Improving University Students' Science-Technology-Society-Environment Competencies

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Abstract
Science, Technology, Society, Environment (STSE) is an education movement that started and developed from 70s through early 2000s. Although this movement had lost emphasis in recent years, it is one of the most important educational reform attempts in science education history. Today, concepts like Socio Scientific Issues (SSI) or Science, Technology, Engineering, Mathematics (STEM) education are more prevalent. STSE reform aims making science more relevant for students while helping them attain scientific literacy. If applied well, this approach is very powerful in achieving this aim. This study explores the effect of an elective course on students' competencies in STSE education. Turned in assignments and presentations of 22 participants were the source of data, which was analyzed through content analysis. Results show that students were able to achieve high competency in certain areas of STSE education, while having difficulties in others. This study may have implications for university level STSE courses.

Key words: Science-technology-society-environment competencies, scientific literacy, teacher competences

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Introduction

STSE education was developed as a reform effort in the 70s through 2000s mostly in certain Western countries (Aikenhead, 2003; Cheek, 1992; Solomon & Aikenhead, 1994; Yager, 1996). It was developed as a result of the inadequacy of teacher-centered, detached from real life, classroom-limited, textbook and memorization-based traditional science education and the increasing influence of science and technology on society and environment in recent decades (Mansour, 2009; Yager, 1996). The main aim of STSE education is to empower individuals by helping them achieve scientific literacy so that people can make informed decisions about science and technology related topics that influence society (Pedretti and Nazir, 2011; Mansour, 2009). The following quote from PISA 2015 Science Framework (OECD, 2013) summarizes the importance of scientific literacy very well.

> Scientific literacy matters at both the national and international level as humanity faces major challenges in providing sufficient water and food, controlling diseases, generating sufficient energy and adapting to climate change (UNEP, 2012). Many of these issues arise, however, at the local level where individuals may be faced with decisions about practices that affect their own health and food supplies, the appropriate use of materials and new technologies, and decisions about energy use. Dealing with all of these challenges will require a major contribution from science and technology. Yet, as argued by the European Commission, the solutions to political and ethical dilemmas involving science and technology 'cannot be the subject of informed debate unless young people possess certain scientific awareness' (European Commission, 1995, p.28). (p. 3).

Yager (2007) argues that for STSE to be successful, teachers must act differently in the classroom. Student must be at the center of activities, data collection procedures, evidence collection to support ideas, and actions taken for solving problems. This paradigm shift has significant implications for teacher training and development. Lawrence et al (2001, p.17) summarize the differences between STSE and traditional orientations in science education in Table 1, which implies the paradigm shift that is necessary to apply STSE education successfully.

Table 1. *Difference between traditional and STSE orientations in science education*

Traditional Orientations	**STSE Orientations**
Teachers and textbooks are the main sources of knowledge	Students actively seek information to use
Science is abstract and has no relation to technology or daily life	Students see science as a way of dealing with problems in everyday life
Students concentrate on problems that are identified by the teacher or textbooks	Students identify problems about themselves or their community and take responsibility to solve those problems by using science
Minimal consideration given to human adaptive capacities	Human adaptation and alternative futures emphasized
Value-free interpretation of discipline bound problems	Value, ethical, and moral dimensions of problems and issues considered
Curriculum is textbook centered, inflexible; only scientific valid is considered (and from a limited view of content)	Curriculum is problem centered, flexible and culturally as well as scientifically valid
Information is in the context of the logic and structure of the discipline	Information is in the context of the student as a person in a cultural/social environment

Challenges that teachers face in STSE education are studied by many researchers (for ex. Bettencourt, Velho, and Almeida, 2011; Elmas, Öztürk, Irmak, and Cobern, 2014; Mansour, 2010; Steele, 2013; Yager, 2007). These studies usually highlight the changing roles of teachers and students in STSE education as well as issues ranging from pedagogy, time limitations, assessment, curriculum integration, and classroom management, all of which needs to be addressed in pre-service teacher education at university level.

This study was conceived with this need in mind and the effect of a university level course on pre-service teachers' competency in preparing STSE activities was evaluated. The one-semester elective STSE Education course provided the context for this study. Students were given the task of developing an STSE activity designed for application in schools at various levels. The model of STSE activities adopted in this course is summarized in Figure 1. A problem that influences the society which has scientific, technological, and environmental dimensions is the starting point in this model. Choosing location and time specific problems that are relevant for learners and suitable for their level is the aim in the first phase. Local media may be an important source of information for this purpose. After a relevant problem is determined, the second phase of the model starts (science and technology). In this phase, an inquiry activity aimed at understanding and solving the problem is designed by the teacher and students. This is followed by data based explanation and a possible solution to the problem is proposed by students. In the final phase of the model, return to society takes place by choosing an appropriate social action. This phase aims developing a sense of social responsibility of students (Dass, 1999; King, 2002).

Pedretti and Nazir (2011) provide a map of the STSE currents in their review of STSE literature. They suggest that there are six major currents in STSE education, first of which is named "application/design" by the authors. This STSE current focuses on solving problems through technology and inquiry. The model used in this course fits in this category of STSE applications.

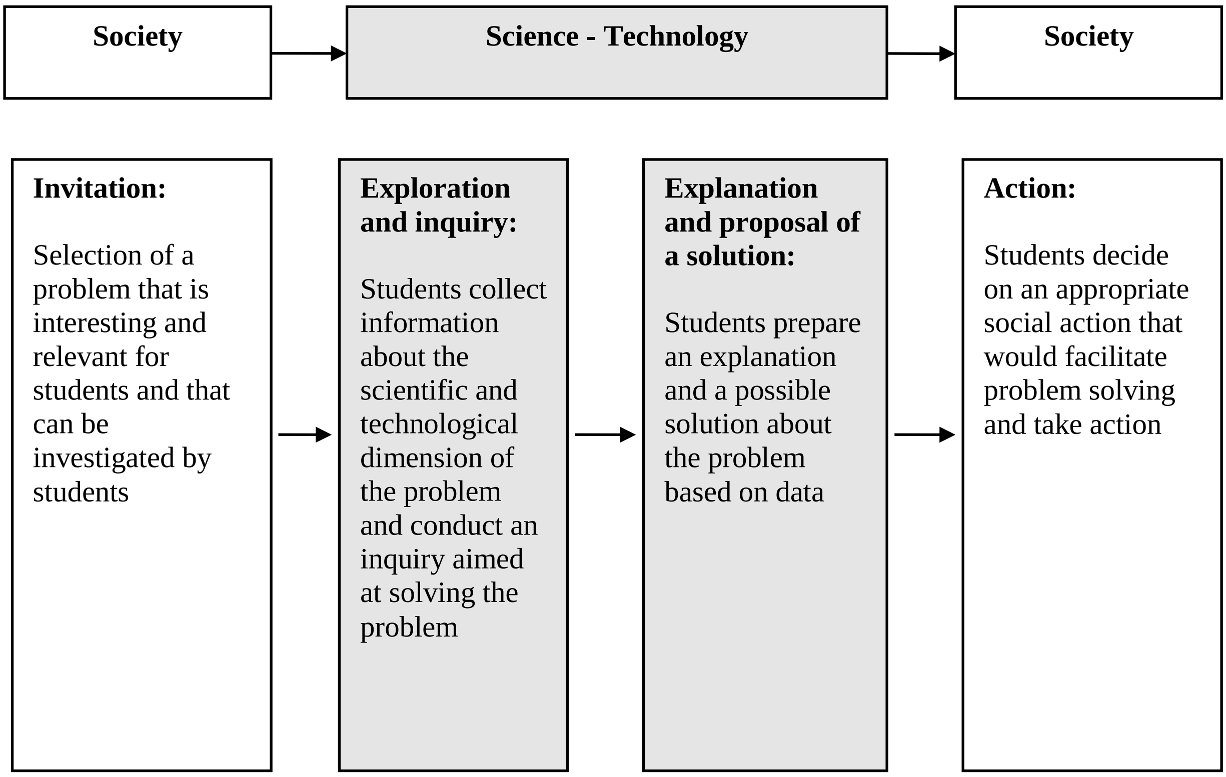

Figure 1: Model for developing STSE activities

Specifically, the research question explored in this study was: "How the competencies of university students about developing an STSE activity were affected after taking the one-semester-long elective STSE Education course?" The sub questions were: "Which competencies matured?" and "Which competencies need more emphasis?" The answers to these questions provided the data to be used for further development of the course, which also have implications for university level STSE courses.

Methods

The methodology of this study was action research, since the ultimate purpose of the study was to improve the practice of STSE teaching and learning at college level. Smith (2007) explains that a common type of action research is done to improve practice, especially in educational fields. Action research does not aim for generalization, since it is context dependent. Therefore convenience sampling is a common method for defining samples in action research, which was the case in this study as well.

22 undergraduate and graduate students were the participants of this study. They took an elective STSE Education course that was offered in the Primary Education Department of a major university in middle Turkey in the summer and fall semesters of 2014. The participants were enrolled in different departments, including primary education, science education, chemistry education, and Turkish Literature. Most of the participants (15) were pre-service teachers in their respective fields. During the course, history, features, types, and applications of STSE education were discussed with students. The main task of the students during the course was to develop an STSE activity that can be applied in a school setting. The following criteria were adopted for developing an STSE activity:

1- It should include a problem that influences society with science and technology dimensions.

2- It should be directly related to students' lives.

3- It should be suitable for students' levels (grades).

4- Science, technology, and society dimensions of the problem should be explained.

5- An inquiry activity that aims to solve the problem should be designed.

Students chose STSE issues at local, national, and global levels and developed activities about these issues during the class and turned in as a written document at the end of the semester and they also presented their work to the whole class. Some of the topics chosen by students for their assignments are listed in the following:

a. Energy saving through solar heating
b. Increasing salt production efficiency at the Salt Lake in Turkey
c. Influence of Afsin – Elbistan thermal power plant on society and environment
d. Increasing soil water retention for irrigation efficiency
e. Substance abuse and its effects on society
f. Influence of technology on how young people use language
g. Modeling global warming
h. Measuring heating effect of cell phones
i. Effect of hydroelectric power plants on the environment
j. Investigation of contagious diseases

Students' assignments and presentations were the source of data for this study. Document analysis method was used to analyze the data. For this purpose, a rubric was developed for coding the data, which is shown in Table 2. 14 codes were determined for data analysis based on common features in an "application/design" type of STSE education (Pedretti and Nazir, 2011). Each code was given points from 0 to 3 based on the four levels of development. After each assignment was analyzed based on the rubric, each code was marked and given points as shown in Table 2. For validity of the rubric, opinions of two experts were requested and revisions were made based on their suggestions. To ensure reliability, an independent coder analyzed a subset of the assignments and 87 % agreement was observed between the coders.

Table 2. *Rubric used for content analysis of data*

	STSE Activity features	**Points**			
		3	2	1	0
1	Includes a suitable problem that has STSE dimensions	Problem has all STSE dimensions	Problem has most STSE dimensions	Problem has one relevant STSE dimension	Problem is not suitable for STSE
2	Directly related to students' lives	Problem is directly related to students	Problem is relevant for students' area	Problem is not directly relevant to students	Problem is not relevant for students
3	Suitable for students' levels	The issue is suitable for students' level	The issue is somewhat difficult for students	The issue is very difficult for students	The issue is not suitable for students'' level
4	Explains the science dimension of the problem	Science dimension of the issue is well explained	Science dimension of the issue is fairly explained	Science dimension of the issue is poorly explained	Science dimension of the issue is not explained
5	Explains the technology dimension of the problem	Tech dimension of the issue is well explained	Tech dimension of the issue is fairly explained	Tech dimension of the issue is poorly explained	Tech dimension of the issue is not explained
6	Explains the social dimension of the problem	Social dimension of the issue is well explained	Social dimension of the issue is fairly explained	Social dimension of the issue is poorly explained	Social dimension of the issue is not explained
7	Explains the environment dimension of the problem	Envr. dimension of the issue is well explained	Envr. dimension of the issue is fairly explained	Envr. dimension of the issue is poorly explained	Envr. dimension of the issue is not explained
8	Links to curriculum is made	All relevant curriculum objective are mentioned	Some curriculum objective are mentioned	At least one curriculum objective is mentioned	No curriculum objective is mentioned
9	Interdisciplinary links are made	All interdisciplinary connections are made	Some interdisciplinary connections are made	One interdisciplinary connections is made	No interdisciplinary connections is made
10	Includes an inquiry activity that aims to solve the problem	Inquiry activity with all steps explained	Inquiry activity with most steps explained	Inquiry activity exist but not well explained	No inquiry activity is included
11	Has nature of science (NOS) and nature of inquiry connections	NOS connections are well made	Some NOS connections are made	At least one NOS connection is made	No NOS connection is made
12	Includes a design	Includes a well-defined product or process design	Includes a product or process design	Includes a poor-defined product or process design	No product or process design is included
13	Includes a social action proposal	Includes a well-defined social action plan	Includes a social action plan	Includes a poor-defined social action plan	No social action plan is included
14	Uses media news as a source of information	Mentions more than two media sources	Mentions at least two media sources	Mentions at least one media sources	No media sources are mentioned

Findings

The main findings of the study can be summarized in Figure 2. As shown in Figure 2, average points for each of the 14 codes were calculated and sorted from high to low in a column graphic. Competency in STSE activity features that have an average point of 2.00 and higher were considered mature, competency in features that had points between 1.00 and 2.00 were considered intermediate, and competencies in features that had points below 1.00 were considered immature.

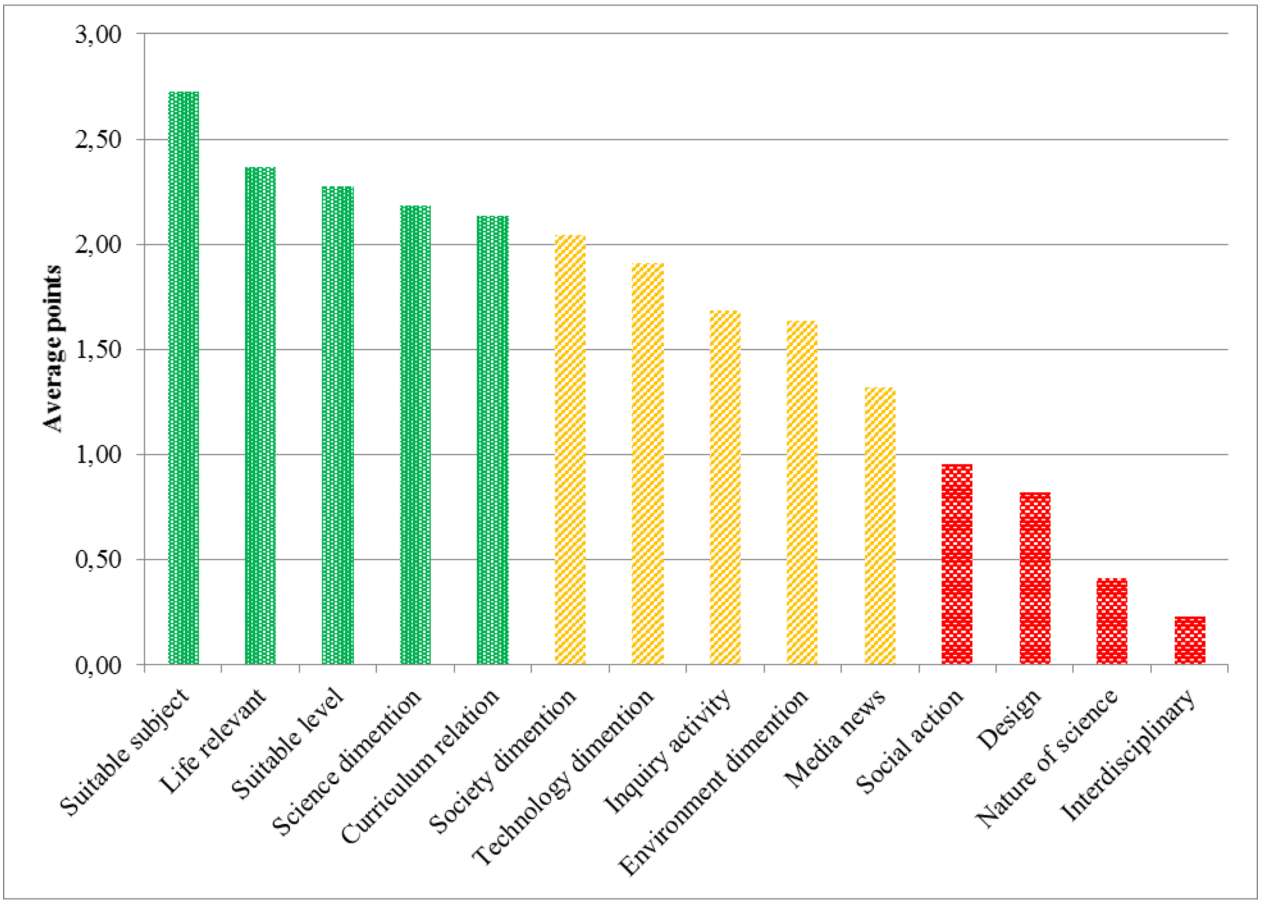

Figure 2: Findings from data analysis

As the findings indicate, students were able to demonstrate mature competencies in developing following features in an STSE activity:

- Includes a suitable problem that has STSE dimensions
- Directly related to students' lives
- Suitable for students' levels
- Explains the science dimension of the problem
- Links to curriculum is made

On the other hand, students were able to demonstrate intermediate competencies in developing following features in an STSE activity:

- Explains the social dimension of the problem
- Explains the technology dimension of the problem
- Includes an inquiry activity that aims to solve the problem
- Explains the environment dimension of the problem
- Uses media news as a source of information

Finally, students demonstrated immature competencies in developing following features in an STSE activity:

- Includes a social action proposal
- Includes a design
- Has NOS and nature of inquiry connections
- Interdisciplinary links are made

Conclusion

Findings show that competencies needed for developing some of the important features of an STSE activity are not matured during the STSE Education course. These include developing a social action proposal, making NOS and nature of inquiry connections, making interdisciplinary links, and including a design element. The data shows that more emphasis on these features is needed. The importance of these competencies in STSE education is emphasized in the literature. For example, Pedretti et al (2008) explain the challenges in teacher candidates' acceptance of science education that promotes social action. Akcay and Akcay (2015) report that STSE instruction improves students' NOS understanding more than traditional instruction. Frodeman, Klein, Mitcham, and Tuana (2007) emphasize the importance of interdisciplinary nature of STSE education with the example of the Hurricane Katrina disaster that hit New Orleans in 2005. A university level STSE education course should put further emphasis on these aspects, especially if designed for pre-service teachers. Inclusion of a design element in an STSE activity may not be as essential depending on the issue at hand.

Other features that needed improvement based on findings include explaining social, technological, and environmental dimensions of an STSE problem, designing an inquiry based activity for solving the chosen problem, and use of media news as a source of information. These findings provide further examples of possible features that need more emphasis in a university level STSE education course. The findings also show the complexity of content and design of such courses, which require a large array of pedagogical and content competencies on the part of the instructor. Developing students' competencies in STSE education is clearly a challenge that needs careful attention.

Applying STSE education requires significant investment in human and material resources at any level. Just including STSE objectives in curriculum does little in terms of real classroom applications, as has been the case in the 2005 and 2013 science curriculums in Turkey (MEB, 2005 and 2013; Yalaki, 2014). For affective and meaningful applications of STSE to take place, involvement of various stakeholders is needed in developing STSE modules or courses for teaching in all levels (Abualrob and Shah, 2012).

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