LOOK ACADEMIC PUBLISHERS
OPEN ACCESS

INTERNATIONAL JOURNAL OF ENVIRONMENTAL & SCIENCE EDUCATION
2016, VOL. 11, NO.15, 8403-8424

Integrating Sustainable Development Concept into Science Education Program is not enough; We Need Competent Science Teachers for Education for Sustainable Development – Turkish Experience

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ABSTRACT

In order to educate science teachers for a sustainable future, recent discussions are going on related to collaboration between science education and education for sustainable development (ESD). Still, ESD has been in a development stage and needs to be improved in terms of developing teacher competencies. Therefore, in this study we focused on competencies of science teachers and ESD educators. We explored the required competencies for science teachers to become ESD educators through basic qualitative research as including gap analysis approach incorporating theoretical (literature review) and tangible part (interviews with science education and ESD researchers). Both literature review and interview results revealed that science teachers' competencies do not cover systems thinking skills together with affective aspects. In order to foster systems thinking and affective aspects of competencies for science teachers, we suggest outdoor ESD approach that support thinking in a systemic way, feeling inter-connectedness with the natural world and understanding social, economic and environmental values of the natural system and developing an intention to act for sustainability.

KEYWORDS
Competencies for science teachers, competencies for ESD educators, systems thinking, outdoor education

ARTICLE HISTORY
Received 16 February 2016
Revised 09 May 2016
Accepted 11 May 2016

Introduction

Environmental protection and sustainable development attempts began in Turkey under the light of Stockholm Conference (United Nations, 1972) and Brutland Report (United Nations, 1987). Although Turkey seemed to adopt the principles of sustainable development (SD), after 2000s the development plans of Turkey focused on economic growth (Şahin, 2008). The need for integration of Rio

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principles into Turkish education system however, has been emphasized in the recent national reports (Ministry of Environment and Forestry, 2010, 2011; Ministry of Development, 2012). It is reported in Turkey's Sustainable Development (SD) Report (Ministry of Development, 2012) for example that, in order to achieve SD, poverty should be reduced, the quality of education should be improved, and gender equality and millennium development goals should be attained. Besides, it is reported that, from elementary level to teacher education, curriculums for education for sustainable development (ESD) will be developed, promoted and integrated to all education programs. Yet, it is possible recently to observe the attempts for the needs outlined in the above mentioned reports. For instance, science education (SE) curriculum was changed in 2013 and the concept of sustainable development was integrated into the new curriculum. However, we believe that such attempts related to integration of this concept into the curriculum is not enough and require further progress related to determining the current and required competencies for science teachers (ST) to be ESD educators.

Science Education and Education for Sustainable Development

SE aims to grow scientifically literate individuals who have an understanding of science content, can draw conclusions from scientific issues and know how to evaluate scientific cases (Wang & Schmidt, 2001). SE has evolved through 100 years. During the early years of the 20th century, SE was influenced by the education philosophers like John Dewey. Because of the influence of Dewey's educational perspective, it was accepted that SE and education in general were more related to social life (Deboer, 2000), thus the role of SE was set as to teach individuals to be effective in a social world; in other words, the target of SE was to integrate scientific knowledge to real life activities. From 1960s to 1980s, SE became more and more interested in the strategic role of scientific knowledge in society. In 1960s, the focus of science education changed especially in the US and Europe through scientific knowledge and basic sciences. It was suggested that science educators should grow citizens who understand science and have positive attitudes toward scientists (Deboer, 2000; UNESCO, 1973). On the other hand, from the beginning of 1980s, the focus of SE changed through science and technology education to meet the needs of daily life and the society.

The focus of SE continued to change in line with the developments in science and technology and people's concerns (Deboer, 2000). Today, industrial and economic developments digital technologies have been influencing SE. Therefore, the aim of SE is described as to develop scientifically and technologically informed citizens (UNESCO, 2008). As stated by Carter (2008), science has changed in recent decades with economic and technological developments and the effects of globalization.

These rapid changes in science and technology brought changes in human life as well (Choi, Shin, Kim & Krajcik, 2011). Today it is possible to travel long distances by plane at cheaper costs but also this causes declining oil supplies and an increase in the amount of greenhouse gases and contributes to climate change (Levinson, 2010). Therefore, there is a need to educate citizens who are aware of the problems in the world and could make critical decisions for the environment and society (Choi et al., 2011). Further, today's students compared to past have broad worldviews and they are more interested in global problems such as climate change and nuclear power issues (Tytler, 2007). Hence, science could be set as a bridge to understand these issues and take action (Tytler, 2007). In terms of changes in the environment and society in the 21st century the purpose of SE could be redefined by considering the current state of the earth. At the same time, as Carter (2008) stated, the purpose of SE in the 21st century has been set as to help students make critical judgments about science and increase their engagement to work for a more socially just, equitable and sustainable world. More recently, a discussion started to integrate sustainability to science teacher education as it is realized that sustainability problems are complex and need an integrated understanding by considering three aspects of sustainability (social, environmental and economic) (Feldman & Nation, 2015). Therefore, we could interpret that the content and the purpose of SE in the 21st century coincide with those of ESD.

ESD has gained importance in teacher education together with UNESCO (2005)'s declaration that is related to reorienting education to promote public understanding, critical analysis and support for SD. This declaration was supported all around the world and it is concluded that ESD is important and essential to succeed SD (UNESCO, 2006). ESD holds a broad perspective including ecological awareness, environmental literacy, understanding human-nature relationship and interaction between natural and social sciences (Dillion, 2014). ESD emphasizes life-long learning for sustainability in informal, formal and non-formal settings (Wals, 2009). Further, UNESCO (2009) described a rich and holistic perception of ESD that is related to principles for supporting sustainable living, democracy, protection of environment and human well-being, sustainable use of natural resources, emphasizing unsustainable production and consumption and maintaining peace in the societies.

Today discussions are going on how to integrate ESD to SE programs and science teacher education in order to grow responsible citizens for a sustainable future (eg. Feldman & Nation, 2015; Hagevik, Jordan & Wimert, 2015). It is suggested that in the 21st century SE should hold a wider perspective to prepare citizens who could explore components of sustainability (social, environmental and economic) and who could make social, political, environmental decisions for themselves and for the community (Choi et al., 2011; Feldman & Nation, 2015). Indeed, SE could be benefited from holistic structure of ESD. Therefore, we are in a position to appreciate the relationship between SE and ESD and we agree that ESD shall be integrated into SE program so that the cooperation between SE and ESD supports and encourages young people to be globally responsive and environmentally sustainable future citizens.

Teachers' Role

In parallel with the developments in the contexts of SE and ESD, teacher education has subjected several developments. Indeed, teacher education has changed substantially after UNCED (1992). ESD is now part of education as a new vision. There are approximately 70 million teachers in the world and they hold a great potential to shape the future through sustainable development (Mckeown, 2012). UNESCO (2004, 2005, 2006) recommended new models of professional development for ESD that include essential skills, cross-cultural approaches and action based learning models for pre-service and in-service teachers. In particular, in the recent report of UNESCO (2014) it is stated that one of the important challenges for the future is preparation of teachers for ESD. Some countries have already created their own environment and sustainability education standards and determined their teacher education requirements for sustainability. For instance, Washington State OSPI (2008) reported that teachers in all fields need to prepare students as responsible citizens for a sustainable world. Scotland is another country determined professional standards for teachers and they included two key principles: 1. Teachers should be knowledgeable about sustainability and competent to apply ESD (Higgins & Kirk, 2006).

In line with the recent developments in SE and ESD and the calls in the national reports for integrating sustainability to Turkish education system and recent integration of the SD concept to our new SE curriculum, we focused on how to prepare science teachers for ESD and we investigated required competencies of science teachers and ESD educators in this study.

We addressed competency as a broader and complex term in this study. There are various definitions of competency in the literature. For instance, the authors like De Bueger (1996) (as cited in Naumescu, 2008) defined competency as a set of capacities to complete a task or an activity. Naumescu (2008, p.25) criticized that these definitions are limited and the author stated that competency is a more complex term that is defined as "the performance of the tasks, the management of the tasks, the ability to respond to irregularities, the capacity to deal with complexities, taking responsibility, working with others, attitudes to new tasks and new situations". In SE literature, Nezvalova (2007) reported that competencies are related to knowledge, skills and dispositions for science teachers' preparation. In another report prepared by National Science Teacher Association (NSTA, 2003) described that science teachers at all levels should hold competencies related to necessary knowledge, skills, motivating students to engage in topics related to science, technology, nature of science, inquiry and scientific issues. Moreover, in a recent study conducted by (Bybee, 2014) addressed that in addition to basic competencies for STs such as subject matter knowledge, pedagogical practices, personal qualities like personal relations with students or willingness to teach science are also essential competencies for science teachers.

In terms of ESD educators' competencies, United Nations Economic Commission for Europe (UNECE, 2011) described the competencies not only for teachers but also educators in all fields (formal, informal and non-formal). UNECE (2011) included ESD educators' competencies related to three essential characteristics of ESD; *holistic approach, envisioning change and achieving transformation.* In ESD toolkit Mckeown (2002) for example, identified components of ESD as including knowledge, skills, perspectives, values and issues. Based on the holistic structure of ESD, competencies for ESD are undertaken not only in cognitive domains but also in affective domains (e.g., Sleurs, 2008; UNECE, 2011). Sleurs (2008) also identified ESD competencies in a holistic notion as including both cognitive and affective domains. Briefly, based on the SE and ESD literature, competency has been accepted as a complex, multi-structured term as including both cognitive and affective aspects.

Purpose of the Study

Holding the above mentioned developments of ESD and SE in relation with the teachers' role, we proposed that ESD is an undeniable need of the 21st century. However, integrating ESD into science education programs is not enough to proceed; we need competent science teachers for ESD. Accordingly, the purpose of this study is to explore required competencies for STs to become ESD educators. The related research questions of the study are set as follows:

1. What are the required competencies for science teachers to become ESD educators?
2. What are the opinions of Turkish ESD and SE researchers on the competencies of Turkish science teachers for becoming ESD educators?

To start with, we targeted to explore the required competencies of STs to become ESD educators through gap analysis. Subsequently, we intended to explore the current situation in Turkey on the competencies of STs for becoming ESD educators in the words of Turkish ESD and SE researchers. In other words, first we attempted to explore the need for STs to become ESD educators in terms of required competencies. Afterwards we wanted to see if the needs explored in theory are valid for the real life in Turkey where SD has just been included in the national strategies. Because, we thought that, the results of such a study could be useful not only for the countries possess similar situation with Turkey, as far as SD strategies are concerned, but this study could also be useful for others where there are still inconveniences due to ESD implementations.

Research Design

In line with the stated targets of the study, the research questions were answered through basic qualitative research as including gap analysis approach. Gap analysis is used to determine the difference between what we are doing (current knowledge, practice or skills) and what we should do (Janetti, 2012). Therefore, "what we are doing" for our case is defined as "competencies of science teachers" and "what we should do" is defined as "competencies of ESD educators". Gap analysis approach was implemented in this study in two parts: 1. Theoretical (detecting the gap and determining the need) 2. Tangible (interviews with the Turkish ESD and SE researchers). Theoretical part is comprised of two stages as: determining the needs (current competencies for STs and ESD educators) and finding the gaps (between current competencies of STs and required competencies for being an ESD educator). Tangible part is comprised of semi-structured interviews with ESD and SE researchers for the purpose of exploring the current situation of STs' competencies for becoming ESD educators in Turkey. Participants of this stage were five SE and ESD researchers (one male, four females) selected purposively. The features of the participants were, having a bachelor degree in elementary science education, having five years teaching experience (research assistants) in the science teacher education department at one of the big universities of Turkey. Further, they completed their master degree in science education and environmental education. Now, they are doing PhD on environmental education and ESD. We chose these PhD students as our sample because these participants are experienced in both SE and ESD and they are representative sample of people for our study. The participants were asked about their opinions on the competencies that science teachers should hold in the 21st century and the competencies that they should hold to become an ESD educator.

This study is a basic qualitative research design (Merriam, 2009) as incorporating document analysis and interviews. In particular, after document analysis, the aim of the researchers was to simply reveal the opinions, views of the participants therefore, semi-structured interviews were conducted.

Data Analysis

The data were collected qualitatively through document analysis and interviews. For data analysis, each interview transcripts were reviewed to make sense of data and thus researcher identified categories and looked for patterns in the whole data (Merriam, 2009). Content analysis was performed while analyzing documents and interviews. The competencies defined as a result of the literature review constituted the categories in the interviews. Yet, additional categories emerged as a result of the interviews. Accordingly, the first stage of the gap analysis (theoretical part: determining the needs and finding the gaps) was realized through reviewing the relevant literature. On the other hand, for the second stage of gap analysis (tangible part: exploring the current situation of STs' competencies for becoming ESD educators) included content analysis of the interviews (category construction and looking for patterns in the data).

Trustworthiness of the Study

In order to provide trustworthiness of this study, validity and reliability issues were considered. For the validity of the data, documents and interview questions were determined together with an expert in SE and ESD and for providing confidence in the findings data triangulation was used (e.g., Patton, 2002). Competencies of STs and ESD educators were investigated through document analysis and conducting interviews. Interview results were triangulated with the document analysis results.

For providing the reliability of the data, inter coder agreement was analyzed. One scholar who is PhD student studying on SE and research assistant for five years in the science teacher education department examined the interview transcripts and 86% inter coder agreement was established between the researcher and the inter coder.

Results

Theoretical Part: Determining the Need - Competencies for STs and ESD Educators

In order to investigate competencies determined for STs and ESD educators several key national and international associations' reports were examined. One of the associations that define standards for science teacher preparation in USA, for example is National Science Teacher Association (NSTA, 2012) and the other one is National Research Council (NRC, 2012) which developed a new framework for K-12 SE. Further, as a part of the European Socrates Program, Nezvalova (2007) determined required competencies for constructivist science teachers. These three international reports reflected core competencies for science teachers therefore, they included in this study. In Turkey context, Ministry of Education (MoNE) (2008) determined required competencies for Turkish science teachers and MoNE (2008) report was examined for this study.

NSTA (2012) determined standards for science teachers' preparation as including different components such as having science content knowledge, using effective teaching methods to develop students' knowledge (content pedagogy), planning appropriate learning environments for students.

NRC (2012) created a new framework for K-12 science education that focused on science, technology and engineering. This new framework included three major dimensions: 1. Scientific and engineering practices 2. Crosscutting concepts that combine science and engineering 3. Core ideas in four fields; physical science, life sciences, earth and space sciences and engineering, technology and applications of science. The first dimension is related to science practices to investigate and build models, theories and engineering practices to design and build systems. Second dimension which is cross cutting concepts are based on all domains of science. Seven concepts were included; *patterns, cause and effect, scale, portion, property, system and systems model, energy and matter, structure and function, stability and change* (NRC, 2012, p. 84). It is stated that these concepts enable students to make connection among various disciplines. The third dimension, disciplinary core ideas refer to teaching students sufficient core knowledge. For instance, there could be core ideas related to technology and engineering reflecting the connections among science, technology and engineering. This framework also has reflections for science teacher education. In the report, it is stated that teachers should be prepared for achieving this new framework. For instance, teachers should have strong scientific understanding, they should know how to develop students' scientific and engineering practices, cross cutting concepts, core ideas. That is to say, teachers should have specific pedagogical knowledge to support students' learning and assessment approaches to measure students' thinking. Similar to STs' competencies explored in NSTA (2012) and NRC (2012), Nezvalova (2007) described basic competencies that especially constructivist science teachers should demonstrate. These competencies included for instance, understanding content knowledge, teaching nature of science, general skills of teaching and using effective assessment tools.

On the other side, UNECE (2011) determined core competencies for ESD to develop a cross-European framework for educator competencies and to support practice and innovations in education. UNECE (2011)'s report were chosen since UNECE's ESD competency framework is a unique report that was created by an expert group in education including 12 countries and could be used in all fields of education (Ryan & Tilbury, 2013). The group determined competencies as a part of the United Nations Decade of Education for Sustainable Development (Ryan & Tilbury, 2013) and based on the principles of UNESCO (1997). This framework could be a guide to educators about what they should know, what they should do, how they should live and how they could contribute to ESD. The framework was shaped by three important characteristics of ESD: *Holistic approach, Envisioning change and Achieving transformation* (UNECE, 2011, p.8). Table 1 summarizes established competencies for STs and ESD Educators explored in the above-mentioned reports.

Table 1. Summary of the required competencies for STs and for ESD educators based on the literature

Domains of Competencies for STs				Domains of Competencies for ESD educators
NSTA (2012)	NRC (2012)	Nezvalova (2007)	MoNE (2008)	UNECE (2011)
1.Having content knowledge of science	1. Having strong scientific understanding	1. Understanding of science content	1.Planing and organizing of learning and teaching process	*1. Holistic Approach* a. Having integrative thinking/systems thinking and providing an integrative approach b. Inclusivity (embracing different perspectives) c. Dealing with complexities (providing students to engage in various concepts and ideas such as poverty, climate change)
2.Using effective teaching methods (pedagogy)	2. Developing students' scientific and engineering practices, cross cutting concepts such as patterns, cause-effect, systems model, core ideas.	2. Teaching nature of science, history of science	2. Teaching nature of science, history of science, science process skills, developing critical thinking	2. *Envisioning change* a. Learning from the past (critically analyze and understand the root causes of the past developments) b. Inspiring engagement in the present (emphasizing the needs of people in the present and also future generations) c. Exploring alternative futures (addressing approaches to positive futures for human and nature)

Table 1. (Continued).

Domains of Competencies for STs				Domains of Competencies for ESD educators
NSTA (2012)	NRC (2012)	Nezvalova (2007)	MoNE (2008)	UNECE (2011)
3.Planing appropriate learning environments	3. Having specific pedagogical knowledge to support students' learning and assessment approaches to measure students' thinking	3.Using scientific inquiry	3. Monitoring and evaluating development of students	*3.Achieving transformation-people, pedagogy and education systems* a. Transformation of what it means to be an educator (e.g., building positive relationship between educator and learner) b. Transformative approaches to learning and teaching (e.g., creating opportunities for learners to imagine alternative ways of living). c. Transformation education system (e.g., being open to change, having collaborative skills)
4.Maintaining safety procedures in the class		4.Demonstrating general skills of teaching	4. Developing cooperation between school, society and family	
5.Demonstrating the impact of science course on students' learning 6.Developing professional knowledge and skills		5. Planning and implementing an active curriculum 6. Using effective assessment strategies	5. Supporting professional development	

At a first glance to Table 1 that lists the competencies for STs, it is easily seen that the competencies given by NSTA (2012), Nezvalova (2007) and MoNE (2008) hold similar points: Both documents included basic competencies for STs like content knowledge of science, professional knowledge and skills, safety, teaching nature of science, using scientific inquiry and effective assessment techniques as presented in Table 1. A critical evaluation of the competences listed in Table 1, however, showed that all the given competencies for STs are related to the cognitive aspects (knowledge, professional development and teaching skills). Kauertz, Neumann and Haertig (2012) reported a similar critic for the competencies of STs that the competencies are evaluated from a cognitive perspective and affective factors are neglected. However, competencies explored in the new framework of SE prepared by NRC (2012) included different items such as developing scientific and engineering practices, cross cutting concepts and core ideas. The framework addressed several components of systems thinking like patterns, flows, cycles, systems models for developing engineering design projects. What teachers should know, what they should do are emphasized implicitly in the NRC (2012)'s report.

Furthermore, the established competencies for ESD educators displayed in Table 1 reported by UNECE (2011) included three essential characteristics of ESD and these characteristics covered sub-competencies; *holistic approach* (eg. integrative thinking/systems thinking), *envisioning change* (eg. considering past, present and future) and *achieving transformation* (eg. transformation in education system, transformation of pedagogy). Evaluation of the competencies for ESD educators given in Table 1 indicated that one of the basic characteristic that an ESD educator should hold is *the holistic approach* which included competencies related to *integrative thinking, inclusivity and dealing with complexities*. That is to say, an ESD educator is expected to understand the interrelatedness and connectivity in the system, interconnections among social, economic and natural systems, accept different perspectives, promote learners to engage in various concepts and ideas and support learners to participate in active citizenship projects.

The second characteristic that an ESD educator should hold according to the information given in Table 1 is titled as *envisioning the change* including competencies as learning from the past, inspiring engagement in the present and exploring alternative futures. Accordingly, an ESD educator is expected to draw lessons from the past experiences by considering three dimensions of SD and promote learners to create vision and take action for a sustainable future.

The third characteristic of an ESD educator is given as *achieving transformation* including competencies as transformation of what it means to be an educator, transformative approaches to learning and teaching and transformation of the education system. That is, an ESD educator is expected to have certain critical competencies, such as challenging unsustainable practices across the education system, understanding the need for transforming the education system and being open to change and having collaborative skills. The remarkable point related to the above mentioned competencies however, is that they include all learning domains (cognitive, affective and action based); thus implying that, ESD educators are expected to hold all domains of competencies.

Finding the Gap: Current Competencies of STs versus Required Competences for Being an ESD Educator

We have listed the gaps between the current competencies of STs and required competencies for being ESD educators in Table 2. We designed Table 2 in terms of categories of the essential characteristics of ESD determined by UNECE (2011) (*holistic approach, envisioning change and achieving transformation*). We looked for whether these characteristics and relevant ESD competencies are covered in STs' competencies identified in the above-mentioned reports and we presented the gaps in Table 2.

Accordingly, as Table 2 displays competencies for STs determined by NSTA (2012); Nezvalova (2007), MoNE (2008) and competencies for ESD educators (UNECE, 2011) are completely different. However, the new framework prepared for K-12 SE include several items that are relevant to characteristics of ESD and it is implied that future STs should be prepared to teach these items. For instance, ESD educator is able to understand the interrelationship among natural, economic and social systems and systems thinking is seen as a valuable tool for ESD educators. Similarly, NRC (2012) addressed interrelationship among science, engineering and technology, developing students' understanding of complex systems and developing systems thinking in engineering projects.

In general, competencies of STs do not include characteristics of ESD such as emphasizing the relationship among environment, society and economy, considering the relationship among past, present and future, understanding different groups, cultures (building empathic relationship) or being open to transformative learning and teaching approaches. Even though systems thinking is implied in new SE framework (NRC, 2012), the focus is on mostly engineering practices.

Results of the gap analysis as displayed in Table 2 put forward that, systems thinking skills (a component of holistic approach) is one of the competency of ESD educators that is also important for STs yet, it is not emphasized broadly in STs' competencies. By definition, systems thinking is seen as a valuable tool to achieve an integrative approach to understand interdependent nature of relationships, understanding complex systems, seeing the big picture, seeing the multiple cause-effect relationships, considering long term solutions and personal worldviews and sustainable development (e.g., Capra, 1996; Sleurs, 2008; Sterling, 2003; Tilbury & Cooke, 2005). Hogan and Weathers (2003) stated systems thinking as one of the goals of education. In the last few years, systems thinking has been revealed as a critical skill in SE (Assaraf & Orion, 2010; Batzri, Assaraf, Cohen & Orion, 2015), as a component of sustainability literacy (Nolet, 2009) and as a required competency to be an ESD educator (e.g., UNECE, 2011). As a result, it may be inferred from the results of the gaps analysis that, a holistic approach through systems thinking is the major gap between the competencies set for ESD educators and those of STs. That is, systems thinking is an essential skill for both STs and ESD educators to be able to see the bigger picture, think holistically and build inter-connectedness with the planet (e.g., Capra, 2005; Sleurs, 2008).

Table 2. The Gaps between required competencies for STs and for ESD educators explored in the literature

Characteristics of ESD and relevant competencies determined by UNECE (2011)	The inclusion of ESD competencies in the reports (NSTA, 2012; NRC, 2012; Nezvalova, 2007 and MoNE, 2008)	The Gaps
1.*Holistic Approach* a.Integrative thinking/systems thinking b.Inclusivity c.Dealing with complexities	a.NSTA (2012): not included b.Nezvalova (2007):not included c.MoNE (2008): not included d. NRC (2012): included several items: • Interrelationship among science, engineering and technology • Understanding complex systems • Earth consists of interconnected systems • Developing systems thinking in engineering projects	NSTA (2012), Nezvalova (2007) and MoNE (2008) reports don't refer to competencies related to holistic approach. NRC (2012) implied several competencies related to holistic approach
2. *Envisioning change* a.Learning from the past b.Inspiring engagement in the present c. Exploring alternative futures	a.NSTA (2012): not included b.Nezvalova (2007): not included c.MoNE (2008): not included d. NRC (2012): included several items: • Thinking about the future energy supply coming from renewable sources • Considering our choices to reduce our impact on natural sources	NSTA (2012), Nezvalova (2007) and MoNE (2008) reports don't refer to competencies related to envisioning change. NRC (2012) implied several competencies related to envisioning change.
3.Achieving transformation-people, pedagogy and education systems a.Transformation of what it means to be an educator b. Transformative approaches to learning and teaching c. Transformation education system	a.NSTA (2012): not included b.Nezvalova (2007): not included c.MoNE (2008): not included d. NRC (2012): included an item related to personal choices • Considering the impact of everyday choices	NSTA (2012), Nezvalova (2007) and MoNE (2008) reports don't refer to competencies related to achieving transformation. NRC (2012) implied a competency related to achieving transformation.

Tangible Part: Turkish SE and ESD Researchers' Opinions on the Competences of STs

The results of the data analysis are presented below based on the participants' answers given to the three open-ended questions:

1. What is your opinion on the competencies that science teachers should have in the 21st century?
2. What competencies do you think a science teacher should have to become an ESD educator?
3. What is your opinion on Turkish science teachers' position for being an ESD educator in terms of the required competencies?

Responses to Question One- Required Competencies of Science Teachers in the 21st Century

Qualitative data analysis related to the participants' opinions on the competencies of science teachers in the 21st century resulted eight categories. The first five of these eight categories were the ones explored in the literature (e.g., MoNE, 2008; NSTA, 2012):

1. Subject matter knowledge 2. Pedagogical knowledge 3. Technology knowledge (MoNE, 2008; Nezvalova, 2000; NRC, 2012; NSTA, 2012) 4. Nature of science (NSTA, 2012; Nezvalova, 2007) 5. Problem solving skills (Nezvalova, 2007). Yet, new categories were emerged during the interviews such as; 6. Affective components 7. Planning environmental education and 8.Holistic perspective (Table 3).

Table 3. The Categories related to competencies, STs should have in the 21st Century

Category	Frequency
Subject Matter Knowledge	4 (P1, P3, P4, P5)
Pedagogical Knowledge	3 (P1, P3, P4, P5)
Technology Knowledge	4 (P1, P2, P3, P4)
Nature of Science	3 (P1, P2, P5)
Holistic Perspective	5 (P1, P2, P3, P4,P5)
Problem Solving	2 (P1, P2)
Affective Components	2 (P2, P3)
Planning Environmental Education	1 (P5)

According to Table 3, the first category resulted as *Subject Matter Knowledge* and the second category resulted as *Pedagogical Knowledge*. Four participants emphasized science teachers should have subject matter knowledge and pedagogical knowledge as presented in the below statement of P3:

> P3: Firstly, science teachers should have enough subject matter knowledge. Pedagogical knowledge is one of the important competencies,

as well. Teachers should know how to teach subject according to grade level and they should know which methods they should use.

The third category resulted as *Technology Knowledge*. Four participants stated that technology knowledge is an important competency that STs should hold in the 21st century as displayed in the below statement of P2:

P2: Science teacher should have knowledge about how to use technological tools in the classroom.

The fourth category resulted as *Nature of Science* that was addressed by three participants in the interviews as presented in the below statement of P5.

P5: In addition to subject matter knowledge science teachers should have an idea about history of science. Chemistry, physics and biology are not separated subjects and science teacher should be aware of history of science and philosophy of science.

The fifth category resulted as *Holistic Perspective* that was revealed in the answers of all the participants. Participants emphasized while teaching science students should be promoted to see the whole picture in a system as presented in the below statement of P1:

P1: Science teacher should teach science subjects in a holistic way instead of separating them into parts in order to see the whole picture of the systems.

The sixth category resulted as *Problem Solving*. Only two participants mentioned that science teachers should present real life problems to students as given in the below statement of P1:

P1: Science teacher should teach students how to solve real life problems and they should help students understand problems' scientific background and their impact to environment and human.

The seventh category is *Affective Components* described by two participants. For instance,

P-3 mentioned that STs should grow students as a responsible citizen as presented in the below statement of P3:

P3: Science teacher should also teach students how to be a responsible citizen through the values like sharing, honesty, justice and sincerity.

The last category resulted as *Planning Environmental Education* that was stated by one participant as presented in the below statement of P5:

P5: In the 21st century environmental problems started to increase therefore, science teachers should have an understanding, view about environmental education and they should know how to increase students' environmental literacy.

In sum, in addition to basic competencies of STs like science content knowledge, pedagogical knowledge, nature of science, participants also addressed several competencies related to ESD which are affective aspects such as being a responsible citizen, holistic perspective and environmental education. According to the frequencies presented in Table 3, the most frequently stated competency by the participants was having a holistic perspective. Yet, affective domains and problems solving skills were mentioned by only two participants. We could infer that some participants do not think or integrate ESD as a part of SE. They may consider holistic thinking in the context of SE like making relationship among physics, chemistry, biology and technology.

Responses to Question Two- Competencies that a Science Teacher should hold to become an ESD Educator

Categories for the second question of the tangible part were decided prior to the data analysis in line with those suggested by UNECE (2011); eight categories including cognitive and affective aspects (Table 4). As presented in Table 4, the categories included; 1. Subject matter knowledge for ESD, 2. Pedagogical knowledge for ESD 3.Cooperation and networking 4. Problem solving 5. Critical thinking 6. Holistic perspective 7. Affective components and 5. Environmental awareness. Among the above mentioned eight categories, the most frequently stated one for STs to become ESD educators was holistic perspective (Table 4). Yet, affective skills, environmental awareness, critical thinking have been mentioned by only one or two participants.

Table 4. The Categories related to competencies, STs should have to become ESD educators

Category	Frequency
Subject Matter Knowledge for ESD	3 (P1, P4, P5)
Pedagogical Knowledge for ESD	3 (P1, P2, P5)
Cooperation and Networking	3 (P3, P4, P5)
Problem Solving	1 (P1)
Critical Thinking	1 (P2)
Holistic Perspective	5 (P1, P2, P3, P4, P5)
Affective Components (e.g., values, attitudes)	2 (P2, P4)
Environmental Awareness	2 (P3, P5)

According to Table 4 the first category resulted as *Subject Matter Knowledge for ESD* and the second category resulted as *Pedagogical Knowledge* for ESD were expressed by three participants as presented in the below statement of P1:

> P1: In addition to subject matter knowledge (physics, chemistry and biology), a science teacher should also know about economy, society and culture. As well, in order to teach about sustainability, a science teacher should know the community culture, should provide appropriate learning conditions.

The third category resulted as *Cooperation and Networking* stated by three participants. Participants emphasized that STs should promote students to develop cooperation with the society as presented in the below statement of P5:

> P5: For example, there is a plastic bag problem because people are using too many plastic bags. Students should understand social, economic, environmental, cultural aspects of the problem and be leaders for a change in the society. Therefore, teachers are needed to encourage students to develop cooperation between themselves, their school and the community.

The fourth and the fifth category resulted as *Problem Solving Skills* described by one participant and *Critical Thinking Skills* stated by another participant. P1 stated that STs should have problem solving skills to be an ESD educator and P2 mentioned that critical thinking skills are important to become an ESD educator. The statements of the participants are presented in below:

> P1: Science teacher should have problem solving skills. They should be aware of real life problems that students might experience in daily life.

> P2: Science teacher should explain real life problems and capable to discuss possible solutions. I mean that an ESD educator should have critical thinking skills.

The sixth category resulted as *Holistic Perspective* mentioned by all of the participants. Holistic perspective in ESD context was interpreted by the participants as incorporating social, economic and environmental aspects of sustainability as displayed in the below statement of P2:

> P2: Having a holistic perspective is the best approach for ESD. Interrelationships among economic, social and environmental aspects should be emphasized and these aspects should be considered holistically.

The seventh category resulted as *Affective Components* (values, attitudes etc.) stated by two participants as displayed in the below statement of P4:

> P4: If a science teacher will become an ESD educator, first he/she should want this from the heart. This is very important because ESD needs too much time, love and willingness. ST should be enthusiastic to teach ESD and he/ she should not see ESD as an extra load.

The eight category resulted as *Environmental Awareness* described by two participants as presented in the below statement of P4:

> P4: First, science teacher should have environmental awareness. Science teachers should be aware of the environment and should make sacrifice for the environment.

Responses to Question Three- Turkish Science Teachers' Position as ESD Educators

All five scholars answered the question related to the Turkish STs' position for being ESD educators as Turkish STs do not hold the required competencies:

> P4: I don't think that STs in Turkey hold the competencies of an ESD educator. According to my observations, STs don't know what SD is and they could not define the concept of ESD. Although there are several attempts in Turkey for achieving ESD, such as integrating SD into elementary science education program and supporting higher education institutions for ESD research and that NGOs for training activities, there are no attempts for developing STs' competencies toward ESD. Therefore, I do not think STs are compatible as ESD educators in Turkey

> P5: I don't think so, because science teacher education programs do not include ESD. There are several courses but, they are not sufficient. Lecturers are not competent as ESD educators. Thus, neither students nor lecturers possess adequate knowledge on SD and ESD.

As far as the opinions of the scholars participated this study are concerned, competencies of ESD educators that science teachers should hold are, subject matter knowledge, pedagogical knowledge, cooperation and networking, problem solving, critical thinking, holistic perspective, affective aspects (values, attitudes etc.) and environmental awareness (Table 4). Moreover, in line with the related literature (e.g., Assaraf & Orion, 2005, 2010; Sleurs, 2008; UNECE, 2011), all the scholars emphasize the importance of holistic perspective in SE as well as in ESD context. Besides, according to the scholars of this study science teachers should interpret the science subjects by considering the three pillars of sustainability (social, economic and environmental) and the relationships among them thus, encouraging students think about the components, as presented in the below quotations:

> P3: Science teachers should not only know physics, chemistry, biology but also environment and technology issues and they should be capable of making conncetions among them.

> P2: Having a holistic perspective is the best approach for ESD. Interrelationships among economic, social and environmental aspects should be emphasized and these aspects should be considered holistically.

Ultimately, the results of the data analysis of the interviews with Turkish SE and ESD scholars (tangible part) support the results of the theoretical part that, the major competence STs required to hold in the 21st century is holistic perspective. Although the participants were not mentioned explicitly, we interpret the overall outcome of the interviews as; the major requirement for a ST to become an ESD educator is to have and transmit systems thinking skills. Further, in line with the results we found that affective aspects are neglected area in SE. As well, in the interviews a few participants (SE and ESD researchers) took attention to affective aspects of the competencies. Therefore, both affective (eg. empathy, wonder, sense of relationship) and cognitive domains could be incorporated. Littledyke (2008) argues that it is necessary to integrate cognitive and affective domains in SE to increase students' engagement in environmental issues and sustainability. Thus, science concepts that are related to SD issues could be more linked to real life phenomena.

Discussion and Conclusion

According to our findings we can draw a profile of a science teacher competent to be an ESD educator with the following example: When discussing water cycle in class, the science teacher with systems thinking skills is expected to transmit the relations that water quality and quantity in our taps are related to the amount of green house gases emitted to the atmosphere through our activities (such as mass production of meat and transportation) and also related to the sea level rise, floods, heat waves and climate refugees in Pacific Islands. For instance, in a recent study Hestness, McGinnis and Breslyn (2015) integrated sustainability into a science methods course through a focus on climate change and the authors enabled pre-service science teachers to discuss global and local impacts of climate change on human health, economy, tourism and ecosystems. Thus, pre-service science teachers developed a broader and more complex understanding of sustainability. On the other side, Shepardson, Roychoudhury,Hirsch and Niyogi (2014) noted, in order to understand climate change and its impact on our planet and people's lives, students should be familiar with climate as a system. Instead of a linear understanding of climate change, the authors drew attention to systems thinking or systemic understanding of the climate.

We imply that ESD could help students make connections among the issues like water cycle, climate change, the impact on the planet and people's live style, energy use, world's climate system and requiring educators capable of evaluating the issues in this trend; thus holding systems thinking skills. In consequence, we could redefine science teachers with systems thinking skills as ESD educators.

Sealing the Gap

The gap between STs' and ESD educators' competencies was explained through systems thinking together with affective aspects. Thus, sealing the gap requires equipping STs as well as SE with systems thinking skills. This new SE framework developed by NRC (2012) emphasized new concepts related to science, technology, engineering and mathematics (STEM) and relevant to systems thinking like patterns, flow and cycles. Fortunately, systems thinking that holds importance in SE to understand complex systems (Assaraf & Orion, 2010) has been unearthed in the new framework of SE. However, there are still limitations in this framework as Zeidler (2016) described STEM should be interpreted in a broader sense as including sociocultural and political context. The author criticized that STEM addressed by NRC (2012) is lack of several social sciences like sociology, psychology, history, fine arts etc. and he suggests there is a need to re-conceptualize STEM education as including socio-scientific issues to grow responsible, informed citizens in the world. In the same way, Feinstetin and Kirchgasler (2014) emphasized that the SE framework (NRC, 2012) supports more technology centered activities that promote students to consider developing new technologies is the best single solution to deal with sustainability issues. Likewise, Zeidler (2016), the authors suggest that socio-political perspective could be integrated to the SE framework thus, sustainability could be interpreted in a holistic perspective.

In the 21st century people should have understanding of big ideas, holistic perspective, systems thinking skills and they should be aware of their responsibilities while making choices and decisions for sustainability (Carter, 2008; Choi et al., 2011). We do agree with these authors' claims and suggestions and we believe that competencies of STs could be reconsidered in terms of competencies of ESD educators. Indeed, our suggestion is to educate competent science teachers for ESD and this could be possible while developing systems thinking skills of STs.

We are aware that setting the collaboration between ESD and SE needs much more effort but, we believe that this is worth pursuing especially in the countries like Turkey that has many social, political, environmental problems and needs sustainability perspective. Moreover, there are increasing efforts for developing relationship between SE and ESD. For instance, a new book namely "Educating Science Teachers for Sustainability (2015)" has been published recently. This new book included many empirical examples that focus on educating science teachers for building a sustainable future. For instance, Foley, Archambault and Warren (2015) designed a sustainability science course for pre-service science teachers. They built upon the course on the new SE framework (NRC, 2012) and they broadened the perspective of the course in order to develop pre-service science teachers' sustainability literacy. For this aim, they developed a sustainability education framework that included four sustainability competencies; futures thinking, values thinking, systems thinking and strategic thinking. The authors addressed that pre-service science teachers were able to understand the complex, multifaceted nature of sustainability after the course. This study provided an example about designing a science education course by integrating competencies related to sustainability.

Feldmand and Notion (2015) stated that informal settings could be effective to engage in sustainability issues. In the following part, we suggest outdoor based ESD as an approach to seal the gap and to develop systems thinking skills.

The Cure: Outdoor Based ESD Approach

Based on the literature and our results, we concluded that systems thinking skill together with affective domains are critical to grow ESD competent science teachers. Systems thinking is an important skill in order to understand the interrelationships in the earth system (Assaraf & Orion, 2010). Multidisciplinary learning environments including both indoor and outdoor activities could be useful to develop systems thinking skills of the students (e.g., Assaraf & Orion, 2005; Keynan, Assaraf & Goldman, 2014).

We propose outdoor education as a cure to develop systems thinking skills of STs so as to become ESD educators. The reason why we take attention to outdoor education is that outdoor learning context could be an effective tool to develop teachers' sustainability literacy that involves knowledge, skills and values related to sustainability (Lugg, 2007). Furthermore, as Orr (2004) emphasized, interaction with the environment is essential to better understand its ecological, social and aesthetic values and develop our connection with it.

In the literature outdoor education has been used in different meanings and for different purposes. For example, in some countries, outdoor education is defined as challenging adventure activities. Outdoor education is also used for gaining skills in adventurous activities such as learning rock climbing. Another purpose for using outdoor education is environmental education (Beames, Higgins & Nicol, 2012). Outdoor education provides many opportunities for environmental education and ESD. Therefore, in this study we use outdoor education as a key approach in educating students about our planet and for sustainable development (Beames, et al., 2012). Further, according to Higgins (2009), outdoor education provides opportunities to integrate all elements of ESD in a meaningful way and it allows direct experiences within the natural environment and fosters a sense of place (e.g., Higgins, 1996). Developing one's relationship with the environment is assumed as a precondition for a better understanding of sustainability (Higgins & Kirk, 2006). Moreover, researchers claim that in the 21st century it is important to incorporate sustainability, socio-ecological and place based approaches to outdoor education (e.g., Higgins, 2009; Lugg, 2007; O'Connel, Potter, Curthoys, Dyment & Cuthbertson, 2005; Watchow & Brown, 2011). Additionally, as Beames et al. (2012) reported, young people can develop a strong affective relationship with nature and they can understand local, inter-national and inter-generational consequences of their actions through outdoor education. Likewise, in a recent study on outdoor education for sustainability, Johnson (2012) developed a curriculum framework of school gardening to examine students' ecological and place based knowledge, competence to take action, skills for environmental engagement and their value system. He suggested that actions taken in the garden develop students' not only gardening skills but also their higher order thinking skills such as designing experiments, exploring natural cycles and discussing beliefs and values of others. Moreover, Keynan et al. (2014)

investigated the influence of a place based outdoor learning on high school students' systems thinking skills in ecology context. Based on the results the authors claimed that place based outdoor course improved students' systems thinking skills to high levels. The authors claimed that field trips were useful to develop a more complex systemic understanding of the local environments. In a recent study Ormond, McClaren, Zandvliet, Robertson, Leddy, Mayer and Metcalfe (2015) investigated pre-service science teachers' experiences in a module designed for reorientation of teacher education in order to address sustainability. The module included place based outdoor education approaches. This sustainability integrated course provided new set of competencies to pre-service science teachers like systems thinking skill, problem solving skills, critical thinking skills and collaboration.

As a consequence, hopefully there are attempts both in Turkey and in the world to integrate sustainability concept to SE programs (e.g., MoNE, 2013; NRC, 2012). We find these efforts are very important for the future. Yet, we believe that we need to educate future science teachers to equip with ESD competencies especially systems thinking skills. We understand that systems thinking is very important in the present times. As Capra and Luigi (2014) emphasized, current problems of the world are systemic problems and they need systemic solutions therefore, today we need a shift in our perceptions, our values and our worldviews for sustainability. As Einstein said; '*no problem can be solved from the same consciousness that created it*', therefore, we have to learn to see the world in a new window. We need to grow responsible citizens who could deal with the current problems of the world. In order to develop ESD competencies of STs, an outdoor ESD approach may be a cure for both pre-service and in-service science teacher education programs. We could learn from the nature and develop our systems thinking skills and systemic view of life. Capra (2005, p. 29) express this in a very good way:

> Nature demonstrates that sustainable systems are possible. The best of modern science is teaching us to recognize the processes by which these systems maintain themselves. It is up us to apply these principles and to create systems of education through coming generations can learn the principles and learn to design societies that honor and complement them.

Contribution of This Paper to the Literature

This paper will have several contributions to the literature:

1. This study will make a contribution to the area for investigating competencies of STs, especially in Turkey and create a discussion environment in order to reconsider STs' competencies to meet the needs of the 21st century.
2. This study explores the gaps between competencies of STs and ESD educators based on the national and international reports and reveal systems thinking that is critically important for STs to become ESD educators. Thus, the researchers of this study suggest a new research area (systems thinking) for SE and ESD in Turkey.
3. Another key component of this study is outdoor education. We believe that outdoor education is a neglected area in Turkey compared to Western

countries. In order to develop systems thinking skills of teachers and students, we suggest outdoor based ESD approach to investigate.

Disclosure statement

No potential conflict of interest was reported by the authors.

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