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Pre-service Science Teachers' Self-efficacy Beliefs to Teach Socio-scientific Issues

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ABSTRACT

This study aims to examine self-efficacy of pre-service science teachers to teach socio-scientific issues (SSI). Twenty-three senior pre-service science teachers participated in the study. Science Teaching Efficacy Belief Instrument (STEBI) was modified with an emphasis on SSI rather than scientific issues. The modified STEBI was applied to the participants before and after the intervention. As for the six-week intervention, three modules, which focused on understanding nature of SSI, teaching and assessing SSI, were followed by micro-teachings on selected SSI. At the end of six weeks, significant difference was found between pre and post-modified STEBI scores. Besides, there was a significant difference between pre and post scores on Personal Socio-scientific Issues Teaching Efficacy subscale, while no significant difference is reported on Socio-scientific Issues Teaching Outcome Expectancy subscale. The paper includes some suggestions for inclusion of SSI in science classes and for further studies on teaching efficacy on SSI.

Key Words: Socio-scientific issues, self-efficacy beliefs, pre-service science teachers.

Fen Bilimleri ÖğretmenAdaylarının Sosyo-Bilimsel Konuları Öğretmedeki Özyeterlilik İnançları

ÖZET

Bu çalışma, fen bilimleri öğretmen adaylarının sosyo-bilimsel konuları öğretme hakkındaki öz-yeterliklerini incelemeyi amaçlamaktadır. Çalışmaya, 23 son sınıf fen bilgisi öğretmen adayı katılmıştır. Fen Öğretimi Yeterlik İnanç Ölçeği'ne (STEBI), bilimsel konulardan ziyade sosyo-bilimsel konulara vurgu yapılarak uyarlama yapılmıştır. Uyarlanan ölçek, uygulanan eğitim öncesinde ve sonrasında katılımcılara uygulanmıştır. Altı hafta boyunca uygulanan eğitim, sosyo-bilimsel konuların doğası, sosyo-bilimsel konuların öğretimi ve ölçülmesi hakkında üç modül ve seçilen sosyo-bilimsel konular hakkında hazırlanan mikro-öğretimleri içermektedir. Altı haftanın sonunda, uyarlanan ölçeğin ön ve son-test sonuçları arasında istatiksel olarak anlamlı bir fark bulunmuştur. Ayrıca, Kişisel Sosyo-bilimsel Konuların Öğretilmesi Yeterliği altölçeğinde de ön ve son-test sonuçları arasında anlamlı bir fark bulunurken, Sosyo-bilimsel Konuların Öğretilmesi Başarı Beklentisi alt ölçeğinde ön ve son-testler sonucunda istatiksel olarak anlamlı bir fark bulunmamıştır. Çalışmada, sosyo-bilimsel konuların fen derslerine dahil edilmesi ve sosyo-bilimsel konuları öğretimi yeterliği hakkında gelecek çalışmalar için öneriler sunulmaktadır.

Anahtar Sözcükler: Sosyo-bilimsel konular, öz-yeterlilik inançları, fen bilimleri öğretmen adayları.

INTRODUCTION

Socio-scientific issues (SSI) are part of the science education curricula in many countries such as Cyprus, Denmark, France, Romania, Spain, Turkey and United Kingdom (Preparing Science Educators for Everyday Science Project [PreeSEES], 2013). Sadler (2004) defined SSI as dilemmas with having central roles in scientific and social aspects. Construction of hydro-electric power stations, consumption of genetically modified organisms, and organ transplantation are examples of current SSI. These SSI have social, ecological, ethical, political, and economical aspects as well as a scientific aspect. Moreover, Kolsto (2001) described SSI as having disagreements between various stakeholders on the reliability of the related scientific statements.

Inclusion of SSI into science classes is not only a current need but also a challenge for today's science teachers (Zeidler, Sadler, Simmons, & Howes, 2005). Teaching SSI enables students to improve their higher order thinking skills such as argumentative thinking, decision-making,

understanding nature of science (Evagorou, Güven , & Muğaloğlu, 2014), and understanding highly nested interrelations between different aspects of the issues.

In the recent Science Education Curriculum, the term SSI is presented as one of the themes under the Science, Technology and Environment learning area (Ministry of National Education of Turkey, 2013, p.1). Hence, teachers are required to integrate SSI into their teaching. In this sense, they have an important role for inclusion of SSI into science education. However, recent studies suggest that teachers have insufficient knowledge about, skills to teach and resources for teaching SSI (Day & Bryce, 2011; Lee, Abd-EI-Khalick, & Choi, 2006). Similar results are reported for Turkish context as well (Topçu, Muğaloğlu & Güven 2014). By taking into account three impediments of SSI teaching, namely limited teacher knowledge, teacher skills and instructional materials, PreSEES project aims to overcome these problems by improving preservice teachers' understanding of SSI, designing and implementing an intervention to support pre-service teachers about teaching SSI hence improving their self-efficacy and developing model instructional materials about teaching SSI. This paper specifically focuses on pre-service science teachers' self-efficacy to teach SSI before and after an intensified SSI training program.

Self-efficacy Beliefs to Teach SSI

Teachers' self-efficacy is significant in their teaching practices (Evans, 2014). Bandura (1986) simply defined self-efficacy as "*people's judgments of their capabilities to organize and execute courses of action required to attain types of performances*" (p. 391).

According to theory of social learning (Bandura's 1977), self-efficacy can be considered in two dimensions. The first dimension is called as outcome expectation. It is related to the tendency of performing if one believes s/he will benefit from the action. The second dimension is self–efficacy expectation. It refers to the state of being certain about one will achieve. In an educational context, in order to encourage teachers to teach a new subject, it is important to improve their self-efficacy (Ramey-Gassert and Shroyer, 1992). Even, concept of self-efficacy is argued to be part of teachers' pedagogical content knowledge (PCK) and embedded in a new PCK model for science teaching as 'teacher efficacy' (Park & Oliver, 2008).

SSI are relatively new for most of the science teachers in the way it was formulated in the literature and expected to be used. Even though, crucial role of teachers to teach SSI has been suggested (Sadler, 2009), how

teachers approach to SSI in their classes is an unstudied area (Evagorou, 2011). Several authors implied the inflexibility of teachers to include SSI in their classes (Hogan, 2002; Roth & Lee, 2004, Zeidler et. al., 2009). Teacher beliefs about science and their goals have an immense effect on this matter because teachers with a traditional view of science usually tend to think that their priority should be to teach scientific principles and science process skills (Hansen and Olson, 1996; Jenkins, 1992). In addition to teachers' perspective about teaching SSI, teachers expressed some practical impediments to inclusion of SSI in their classes. Teachers stated that they feel uncomfortable and they have concerns about classroom management problems during class discussions while teaching SSI (Sönmez & Kılınç, 2012). Moreover, they expressed they have inadequate background knowledge (Day & Bryce, 2011; Lee, Abd-EI-Khalick, & Choi, 2006). Time management problems due to heavy load of curriculum and inadequate lesson materials were other issues that teachers come up with. And, some teachers thought that levels of students were not appropriate to discuss SSI in their classrooms (Lee et al., 2006).

Topcu, Mugaloglu, Guven (2014) reviewed SSI literature and selected 11 published papers to analyze based on the four criteria: contemporary empirical investigations (2002- 2012), conducted in Turkish context, focusing on SSI in science education, and using first-hand data. Two of these published papers had findings related with self-efficacy to teach SSI. For instance, Kara (2012) concluded that pre-service teachers have low self-efficacy to teach SSI. The pre-service teachers also mentioned SSI teaching difficulties, such as time and classroom management during discussions, insufficient materials, and assessing SSI by taking into account ethical and cultural norms. In another selected study, Sönmez and Kılınç (2012) found that pre-service teachers had moderate level of self-efficacy beliefs about teaching GM Food.

Sadler (2011) argued that science teachers should have strong self-efficacy to deal with the impediments stated previously. Sönmez and Kılınç (2012) claimed that teachers with high self-efficacy beliefs were likely to develop appropriate teaching strategies to overcome difficulties in classrooms. Kılınç et. al. (2013) determined learning and teaching experiences, communication skills, experiences in modeling (ie. vicarious experiences), emotional states, and interest to the subject as sources of self-efficacy to teach SSI. In their regression model to explain self-efficacy to teach SSI, Sönmez and Kılınç (2012) identified content knowledge about the SSI as the variable that explained 8% of the variance. This is an important

finding that supports inclusion of SSI in pre-service teacher training in order to improve both their content knowledge and self-efficacy to teach SSI.

PreSEES Project

There is limited research on teaching SSI with specifically developed materials in the field of teacher education (Evagorou, Güven, & Muğaloğlu, 2014a). Sönmez and Kılınç (2012, p.51) mentioned that:

> We believe that SSI and teaching SSI should be incorporated into the education of preservice teachers. The development in academic knowledge, risk perceptions and attitudes should be taken into account during this education. In order that preservice teachers can improve strong self-efficacy beliefs regarding teaching SSI, the environments where the academic knowledge can be enhanced should be created and the importance should be given to the out-of-school activities such as science camps.

Considering this gap in the literature, a Comenius project called "Preparing Science Educators for Everyday Science" (PreSEES) was developed with the participation of seven countries (Cyprus, Denmark, France, Romania, Spain, Turkey, and UK). The main aim of the project was to engage pre-service teachers with everyday science through SSI and to prepare them to teach SSI (http://www.ssieurope.net). Espaja and Couso Lageron (2015, p.83) summarized the objectives of the project as follows:

1. Understand the main characteristics of SSI: its controversial nature, the existence of uncertainty and the diversity of arguments that are used to back up the different positions.
2. Reflect on teaching SSI: the reasons to incorporate SSI's at Primary School and the specific pedagogy when designing and implementing SSI activities.
3. Design and implement SSI lesson plans with primary school students, and reflect on the process.

The project provided an agenda for addressing teachers' difficulties when teaching SSI. For the development of the agenda, science curricula and teacher training programs of the seven participant countries were examined. It was found that there was an emphasis on scientific literacy and some statements related to teaching SSI in all the school curricula. However, SSI and teaching SSI were not explicitly mentioned in teacher training programs (Evagorou et. al., 2014b). For the teacher training program, a framework that included three aspects related to teacher development were identified as understanding the curriculum, understanding the pedagogy, and being

prepared for the assessment, all within the context of SSI. The framework was also served as a theoretical guideline to develop three SSI modules for in-service and pre-service teachers. Table 1 summarizes the constructed framework by referring to the SSI modules (Güven, Muğaloğlu, Evagorou, 2013)

These modules aimed to train pre-service science teachers to teach SSI. All the modules were designed to encourage learning about the content and then transforming the experience into teaching practices (Evagorou et. al., 2014a). The three SSI modules covered Global Warming, Edible Insects, and various SSI selected by the participants, respectively. With the contribution of all participants of the project, the framework and the modules were finalized and applied to pre-service elementary and secondary science teachers. All the developed educational materials including teacher guides, lesson plans, activities, and worksheets are published online and in print in six languages for dissemination of the materials to in-service and pre-service teachers in various countries (http://www.ssieurope.net).

Table 1. Theoratical framework for SSI module development

	Module 1: Nature of SSI	Module 2 - Teaching SSI	Module 3 - Assessing SSI Learning
Contextualization	Introducing the SSI through the GLOBAL WARMING	Introducing the teaching SSI through EATING INSECTS	Introducing the SSI assessment through current issues
Discursive Activity	Reflection on nature of SSI	Reflection on issues of teaching SSI	Reflection on assessment
Elaboration	Selecting/Connecting and justifying a curricular topic as SSI	Planning and designing materials to teach SSI	Designing materials to assess SSI learning
Further Work	Reading Research on SSI	Pre-service teachers Sharing SSI Designs	Pre-service teachers Sharing SSI Assessment Designs
TRANSFER to TEACHING			

METHOD

Participants of the Study

There were 30 senior students in Undergraduate Science Education Program at a state university took the course in the 2013-2014 Fall Semester. But, 23 of them attended the modules and voluntarily filled out both pre and post-test and participated to the intervention; hence these pre-service teachers constitute the participants of the study. The participants of the study were 23 pre-service science teachers who were enrolled, in Istanbul, Turkey. All the participants took the "Teaching Science II" course, a science pedagogy course on science curriculum, science teaching methods, application and evaluation of microteachings. There were 4 male and 19 female senior students whose age range was 22-27.

Context of the Study

In Turkey, there has been a recent reform in school curricula including elementary and middle school science curriculum. In the reformed curriculum, SSI are explicitly mentioned for the first time. One of the aims of science teaching is stated as 'the development of scientific habits of mind through study of socio-scientific issues' (Ministry of National Education, 2013, p. ii). Although, SSI are included in the science curriculum theoretically, science class practices remain to be seen.

As one of the participant country of PreSEES Consortium, the application of SSI modules took place at a state university in Istanbul. Table 2 summarizes the content of the SSI modules. In the first module, pre-service teachers were introduced with nature of SSI through discussions about Global Warming. After analysis of given evidences, the participants conducted brainstorming sessions about controversies by taking into account the positions of different stakeholders in the global warming issue. Finally, pre-service teachers were expected to reflect on significance of teaching SSI and difficulties they faced during learning SSI. In the second module, pre-service teachers experienced a SSI-focused lesson on Edible Insects issue, reflected on the lesson plan and designed their own lesson plans on a SSI that they chose. The final module was on assessment of SSI and pre-service teachers were expected to include summative and formative assessments into their own SSI lesson plans (Evagorou et. al., 2014a).

Table 2. Content of the SSI modules

Modules	SSI	Focus
Module 1	Global warming	✓ Understanding SSI and its characteristics ✓ Analysis of data and arguments in SSI ✓ Decision making about SSI ✓ Reasons to teach SSI
Module 2	Edible insects	✓ Emphasizing how to prepare lesson plans to teach SSI ✓ Reflecting on exemplary lesson plans on SSI ✓ Designing lesson plans to teach SSI ✓ Risk assessment
Module 3	Selected SSI	✓ Assessment strategies for SSI ✓ Designing assessment tools for SSI lessons

Design

This study has a non-experimental pre-test-post-test design. At the beginning of the term, the modified version of STEBI was conducted for pre-test. Then, SSI modules were applied for the following three weeks. Each module took three hours. After the modules, six groups performed their microteachings on the SSI that they selected in the following three weeks. After six weeks of SSI training, modified STEBI post-test was conducted.

Instrument

The Science Teaching Efficacy Belief Instrument (STEBI) was designed for measuring science teaching self-efficacy and outcome expectancy of pre-service teachers by Enochs and Riggs (1990) based on Bandura's theory of social learning (Bleicher, 2004). STEBI is a well-known, highly reliable, and commonly used test for measuring teaching efficacy at different subject areas such as science (Enoch and Riggs, 1990), chemistry (Rubeck & Enochs, 1991), and mathematics (Enochs, Smith, & Huinker, 2000) and for different target populations like in-service science teachers (STEBI-A by Riggs, 1988) and pre-service science teachers (STEBI-B by Enoch and Riggs, 1990). For modification of STEBI-A to STEBI-B, some little alterations took place like changing tenses of the statements for referring future orientations of pre-service teachers (Bleicher, 2004). Wenner (2001) used two versions of STEBI for assessing self-efficacy of science and mathematics teachers by just changing the words "science" and "mathematics" in his study and he assured that the validity of

the construct "self-efficacy" is still viable for modified versions of STEBI in different subject matter domains.

In this study, STEBI is adapted and modified to SSI-TEBI for the PreSEES Project to measure pre-service teachers' self-efficacy on teaching SSI. For adaptation the words "scientific" in the original instrument were replaced with the words "socio-scientific" to keep in line with the theme of the project. There are 23 items with a 5-point Likert scale ranging from "strongly agree" to "strongly disagree". The reliability coefficient for the modified version of STEBI is calculated as, 70. For ensuring validity of the instrument, two science educators from Turkey and two science educators from Denmark examined the SSI-TEBI. The SSI-TEBI has two subscales: Personal Socio-scientific Issue Teaching Efficiency (PSSITE) and Socio-scientific Issue Teaching Outcome Expectancy (SSITOE). PSSITE dimension refers to the extent that how much teachers (or pre-service teachers) believe they have the potential to positively affect student's achievement. SSITOE dimension refers to teachers' (or pre-service teachers') beliefs on the significance of teacher effectiveness on student learning. Sample items for each dimension of the SSI-TEBI test are presented on Table 3.

Table 3. Sample items for dimensions of SSI-TEBI test

PSSITE item	*I know the steps necessary to teach socio-science concepts effectively.*
SSITOE item	*The inadequacy of a student's socio-science background can be overcome by good teaching.*

RESULTS

Table 4 includes descriptive data related to pre-SSI-TEBI and post-SSI-TEBI tests. In this study, there were less than 30 participants (N= 23). So, Shapiro-Wilk test was more appropriate and applied to test whether the distributions of pre-SSI-TEBI and post-SSI-TEBI were normally distributed.

Table 4. Descriptive Statistics for pre-SSI-TEBI and post-SSI-TEBI scores

	N	Minimum	Maximum	Mean	Std. Deviation
Pre-SSITEBI	23	67	96	75,83	7,06
Post-SSITEBI	23	75	94	82,43	5,16

Table 5 includes normality test result. It is found that post-SSITEBI distribution was normal, whereas the pre-SSI-TEBI distribution was not. Hence, it would be appropriate to conduct a non-parametric test to compare results of these two tests. It was found that there was a significant difference between pre-SSI-TEBI and post-SSI-TEBI results based on the Wilcoxon Signed Rank Test (Z= 3,47; p < ,05, d= *1,06*).

Table 5. Normality test results for pre-SSI-TEBI and post-SSI-TEBI scores

	df	Static	Sig.
Pre-SSITEBI	23	,91	,03
Post-SSITEBI	23	,92	,07

The two dimensions of SSI-TEBI were also analyzed separately. Table 6 shows descriptive statistics and Shapiro-Wilk Normality Test results for the dimensions PSSITEB and SSITOE. It was found that SSITOBE_ pre and SSITOE_post scores were normally distributed (p >,05) whereas PSSITEB_ pre and PSSITEB_post scores were not (p < ,05).

Table 6. Descriptive statistics and normality test results for the dimensions PSSITEB and SSITOE

	N	Minimum	Maximum	Mean	Std. Deviation	Static	Sig.	d
PSSITEB_pre	23	37	52	42,78	4,07	,84	,00	1,33
PSSITEB_post	23	43	58	48,04	3,82	,93	,09	
SSITOE_pre	23	23	40	29,87	4,03	,97	,76	,37
SSITOE_post	23	22	38	31,26	3,58	,93	,14	

Wilcoxon Signed Rank test was applied to compare PSSITEB_pre and PSSITEB_post scores. It was found that there was a significant difference between PSSITEB_pre and PSSITEB_post scores at .05 significance level (Z= 4,11; p < ,05, d = *1,33*). However, no significant difference was found between SSITOE_pre and SSITOE_post scores after applying Paired-Sample t-test (t(22)=1,26; p =,22).

DISCUSSION

The main goal of the PreSEES project was to introduce nature of SSI to pre-service teachers, to develop educational materials to teach SSI and prepare them to teach SSI in their future classes. Sönmez and Kılınç (2012) advocate that pre-service teachers' self-efficacy beliefs are important for inclusion of SSI in their future classes. In this study, self-efficacy beliefs of pre-service teachers were studied before and after six weeks of SSI training. It was found that there was statistically significant difference after application of SSI modules and micro-teachings. In the literature, there are several studies on development of pre-service teachers' self-efficacy and mostly, STEBI-B is used as both pre-test and post-test for measuring self-efficacy before and after an intervention (El-Deghaidy, 2006; Hetcher, 2010; Palmer, 2006; Slater, Slater, Shaner, 2008). In these studies, the interventions took place in science teaching courses throughout one semester. In our study, it was encouraging to observe a positive change in pre-service teachers' self-efficacy on teaching SSI in such a short time.

Analyses of scores on the dimensions of Modified STEBI results gave some important insights about the positive change in their teaching efficacy beliefs. It was found that there was a statistically significant increase in their personal beliefs on their potential to positively affect students' achievement. However, no significant difference was found between their beliefs about teaching outcomes before and after the intervention. Since the pre-service teachers participated in this study have limited or no teaching experiences in real classroom settings, it might have been difficult for them to anticipate and improve positive outcome expectancy. Another possible explanation can be traced from Spain, one of the partner countries in the PreSEES Project. Espeja and Lagaron (2015) also trained primary school teachers' about the nature of SSI and how to teach it. They found that most of the participants did hardly realize the relation between teaching SSI and developing scientific knowledge. In other words, teachers do not expect to develop students' scientific knowledge by teaching SSI. To some extent, their low outcome expectancy related to the beliefs about their effectiveness on student learning by teaching SSI might be related with their understanding about the goals of teaching SSI. At the end of their study, Espeja and Lagaron (2015) also emphasized the challenge of internalizing goals of teaching SSI for teachers.

On the other hand, it might not be possible to compare self-efficacy beliefs and its changes in different cultures. Evans (2014) emphasized that self-efficacy is "highly dependent on cultural surroundings" (p.36). In other

words, even if self-efficacy studies conducted in different cultures are valuable, cultural surroundings is crucial in understanding self-efficacy beliefs and how they change. Regarding preservice teachers' self-efficacy beliefs to teach SSI there is a need to conduct research focused on an in-depth analysis of cultural environment. For instance, how teachers' self-efficacy beliefs in teaching SSI such as global warming or edible insects are affected by the cultural beliefs in the society would be an interesting research topic.

Another further research would be to follow these pre-service teachers after they start teaching professionally. In the literature, there are widely stated impediments to teaching SSI such as classroom management problems, having inadequate background knowledge, and time management problems (Lee et al., 2006; Day & Bryce, 2011; Kara, 2012; Kılınç & Sönmez, 2012). Some of these problems such as time and classroom management mostly appear in real classroom settings. Yet, since the participants of the project were preservice teachers, and they did not have any real classroom experience, it is possible to say that they did not face any real classroom problems. So, it is quite reasonable not to observe any improvement in outcome expectancy. Hetcher (2011) had some similar findings in his study with pre-service teachers. He administered STEBI-B as pre and post-test before and after a science teaching course and found out a significant difference in self-efficacy scores of the pre-service teachers. The difference stemmed from the dimension personal science teaching efficacy, however there was not any significant change in science teaching outcome expectancy scores.

Moreover, in this study, the pre-service teachers were expected to design SSI lesson plans and include learning objectives that link the selected SSI to the curriculum. By doing so, they were able to include SSI in their course load. However, the question whether these pre-service teachers will design SSI-based lessons and implement in their future classes remains to be seen.

CONCLUSION

More complicated, nested, and controversial issues with multiple perspectives emerge, as science and technology advance. Together with the advancements and emergence of new problems, science curricula are shaped. Reforming curricula should be based on empirical evidence and go in line with teacher training programs. The problems arise when the reforms in

curricula do not match with the reforms in teacher training. The last reform in the curriculum includes SSI teaching in science education. So, it is important to train teachers about how to teach SSI and to develop their self-efficacy in teaching SSI. Blonder, Benny, and Jones (2014) argued that existing SSI literature scarce with respect to studies focusing on SSI teaching practices and suggested more studies to be conducted with that focus. In this study an intervention with SSI specific practices was designed and implemented in a preservice science teaching methods course. The results suggest that participants' self-efficacy beliefs about teaching SSI were improved and one of the barriers suggested in the literature, low self-efficacy in teaching SSI (Kara, 2012), was improved with this study. In line with the literature, we conclude that specially designed programs for supporting pre-service science teachers to teach SSI can increase their self-efficacy to include SSI in their classes. However, this study also showed that peer teaching practices were not sufficient to improve outcome expectancy dimension of self-efficacy. For this dimension, it is important to encourage preservice teachers to teach SSI in real classroom settings during their internship practices. Briefly, teacher training programs should integrate SSI teaching in their existing curriculum and provide opportunities for pre-service teacher to teach SSI in authentic classroom environments.

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