednog mjesta u drugo iziskivao puno vremena, međutim danas možemo ići bilo gdje u relativno kratkom vremenu*" ili "*T13: Tehnologija štedi vrijeme i energiju. Zbog tehnologije, moguće je dovršiti nešto u kraćem vremenu i uz manju potrošnju energije.*" Drugi je student napisao: "*T5: Tehnologija povećava proizvodnju te društvo postaje produktivnije.*" Vrlo mali broj studenata iz obje skupine opisao je korist koje društvo ima od tehnologije u vidu povećanja osviještenosti (5% studenata iz obje skupine). Primjerice, jedan je student napisao: "*C18: Tehnologija je jedan od neophodnih faktora u društvu. Koristeći tehnologiju, ljudi stječu znanje i osviještenost.*"

Neki su studenti iz obje skupine iskazali negativan stav što se tiče odnosa tehnologije i društva (22% budućih kemičara; 20% budućih nastavnika kemije). Studenti navode kako tehnologija šteti društvu nanoseći nevolju ljudima i okolišu, stvaranjem lijenih ljudi, nedruštvenih ljudi i kulture robota. Neki su studenti tako napisali: "*C5: Činjenica je da tehnologija kvari ravnotežu u prirodi. Štetni otpad iz tvornica stvara različite tipove onečišćenja na zemlji što predstavlja opasnost za ljudsko zdravlje,*" "*T16: Tehnološki napredak čini ljude posebno lijenima,*" "*C28: Tehnologija oslabljuje veze i dijalog među ljudima. Upravo zato što društvene veze postaju nebitne, ljudi postaju nedruštveni*" ili

"*T30: Moja razmišljanja o ovome nisu na žalost vrlo pozitivna jer umjesto da ljudi vladaju tehnologijom, tehnologija vlada ljudima, pretvarajući ih zapravo u robote. U društvu se polako razvija kultura robota.*"

S druge strane, dok samo budući nastavnici iskazuju kako tehnologija kvari društvo ubijajući ljudske emocije (2%), povećavajući nezaposlenost (%2), stvarajući ovisnosti (2%), kulturnu izrođenost (2%) i kulturološki imperijalizam (2%), budući kemičari štetu koju tehnologija nanosi društvu vide u smislu življenja monotonih života (3%). Primjerice, jedan je student napisao: "*T8: Tehnološka oprema zamjenjuje ljude u tvornicama. Broj zaposlenih ljudi smanjuje se svakodnevno. Stopa nezaposlenosti u društvu raste,*" "*T12: Ljudi, kao rezultat, postaju mehanizmi, a ljudske emocije izumiru,*" "*T18: Proizvodi visoke tehnologije stvaraju ovisnost,* "*T26: Tehnologija pretvara svakoga u prototipove a kultura se u društvu počinje degenerirati. Upravo zato društvo mora zaštiti svoje osnovne vrijednosti i čvrsto ih se držati. Društva koja ne proizvode tehnologiju moraju se izmaknuti te prepustiti kulturnom imperijalizmu i u konačnici postati kolonija. Mnogi su takvi primjeri širom svijeta*" ili "*C32: Tehnološki alati i oprema život čine monotonim. Umjesto igranja vani i upoznavanja prirode, djeca vrijeme provode igrajući se na računalu i rastu u monotoniji.*"

Na kraju, vrlo malen broj studenata nije ponudio odgovor na pitanje: "Zašto je tehnologija važna za društvo?"

Rasprava i zaključak

Literatura o prirodoslovnom/znanstvenom obrazovanju jasno ukazuje na to da je poznavanje znanosti i tehnologije obrazovni cilj (DiGironimo, 2011; Solbes i Vilches, 1997). Prema tome, istraživanja su provedena kako bi se saznali stavovi studenata o tehnologiji i znanosti. U ovome je istraživanju uočeno da su neki stavovi studenata o znanosti i tehnologiji vrlo slični rezultatima iz prijašnjih studija. Objašnjenja koja su dali studenti vezana uz znanost kao eksperiment, skup znanja, metodu ili ljudsku aktivnost mogla bi biti citirana kao primjeri iz literature. (Celik i Bayrakçeken, 2006; Constantinou i sur., 2010; Craven i sur., 2002; Lederman, 1992; Mellado, 1997; Murcia i Schibeci, 1999; Nuangchalerm, 2009; Scherz i Oren, 2006; Tairab, 2001). Postoje primjeri u kojima studenti opisuju tehnologiju kao tvorevinu, dizajn proizvod, disciplinu, ljudsku aktivnost, izum, materijalni proizvod ili tehniku, što također nalazimo u literaturi (Constantinou i sur., 2010; DiGironimo, 2011; Scherz i Oren, 2006; Sunar i Geban, 2011; Tairab, 2001; Yalvac i sur., 2007).

Važno otkriće u ovome istraživanju bilo je da ne postoje razlike u opisima znanosti i tehnologije između dvije skupine studenata. Primjerice, samo su budući nastavnici kemije definirali znanost kao način učenja i razumijevanja. S druge strane, definicija tehnologije kao znanja uglavnom prevladava kod budućih nastavnika kemije, a budući kemičari tehnologiju većinom doživljavaju kao materijalne proizvode.

Prijašnja istraživanja pokazala su da studenti imaju različite poglede na znanost, odnosno objašnjenje znanosti, primjerice iz pozitivističkog, empirijskog, induktivnog ili idealističkog stajališta (Gallagher, 1991; Hodson, 1985; Lederman, 1992; Mellado, 1997). U ovome istraživanju studenti iz obiju skupina znanost su objasnili iz epistemološke, povijesne, pedagoške, filozofske i sociološke perspektive, a mnogo je studenata imalo empirijski pogled na znanost. Ti pojmovi usklađeni su s tradicionalnim pristupom u razredu (Lederman, 1992; Tsai, 2002). Nadalje, dok budući kemičari uglavnom definiraju znanost iz epistemološke i filozofske perspektive, budući nastavnici kemije često objašnjavaju znanost iz epistemološke i pedagoške perspektive. Takav rezultat ukazuje na to da postoje jasne razlike u načinu razmišljanja o znanosti između dvije skupine studenata.

Činjenica da su samo budući nastavnici kemije formulirali definiciju znanosti iz pedagoške perspektive (npr. znanost je način učenja ili razumijevanja) odraz je kurikula koji je utemeljen na činjenici da je 28% kolegija u kurikulu za buduće nastavnike zapravo obveznih nastavnih kolegija. Zbog toga budući nastavnici kemije pokazuju naklonjenost pedagoškim pojmovima prilikom definiranja znanosti. S obzirom na to da kolegiji vezani uz obrazovanje nisu dio programa za obrazovanje budućih kemičara, takva perspektiva nije otkrivena u njihovim definicijama znanosti. Štoviše, činjenica da je više definicija znanosti iz epistemološke perspektive dano od budućih kemičara u usporedbi s budućim nastavnicima kemije također se može pripisati studijskom programu. Budući kemičari više su izloženi teorijskim i praktičnim znanstvenim kolegijima nego budući nastavnici kemije. Upravo zato što budući kemičari provode više eksperimenata u laboratorijima (imaju više interakcije s eksperimentalnim radom) sposobniji su identificirati pojam znanosti preko epistemoloških pojmova poput promatranja, mjerenja, eksperimenta i metode u odnosu na buduće nastavnike kemije.

U ovome istraživanju obje skupine ispitanika izjavile su da znanost i tehnologija utječu na društvo na negativan i pozitivan način. Uglavnom su imali pozitivan stav na odnos znanosti i društva i tehnologije i društva. Međutim, neki studenti iz obje skupine iznijeli su i negativan stav vezan uz odnos znanosti i društva i tehnologije i društva. Taj negativan stav proizlazi iz znanja o škodljivim učincima teških metala, nuklearnog otpada, nuklearnih nesreća i ostalih štetnosti na ljudsko zdravlje i društvo. Kurikul za obje skupine sadrži kolegije poput "Kemija okoliša," "Okoliš i čovjek" ili "Kemija, čovjek i društvo," koji su osmišljeni kako bi naučili studente o negativnim aspektima znanstvenih i tehnoloških primjena (atomska bomba nuklearne nesreće, ispuštanje nedovoljno filtriranih plinova iz tvorničkih dimnjaka itd.) i njihovim učincima na okoliš i društvo. Takve informacije kod studenata izazivaju negativne stavove o odnosu znanosti, tehnologije i društva. Studenti poimaju znanost i tehnologiju s negativnog stajališta, što možda otežava učenje s razumijevanjem (Gil-Perez i sur., 2005; Mansour, 2010). Prema tome, bilo bi korisnije da osobe koje se bave obrazovanjem i osobe koje se bave društvenom znanošću procijene negativne stavove koje studenti pokazuju.

S druge strane, ovo istraživanje također je pokazalo da neki studenti imaju prilično naivne poglede na znanost i tehnologiju, kao i da uglavnom u nedovoljnoj mjeri razumiju pojmove znanost i tehnologija. Primjerice, neki su studenti definirali znanost kao "*Znanost je znatiželja*," "*Znanost je ovisnost*" ili "*Znanost je zadovoljavanje ega*." Neki su studenti tehnologiju objasnili kao "*Tehnologija je vještina*" ili "*Tehnologija je izumljivanje novoga*." Tvrdnje koje su neki studenti iz obiju skupina iznijeli ukazale su na činjenicu da imaju naivne poglede na predmet istraživanja. Ti naivni stavovi studenata vezani uz znanost i tehnologiju mogu se pripisati nedovoljnom znanju o znanosti i tehnologiji (Abd-El-Khalick i Lederman, 2000b; DiGironimo, 2011). Neka istraživanja otkrila su da su znanstveni kurikuli još uvijek neuspješni u priopćavanju takvog znanja (Hanuscin i sur., 2006; Mansour, 2010; Pekdağ i Erol, 2013; Rowell i sur., 1999), a poznato je da su znanstveni kurikul, udžbenici i nastavne metode važni čimbenici u stvaranju dovoljnog i prevladavajućeg razumijevanja znanosti i tehnologije u glavama studenata (Gil-Perez i sur., 2005; Lederman, 2007; McDonald, 2010). U dogledno vrijeme ti bi čimbenici trebali biti proučeni i revidirani iz racionalne i realne perspektive.

Kako bi unaprijedila konceptualno razumijevanje znanosti i tehnologije kod studenata, oba dodiplomska kurikula trebala bi proći reviziju, trebali bi biti dodani novi kolegiji i novi pedagoški pristup uz učinkovite nastavne metode trebao bi biti razvijen. Primjerice, kolegiji o povijesti i filozofiji znanosti, o povijesti kemije, o povijesti i filozofiji tehnologije, o tehnologiji kemijskih laboratorija mogli bi se pridodati kurikulu za oba programa buduće nastavnike kemije i buduće kemičare. Nadalje, kolegiji o računalnom softveru (npr. *Avogadro*, *ChemSketch*, *HyperChem*) također bi mogli biti dijelovi nastavnog programa za buduće kemičare i buduće nastavnike kemije. U Turskoj kolegiji o znanosti, tehnologiji i društvu (izvan laboratorijskih kolegija) obično su dio kurikula za studente u Fakultetu za znanost i umjetnost, i obično se poučavaju koristeći se tradicionalnim pristupom (ex-katedra). Studenti Fakulteta za obrazovanje slušaju te kolegije preko tradicionalnih i konstruktivističkih metoda (nastava orijentirana na nastavnika i studenta). U oba programa, kolegiji o znanosti, tehnologiji i društvu kroz konstruktivističke/socijalno konstruktivističke metode (nastava orijentirana na studente) trebali bi biti ponuđeni i budućim kemičarima i budućim nastavnicima kemije.

Nastava kemije trebala bi omogućiti studentima da razviju primjereno razumijevanje znanosti i tehnologije te vezu znanosti, tehnologije i društva (AAAS, 1993; ITEA, 2006; NAE i NRC, 2002; NRC, 1996). Puko uključivanje u aktivnosti zasnovane na znatiželji i implicitna metoda nisu dovoljni da poboljšaju konceptualno razumijevanje studenata o znanosti i tehnologiji. Naprotiv, eksplicitna metoda koja se usredotočuje na povijest i filozofiju znanosti i tehnologije i diskusije o toj problematici u nastavnom procesu, uz aktivnosti vezane uz znatiželju morala bi biti prihvaćeni (Abd-El-Khalick i Lederman, 2000b). Takav pristup može uključivati gledanje videa o životima znanstvenika, posjećivanje centara i muzeja za znanost i tehnologiju, čitanje i razgovor o člancima vezanima uz znanost i tehnologiju, stvaranje i provođenje istraživačkih projekata, pisanje istraživačkog rada, itd. (Cakmakci, 2012; Schwartz i sur., 2004; Solomon, 2002).

Rezultati ovog istraživanja otkrili su da je značenje znanosti i tehnologije u glavama studenata iz obje skupine ukazalo na neke bitne razlike u ovome uzorku. Drugim riječima, rezultati istraživanja ukazuju na broj važnih razlika u pogledima studenata na znanost kod onih koji se njome bave i kod onih koji poučavaju znanost vezano uz problematiku ZTD-a. To se može objasniti razlikom u kurikulima koji se prakticiraju za buduće kemičare i buduće nastavnike kemije. Drugim riječima, konceptualno učenje znanosti i tehnologije povezano je sa sadržajem kolegija a razlika u stajalištima dviju skupina studenata potječe iz produkta iskustava u učenju kemije. Vjeruje se da će ovo istraživanje pomoći nastavnicima kemije da se upoznaju sa stavovima studenata koji su podvrgnuti različitom obrazovanju, te će im pomoći u razvijanju učinkovitijih pedagoških strategija i kurikula koji će u konačnici dovesti do poboljšanja u razumijevanju znanosti i tehnologije budućih nastavnika kemije i budućih kemičara.

Nadalje, ovo istraživanje doprinijet će obrazovanju znanstvenika koji imaju za cilj usporediti poglede budućih znanstvenika i nastavnika znanosti u poljima fizike i biologije a vezano uz problematiku ZTD-a u okviru metodologije istraživanja (načini usporedbe dodiplomskih kurikula, načini analize podataka) i empirijskog aspekta (rezultati istraživanja). Međutim, ovo istraživanje imalo je i određene nedostatke s obzirom na malen uzorak. Istraživači znanstvenog obrazovanja mogu provesti takvo istraživanje na drukčijem uzorku (primjerice, u području fizike ili biologije) ili istraživača nastave kemije na većim uzorcima.