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Impact of STS Issue Oriented Instruction on Pre-Service Elementary Teachers' Views and Perceptions of Science, Technology, and Society

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The purpose of the study was to investigate the impact of Science, Technology, Society (STS) issue oriented science methods course on pre-service teachers' views and perceptions toward STS issues and instruction as well as their levels of environmental literacy. The STS issue oriented curriculum was designed to help pre-service teachers improve their knowledge, perceptions, and attitudes toward STS issues. A mixed methodology design was utilized in this study with a sample of 93 elementary pre-service teachers. The quantitative segment of the study employed a quasi-experimental pretest-posttest design incorporating a treatment and a comparison group. The qualitative component included both the observation data and interview data collected shortly after the completion of the pre and post-surveys. The quantitative and qualitative data sets were used in conjunction to present a comparative case study where the outcomes for the two groups (comparison and treatment) were compared. The sample consisted of four sections of an elementary science methods class, two of which received the experimental treatment while the other two sections received the comparison treatment for 16 weeks. A pretest on variables of environmental literacy, STS views, and STS teaching views was administered to all subjects prior to the treatments to establish the equivalency of the two groups. A posttest was also administered to all subjects at the end of the semester. The experimental group outperformed the comparison group on all the aforementioned variables and a statistical significant difference was attained at the .05 level with respect to each variable. Furthermore, the results of pre and post interview data collected on environmental literacy, STS views, and STS teaching views further corroborated the quantitative data. The findings suggest that the STS issue focused program positively influenced pre-service teachers' level of environmental literacy as well as their perceptions and attitudes toward STS issues and instruction of such issues to elementary students. The findings of this study revealed that pre-service teachers gain considerably from an STS framework for teaching and learning.

Keywords: environmental education, environmental literacy, elementary preservice teachers, teachers' belief, STS education

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INTRODUCTION

Reforms in science education have continually emphasized the goal of achieving scientific literacy for all students (Bybee, 1997; 2010). Key reform documents (AAAS, 1989, 1993; NRC, 1996, NSTA, 2010), including the most recently released *Next Generation Science Standards* (NGSS Lead States, 2013), indicate the urgent need for scientific literacy in various arenas in society, including the workforce. With human society becoming increasingly shaped by and dependent upon science and technology, a global awareness of the impact of science and technology upon our living environment is becoming more and more critical. However, as Cheek (1992) suggested, "many citizens are ill prepared to exercise their citizenship rights when faced with complex social issues involving science and technology."

As future citizens, students will have the enormous responsibility of making decisions that will impact themselves as well as society. Many of these decisions will require an understanding of the interaction of science and technology and its interface with society. Teaching science in its social context and helping students both understand and think through the implications of the social nature and culture of science and technology is essential to achieving scientific literacy (NRC, 2013; NSTA, 2010). The Science, Technology, and Society (STS) effort is one of the reform movements in the past few decades strongly identified with meeting the challenge of preparing a scientifically literate public (Bybee, 1993; Roth, 1992; van Eijck & Roth, 2013).

STS curricula focus on issues originating from the interactions between science, technology, and society where people or groups of people may not agree on one aspect or another of such issues as a result of differing value systems. Many such STS issues besiege all of human society today. Some of the more common STS issues that the average citizen will be confronted with include overflowing landfills, over-consumption, global warming, energy shortages, nuclear and toxic waste disposal, genetic engineering, use of growth hormones in beef and poultry, and stem cell research.

The STS curriculum enables students to understand the interdependence of science, technology, and society and become empowered to make informed and responsible decisions; and to act upon those decisions (Pedretti, 1996; van Eijck & Roth, 2013; Yager, Choi, Yager, & Akcay, 2009). This is an aspect of social responsibility. Many researchers have maintained that empowerment of students and exploration of personal relevance and meaning in content and ideas in science are major contributing factors in the development of more positive attitudes toward learning and teaching science (Bradford, Rubba, & Harkeness, 1995; Maypole & Davies, 2001). Studies regarding the benefits of STS instruction on student learning have revealed improvements in students' achievement, decision making, attitudes toward science, creativity, questioning abilities, and process skills such as hypothesizing, investigating, and evaluating (Maypole & Davies, 2001; Yager & Akcay, 2008; Yager et al. 2006; Yager et al. 2009).

Various science education organizations and governmental agencies have proposed recommendations embracing the Science-Technology-Society (STS) perspective as an important path in promoting and achieving scientific and technological literacy. (NRC, 2013; NSTA, 2010). Yet, regrettably, the STS effort has not been as widely accepted and implemented in classrooms as many science educators had anticipated (King & Milson, 2002). Teachers may not be adopting an STS curriculum for several key reasons (Mitchner & Anderson, 1989; Mansour, 2007). First, they may not feel comfortable with an STS-based curriculum because they were not adequately trained to address STS issues (Amirshokoohi, 2009). Second, STS-based instruction challenges teachers' beliefs about science teaching by raising vexing questions about the purpose of science education (Massenzio, 2001). Finally, in the case of elementary teachers, their negative attitude toward science may also be an important contributor to this trend. (Amirshokoohi, 2009; Stahl & Stahl, 1995) As a result, there may be resistance and reluctance by teachers to implement such curricula in their classrooms (Battencourt, Velho, & Almeida, 2011; Makki, 2008; Sweeney, 2001).

According to Dewey (1938), teacher education is a process that involves the transformation and expansion of beliefs based on prior experiences, especially K-12 school experiences. Before an STS curriculum can be developed and put into practice, science teachers' beliefs must be compatible with the goals of the STS curriculum (Brunkhorst & Andrews, 1996; McComas, 2002). Pre-service and in-service teachers must have an opportunity to examine their beliefs about the goals of STS education and its place in the school science curriculum and to confront inconsistencies in their beliefs. Hence, the role of teacher education is of paramount importance to the success of STS reforms (Kumar & Altschuld, 2000; Brunkhorst & Andrews, 1996; McComas, 2002).

Regrettably, very little research has been performed concerning pre-service elementary teachers' perceptions regarding STS instruction or the impact of STS-based teacher education courses on their beliefs (Amirshokkohi, 2009; Jamuluddin, 1990; Scharmann, et al., 1997). Most studies dealing with STS and teacher education have focused on in-service science teachers and secondary science pre-service teachers (Dass, 2005; Henning & King, 2005; Milson & King, 2001; Nashon, Nielson, & Petrina, 2008). Additionally, those few studies (e.g. Jamuluddin, 1990; Ngwidibah, 1997), focusing on the impact of STS instruction on elementary pre-service teachers, employed a mainly quantitative post-test only approach. A complete pre-test post-test design would indicate pre-service teachers' initial beliefs and attitude as well as the presence or absence of a change in their beliefs as the result of the intervention. Concurrent analysis of qualitative data would further clarify and elaborate on the quantitative data.

The current study aimed to address the deficiencies highlighted above by employing a mixed-method design (Creswell, 2003) to investigate the impact of STS-issue oriented instruction in a science methods course on pre-service elementary teachers' level of environmental literacy and views toward STS issues and the teaching of such issues to their prospective students.

A conceptual framework for STS education

Even though the STS advocates strongly encourage and promote scientific and technological literacy (Aikenhead, 1990; De Vore, 1992; Fleming, 1990; Roberts, 1982; Waks, 1986; Yager, 1990), they do not agree on a definition for this concept. There is, however, overwhelming agreement that scientific and technological literacy, as an educational goal, must be for all students (De Vore, 1992; =; Hurd, 1990;; NRC, 2013). The concepts of scientific and technological literacy can be examined from personal literacy and social/civic literacy perspectives which will be described below.

Scientific and technological literacy: Personal literacy

One aim of science education is to engage students in lifelong learning and prepare them to lead satisfying and responsible lives. Personal and intellectual growth stimulate the development of values, attitudes, and skills (i.e. habits of mind) that "all relate directly to a person's outlook on knowledge and learning and ways of thinking and acting" (AAAS, 1989, p. 133) as well as character necessary to becoming compassionate human beings. STS and other curricula aimed at achieving scientific and technological literacy should meet the "emotional and spiritual needs of all students" (Hodson & Reid, 1988) and promote lifetime learning and the development of habits of mind that are necessary for leading fulfilling and responsible lives.

Science education curricula must be relevant to students' lives and the world around them. Students should be familiar with and find relevance in the issues included in the curricula at the personal, local, or community level. Therefore, the everyday experiences of students should be drawn upon in the development and implementation of science curricula. This is one of the main features of the STS curriculum, which is based on the constructivist model of learning. Students construct their own meanings based on their prior ideas, beliefs and experiences in science (Driver, 1989; Nussbaum & Novak, 1976; Osborne & Wittrock, 1985) and their personal interpretation of information is seriously considered in the STS curriculum. STS integrates students' prior conceptions and experiences and promotes the active engagement of students in their own learning. Language, culture, social interactions, and context are among the numerous factors that influence students' construction of ideas about science, technology, and society. Students' understanding of STS related issues depends heavily on their beliefs and interpretation of knowledge (Pedretti, 1999). STS education, in considering students' personal construction of knowledge, highlights the importance of student exploration, investigation, and critical reflection.

Scientific and technological literacy: Social-civic literacy

Social-civic literacy, a key component of STS curriculum, is viewed by many (e.g. Prakash & Waks, 1985; Hurd, 1990), as an educational goal to be recognized and adopted nationally. Social/civic literacy encompasses numerous issues and perspectives including citizenry, decision-making, critical social literacy, action oriented literacy, moral and ethical education, and sustainability.

Citizenry

One of the key components of STS education and social/civic literacy is the promotion of a citizenry that is informed about STS related issues, understands the role of science and technology in their lives, recognizes the potential benefits and harms of science and technology, and acts responsibly toward these issues (Bybee, 1985; Layton, et al., 1986).

Decision-making

An enlightened citizenry is necessarily engaging in responsible decision making regarding STS issues. Scientific and technology literacy should allow individuals to recognize the important role of knowledge and values in the decision making process. Several educators including Aikenhead (1990) and Fleming (1989) call for curriculum emphasis on STS education aimed at understanding and participating in the public decision making process. This type of curriculum explores the decision making process, political influences that are involved in the process, and the role and politics of science. It encourages student understanding of the role of local, state, and national government levels and private and industrial sectors in public decision making process. Rubba states (1991, p. 303):

Our best hope for the resolution of STS related issues are citizens literate in science and technology, and empowered to make informed decisions and take responsible action.

Critical social literacy

According to Aikenhead, (1992), critical thinking and "intellectual independence" are necessary in making personal and public decisions related to STS issues. Critical thinking allows one to intellectually and ethically examine the pros and cons, benefits and costs, and possible external driving forces of scientific and technological developments. Critical thinking goes beyond understanding scientific principles and the impact of science and technology on society. Critical social literacy enables individuals to be prudent in making decisions and acting upon them. It allows individuals to develop the potential and the character necessary to act upon social issues related to science and technology in an effort to generate change and improvement.

Action oriented literacy

Social/civic literacy moves beyond simple understanding of scientific and technological issues. Informed citizens are able to take action and confront such issues that arise in their private and public lives. Action oriented literacy allows for the empowerment of the citizenry and hence personal and social action. Individuals are encouraged and empowered to act responsibly in dealing with scientific and technological problems and recognize their responsibilities in the societal, political, and economic arenas locally, nationally, and globally (Waks, 1986).

Moral and ethical education

Traditionally, science has been presented as value-free and objective. Scientists are often depicted as individuals that carry out their work "independent of personal, social, and cultural values" and produce knowledge that is therefore "uncontaminated by contextual preferences external to science" (Layton et al., 1986, p. 159). However, in reality, science is not a neutral endeavor unaffected by personal, cultural, and social values. It is indeed quite intertwined with economy, ethics, politics, culture, society, and ideology.

STS education integrates sciences and value education (Lewis & Gagel, 1992, p. 135). An informed, responsible citizenry that understands the positive benefits and power of science and technology must also be aware of the moral and ethical dimensions of science and technology. Responding to the complex social and moral issues in our society in an intellectual and informed manner requires students to be educated scientifically and morally (Pedretti, 1999).

The moral and ethical component of STS education has been further promoted by a Socio-Scientific Issues (SSI) effort initiated by Zeidler et al., (2005). "Values and ethics maintain a rightful position in both the discussion of SSI and in the broader domain of science, and therefore, should not be excluded from science classrooms" (Sadler, Amirshokoohi, Kazempour, & Allspaw, 2005, p. 3). The SSI framework advocates empowering students and explicitly addresses how science related issues are, to some extent, intricately linked to moral and ethical issues which are embodied into the students' lives and the society (Zeidler et al., 2005).

Sustainability

In the past couple of decades, social/civic literacy has come to embody a new type of literacy which promotes the design of a sustainable community suitable for the lasting well-being of all living things (De Vore, 1987). This theme questions and calls for a shift in the western education system which has a mechanistic and compartmentalized view of the world. Science education must promote the development of a citizenry that respects nature by viewing the "intrinsic worth of all life" rather than "viewing life in instrumental ways" (De Vore, 1987; AAAS, 1989), makes informed decisions on issues of science and technology that affect the environment and community at large, and works toward creating a sustainable environment.

This viewpoint is reflected in the environmental education (EE) reform documents and international reports issued by United Nations Educational, Scientific and Cultural organization (UNESCO, 1984) and International Council for Science (ICSU, 1987) calling for programs focused on sustainability, stability, and justice. A number of important issues that are highlighted in these reports include health, the environment, food and agriculture, energy, land use, and natural resources. Environmental education, aims "to demonstrate how a concern for environmental improvement can be articulated through a science and technology education which promotes sustainable development" (ICSU, 1987, P.9) and moves beyond awareness and towards meaningful responsible action. Hence, the goal of environmental education is environmental literacy, which Roth (1992) defines as "... essentially the degree of our capacity to perceive and interpret the relative health of environmental systems and to take appropriate action to maintain, restore, or improve the health of those systems" (p. 14). Although not all STS issues are environmental issues, many, if not all, environmental issues, such as pollution, waste, consumption and population control may be categorized as STS issues which have environmental ramifications (Bodzin et al., 2010) Research in the field indicates that there exist EE programs that promote aspects of environmental literacy. Since environmental issues lend themselves to STS topics, it is possible to assume that a properly implemented STS curriculum may likewise encourage and promote environmental literacy. The following sections will examine the literature on STS and EE and the impact of STS/E instructions on teacher beliefs.

REVIEW OF THE LITERATURE

Impact of STS & EE instruction on K-12 students

The impact of STS and EE instruction on K-12 students' achievement, attitudes, and beliefs, has been the focus of numerous studies in the past few decades. Pedersen (1990) compared the attitudes toward science, anxiety toward science, anxiety toward science, problem-solving perceptions, and achievement of students exposed to STS to those exposed to traditional methods of instruction. Significant differences were found in all variables except achievement. Students began to view themselves as capable of generating scientific ideas and solving problems.

In their study focusing on the impact of the STS-based Iowa Scope, Sequence, and Coordination (Iowa-SS&C) program, Yager and Weld (1999) measured improvements in student learning in the six assessments domains of learning and assessing success in science including concepts, process, connections and application, creativity, attitude, and worldview. They found that students in SS&C course, compared to traditional textbook-oriented course, achieved significantly more in all six domains. Students exhibited better attitudes toward science and science careers, improved ability to apply science concepts to everyday life, equal or better improvement on standardized test, and improved ability in decision-making skills and creative qualities. An earlier study (Yager & Tamir, 1993) on the impact of STS education on grades 4-9 students showed no statistically significant differences in achievement in the content knowledge domain, but substantial gains occurred in the domains of application, processes, creativity, and attitude.

Similar results demonstrating improvements in student attitude, creativity and motivation to learn science, and enhanced understanding of nature of science have been reported in a number of recent studies (e.g. Aikenhead, 2003; Akcay & Akcay, 2015; Lee, 2007; Yager et al., 2009). Amirshokoohi and Kazempour (2010), working with biology students in a rural Midwestern community, incorporated an STS-based project in which students working in teams researched characteristics of a various taxonomic groups and STS issues related to those groups of organisms. The study found that students gained a better understanding of the interaction among organisms and the impact of environmental issues on organisms. They also recognized the role humans can play, either positively or negatively, on impacting the environment.

Relationship between teachers' STS beliefs and instructional practices

Bandura (1997) states that beliefs are the best indicators of the decisions people make in their lives; however, there is much debate as to whether beliefs influence actions or actions influence beliefs. For example, Pajares (1992) suggests that clusters of beliefs influence attitudes, which influence action agendas, which ultimately lead to decisions or behaviors. Unfortunately, changing teacher beliefs is not a simple task. According to Lumpe, Haney, and Czerniak (2000), beliefs tend to be stable and resistant to change. Luft (1999) suggests that in-service teacher beliefs are more likely to change than pre-service teacher beliefs because in-service teachers have the opportunity to quickly implement what they learn in training and reflect on their experiences.

The study by Rubba and Harkness (1993) explored comparisons between pre-service and in-service secondary science teachers' beliefs about STS. Their findings suggested that the pre-service and in-service teachers often did not understand the nature of science and technology and their interactions within society and that their beliefs about the nature of science and technology and their interaction within society were equivalent for practical purposes. The results also showed a majority of the pre-service and in-service science teachers in the sample held misconceptions about the nature of science and technology and their interaction within society. Similar obstacles were noted in the work of Ben-Chaim et al. (1994) and Zoller et al. (1991) which found that teachers had trouble distinguishing between scientific technology tools and general technology and that their knowledge and skills of STS issues were lacking.

Lumpe, Haney, & Czerniak (1998) identified teacher beliefs regarding the implementation of an STS curriculum and examined the influence that these beliefs had on their intent to implement an STS curriculum in their classroom. The K-12 teachers surveyed believed that an STS curriculum influences students by providing students meaningful application to real life, helping students become decision-making citizens, sparking interest in students, using everyday materials to provide relevant experiences for students and fostering science learning. However, they expressed a greater need to have certain external factors in place such as resources and materials, funding, time, support, and staff development training before implementation can occur.

Almost a decade earlier, Mitchener & Anderson (1989) studied secondary science teachers' intentions to implement a model STS curriculum. Results indicated that of the 14 teachers participating in this study, four strongly accepted the model with only a few uncertainties; five accepted, but significantly altered the model to fit their beliefs; and the remaining five rejected the model. Five factors were identified as ones that impacted teachers' rejection of STS-instruction or acceptance with uncertainties. Those who altered the model had done so because of their perceived lack of science content in the STS model. Another reason was the foreseen discomfort implementing and evaluating cooperative grouping, which contradicted their view of the teacher's role as expert lecturer as well as their view of the importance of objective, value free assessments. Those that completely rejected the STS model viewed the model as one that emphasized social skills and de-emphasized science content. They saw science course objectives as highly academic and fact-based, and considered application of science as a potentially hazardous element of science curriculum.

Other studies, mainly focusing on secondary science teachers, have also focused on teachers' resistance and reluctance (DeBoer, 1991) to teach using an STS-based approach. Massenzio (2001) reported that teachers' reluctance to embrace STS-based instruction stems from their lack of familiarity and comfort with this type of approach as opposed to the traditional, teacher-directed approaches to science instruction.

Cross and Price (1996), in their interview study focusing on science teachers from Scotland, Australia, and the United States, found that although many were supportive of teaching social issues, they cited a number of practical concerns such as the fear of appearing to indoctrinate students as well as lack of appropriate resources to allow for effective STS instruction. Mansour (2007) reported a number of internal constraints and two forms of external constraints cited by science teachers as problems they face in teaching STS in Egypt. The internal constraints included teacher's background and experience with STS, religious views, and professional abilities. The external physical constraints included the country's "examination system, lack of time, overload work, and high density in the classrooms" while the external interpersonal constraints included the school administration, families, and educational decision makers.

Pedersen and Turkmen (2005) conducted an online survey study to identify and examine conceptions of pre-service elementary education teachers to teaching social issues in the K-12 classroom. The findings suggested that reading textbooks, magazines/journals, and trade books were the primary methods for students to acquire information on societal issues in the classroom. Many of the pre-service teachers indicated that while they felt they could have an influence on social issues at the local city level, many expressed the disbelief that they could foster change at higher levels. Amirshokoohi (2010) examined elementary pre-service teachers' level of environmental literacy and views toward STS before enrolling in any science methods course. The findings revealed low levels of environmental literacy among this group but a willingness to teach socially contextualized issues.

Impact of interventions on teachers' sts beliefs and environmental literacy

Lane, Wilke, Champeau and Sivek (1995) surveyed 915 Wisconsin teachers and found that only 18.2% of the respondents reported having pre-service training in EE. They also found that the teachers who had pre-service EE training had significantly more positive responses than the teachers who did not have pre-service EE training with regards to perceived competencies in EE teaching, attitudes toward EE teaching, and class time for teaching EE. This section examines the impact of teacher education programs or courses with an STS focus on pre-service teachers.

Because STS education and EE both have the overall goal of producing responsible citizens, and the current study focuses on the impact of an STS course on both STS beliefs and environmental literacy, several research findings in the area of EE have relevance and will also be discussed below.

Jamuluddin (1990), in his dissertation study, utilized a post-test only quasi-experimental design to assess the effects of an STS issue-focused elementary science methods course on selected variables associated with issue investigation/evaluation, citizenship, behavior and attitudes toward teaching STS issues to elementary students. The results of Jamuluddin's study indicated that certain STS/EE programs could promote aspects of environmental literacy and successfully foster overt citizenship behavior in elementary education pre-service teachers.

In another dissertation study, Ngwidibah (1997) examined the effects of an EE/STS-based curriculum on pre-service teachers with regard to their environmental literacy, perceptions, and attitudes towards STS issues as well as perceptions and attitudes towards teaching STS issues to elementary students. The findings of this study revealed that the experimental group numerically outscored the comparison group on all variables. All variables achieved statistical significance at the .05 level except perceived importance of elementary students becoming knowledgeable about STS issues ($p=0.51$) and perceived willingness to teach STS issues to elementary students ($p=0.45$).

Meyer and James (2002) conducted a qualitative study aimed to determine whether a science methods course with an STS focus could provide pre-service science teachers with the information and knowledge necessary to acquire an interest in STS. Most students reported that they felt comfortable working collaboratively in groups and felt that working with content in an integrated format helped them to understand the importance of real life applications in the learning process. Three years after the completion of the study, the participants, now in-service teachers, responded positively about the importance of making STS units that were multidisciplinary in nature; however, all but one had not yet implemented STS in their classrooms due to perceived time and curricular planning constraints.

Dass (2005) examined the impression that STS approaches had on the views of pre-service science teachers with regards to science education reform. Qualitative analysis revealed that although they initially did not completely agree with the STS experience, as the study progressed, most students became more comfortable and began to recognize the value of STS instruction and felt that they could use it with their own students. Two of the fifteen participants implemented STS instruction in their student teaching experience.

More recently, several studies have focused on the impact of STS instruction on pre-service teachers. Bakar, Bal, & Akcay (2006) used a quasi-experimental approach to examine the beliefs of 66 Turkish pre-service science teachers about the interrelationship of science, technology and society. The data from the Views on Science Technology and Society (VOSTS) instrument indicated that those participants experiencing an STS approach outperformed the comparison group with respect to their understanding of the scientific process, attitudes toward science, possession of creativity skills, and ability to apply scientific concepts.

Ozturk Akar & Dogan (2013) explored a similar question, focusing on the impact of a history of science (HOS) course on 93 pre-service teachers' STS views using the VOSTS questionnaire. However, the pre and post test comparisons revealed no significant differences between the pre and post scores; hence, no significant impact on the pre-service teachers' beliefs about STS. The authors concluded that "prior beliefs, conceptions, and learning experiences could be more influential than a course and/or instructional approach used to improve pre-service teachers' related conceptions." (p. 801)

Makki (2008) examined the experiences of two groups of preservice science teachers with STS instruction. Several themes emerged from this naturalistic design study. First, participants recognized STS as an "add-on approach rather than a curricular orientation." (p. iv) Second, they viewed STS curricula as dealing with controversial issues which could potentially lead them to not adopt such an approach. Finally, Makki found that very few participants implemented the STS approach in their student teaching classrooms which the author attributed to "practical considerations rather than stable beliefs." (p. v) Research focusing on the impact of STS instruction on pre-service teachers, in particular elementary pre-service teachers, is scarce. Although, the findings of the above studies indicated that pre-service teachers could benefit from a program that uses the STS-based model, they are either quantitative or qualitative in nature. The current study aimed to address previous gaps within the literature by implementing a triangulation mixed-method design in which pre and post quantitative and qualitative data are utilized to examine the extent to which pre-service teachers receiving STS-oriented instruction in certain sections of an elementary science methods course differ from those receiving instruction in non STS-oriented sections with respect to their:

1. Levels of environmental literacy
2. Perceptions and attitudes toward STS issues
3. Perceptions and attitudes towards STS issue instruction

METHODOLOGY

Research design

This study utilized a triangulation mixed method design (Creswell, 2003), in which a combination of quantitative and qualitative methods was simultaneously used "to bring together the differing strengths and non-overlapping weaknesses" of the two methods to address a series of research questions (Patton, 1990). The main rationale behind this design was that the in-depth qualitative data would offer different but complimentary data to the quantitative survey data.

The quantitative segment of the study employed a quasi-experimental pre-test-post-test design incorporating a treatment and a comparison group. The qualitative component included interview data that were collected both at the beginning and end of the semester upon the completion of the pre and post-test.

Sample

The sample consisted of 96 students in four sections of an elementary science methods class offered at a large Midwestern university. Two sections, which were taught by the researcher and had an STS focus served as the treatment groups, while the other two sections, without the STS focus and taught by a different instructor served as the control groups. The majority of the participants were female (92.5%) and in their third year (73.9%) of the undergraduate elementary teacher education program.

The intervention

Two sections of the elementary science methods course (E328), which did not focus on any particular theme(s) including STS issues, served as comparison groups. The other two sections served as the treatment groups which received the semester-long STS intervention. The two treatment sections were taught by the researcher while the comparison sections were taught by a different instructor.

The treatment and comparison groups were similar in terms of the science teaching tools and pedagogical methods that were emphasized throughout the semester. Both used a student-centered mode of teaching and learning and involved pre-service teachers in doing similar activities such as writing lesson plans, conducting labs, and teaching their lesson plans to elementary students during the field placements. Meetings and discussions among the instructors aided in making sure that all sections covered similar materials in terms of general teaching skills and tools. The only element that distinguished the treatment sections from the comparison sections was the focus of instruction and class activities on STS themes as the context for simulating the various pedagogical concepts. The STS-focused section was divided into several units, each with an STS related theme, which aimed to elucidate the interconnection between science, technology, and society, while addressing the main goals and instructional approaches that were central to all sections of the course.

The course utilized an inquiry/hands-on mode based on constructivist philosophy of learning and student-centered instruction where students are actively involved in their own learning; and the course material is relevant to students' lives and the world around them. In elementary science classrooms, hands-on/inquiry methods are seen as a means of developing content through the use of scientific processes. In STS issue oriented classrooms, hands-on/inquiry techniques serve another purpose. Once an issue or problem has been identified, such methods are employed as a means of unveiling evidence and information that will help to clarify the issue or seek solutions.

In the STS-focused course, there were certain instructor-student relationships and roles which may differ from non-STS sections. For instance, the issue-centered instructor would initiate, probe, facilitate, guide, encourage, and investigate in his/her classroom. In a joint venture with the students, the instructor would raise certain issues and passionately explore them along with possible solutions. The instructor would ask provoking questions, set the stage for investigation, encourage communication, and create an arena for opposing and divergent views. Furthermore, he would not shy away from sensitive or moral issues, foster a comfortable and open environment for exchange of ideas, aim for synthesis, reflection and assessment, and draw from the total environment and experiences of the student.

As recommended by STS educators (e.g. Hurd, 1990; Loving, 1991; Pedretti, 1992; Van der Valk, 1989; Waks, 1986), students in the STS issue oriented classroom played an active and fundamental role in the learning process. They were involved in various forms of investigative and explorative inquiries such as individual, team, and whole-class activities, discussions, viewing and discussion of films/videos, essay and lesson plan writings, role-playing, debates and simulations, and issue centered projects. The practical work essential to STS teaching was context bound, meaningful and relevant to students as they engaged in problem solving inquiries and investigations. The students' knowledge and scientific skills were developed in the context of issues and problems drawn from their own environments.

Data collection

Quantitative

This investigation utilized two separate instruments, which were administered to the students once during the first meeting of the course (pre-test) and once at the end of the semester during the week before the scheduled final examination period (post-test). In order to protect the subjects and limit instructor bias, a department colleague not involved in the project, administered the instruments (pre and post) and the data were not analyzed until after the completion of the semester and submission of the final course grades.

The first instrument used was the seventh edition of the Environmental Literacy Instrument (ELI) developed and field tested by Wilke, Hungerford, Volk, and Bluhm (June 1995). The ELI (Appendix A) begins with a section that deals with demographics and familial/personal environmental sensitivity indicators. The main body of the ELI consists of two major tests, labeled Test One and Test Two respectively, which focus on seven sub-categories: issue familiarity, perceived knowledge, perceived skills, personal action history, action plan, issue analysis, and issues identification. The Perception of STS Issues Instrument (PSTSI), originally devised by Jamuluddin (1990) and later modified by Ngwidibah (1997), consists of two parts, each containing four questions to respond to on a five point Likert Scale (Appendix B). The first part focuses on participants' perceptions on STS issues and the second part focuses on their perceptions related to STS issue instruction.

Qualitative

Three to four students from each of the two groups were randomly selected from the list of students who had express willingness to be individually interviewed. The pre and post interviews were conducted, by a departmental colleague, approximately a week after students filled out the pre and post-surveys respectively. An interview protocol was developed with questions corresponding to particular segments of the instruments in an effort to obtain verification and clarification of participants' responses on the survey questionnaire. The interviews were recorded and fully transcribed. Pseudonyms are utilized in this article in order to protect participant identity.

Data analysis

Descriptive statistical analysis included frequency and percentages for the nominal data and means/standard deviations for continuous data. In addition, the inter-rater reliability was established (0.96) to determine the consistency between the two scorers. Three MANOVAs were conducted to assess if the treatment and control groups were initially (at the pretest) equivalent on the three dependent variables of environmental literacy, STS Views, and STS Teaching Views. The assumptions of normality and homogeneity of variance along with power and effect size were reported. The data collected were analyzed to examine the following research hypotheses.

Hypothesis 1. There is a difference on the seven Environmental Literacy sub scores by

Group (Comparison vs. Experimental) and Time (Pre vs. Post).

Hypothesis 2. There is a difference on the five STS Views by Group (Comparison vs.

Experimental) and Time (Pre vs. Post).

Hypothesis 3. There is a difference on the five STS Teaching Views by Group (Comparison

vs. Experimental) and Time (Pre vs. Post).

To examine each hypothesis, a doubly multivariate repeated-measures MANOVA and subsequent ANOVAs were conducted to assess if differences exist on the sub scores by Group over time (pre- test vs. post-test). The assumptions of normality and homogeneity of variance were assessed; power and effect size were reported. If a significant difference was revealed, a series of post hoc tests were conducted. Detection of any statistically significant differences with regard to the above variables indicated that the experimental treatment had produced some gains in the participants.

The interview data were analyzed through an analytic induction method (Bogdan & Biklen, 1992). Regularities and patterns occurring across the data within each category were coded as themes emerging from the interview responses regarding pre-service teachers' (a) level of environmental literacy, (b) views and perceptions toward STS issues, and (c) views and perceptions toward teaching STS issues to their prospective students. A peer-debriefer was asked to review the respective steps of the data analysis undertaken and the narrations and themes that resulted from the data analysis.

RESULTS

Results of the MANOVA conducted on the pretest Literacy variables suggest that no significant difference, F (8, 84) = 1.54, p = .155, existed between the comparison and experimental groups on the seven sub-categories of Issue Familiarity, Perceived Knowledge, Perceived Skills, Personal Action History, Issue Identification, Issue Analysis and Action Plan. Similar equivalency results were obtained for the STS Views, F (4, 88) = 0.55, and STS Teaching variables, F (4, 88) = 0.84. Quantitative and qualitative findings related to each of the questions are addressed below.

Levels of environmental literacy

Quantitative analysis

Table 1 summarizes the descriptive statistics related to the ELI pre and post data. The results of the doubly multivariate repeated measure MANOVA revealed that a significant main effect exists on Literacy Sub scores F (8, 84) = 44.79, p < .001 (η^2 = .81, Power = 1.00) and a significant interaction effect exists on Literacy Sub scores by Group, F (8, 84) = 34.36, p < .001 (η^2 = .77, Power = 1.00). Follow-up ANOVA revealed significant main effects & interaction by Group for the Total ELI score and each of the ELI sub-scores except issue identification. Post-hoc analyses on the Total ELI scores and the ELI sub-scores revealed two significant findings: (1) Experimental Group Posttest means were significantly greater than the Experimental Group Pretest means and (2) Experimental Group Posttest means were significantly greater than Comparison Group mean.

Qualitative analysis.

The pre and post interview questions covered the three major categories of the ELI instrument: perceived knowledge of environmental issues, perceived skills relating to environmental issues, and personal action history. Hence, the qualitative data analysis will be presented for these three major categories.

Perceived knowledge

When asked about their knowledge of environmental issues at the beginning of the semester, students from both the comparison and treatment groups reported having very little knowledge or simply a broad and general knowledge of environmental issues. They were able to identify a number of issues, such as global warming, deforestation, and pollution, which they had encountered throughout their

Table 1. Pre and post ELI total and sub-scales scores

	Experimental Group (Pretest)		Experimental Group (Posttest)		Comparison Group (Posttest)	
	M	SD	M	SD	M	SD
Issue Familiarity	4.90	3.15	11.94	3.59	4.20	2.21
Perceived Knowledge	5.48	2.33	10.25	2.09	6.16	2.86
Perceived Skills	4.90	2.57	9.08	2.34	5.76	2.96
Personal Action History	29.65	12.10	37.40	12.35	27.78	12.25
Action Plan	12.77	5.51	16.23	3.28	12.38	4.84
Issue Analysis	10.33	5.19	15.25	1.73	12.04	3.92
Issue Identification	4.54	1.88	5.25	1.28	4.49	2.09
Total	72.56	18.11	105.4	17.30	73.71	17.93

lifetime. However, they indicated that they were merely aware of the existence of such issues but that their knowledge of these issues was very limited and vague.

> I feel like I have a general, very basic understanding about environmental issues. Therefore, I don't consider myself very knowledgeable. I know the obvious issues, like global warming and how vehicles, like SUV's are causing harm. I know to recycle and to take hazardous materials where they belong. I feel like I have an overall sense of environmental issues without details. (Brettani)

When asked about factors that contributed to their prior knowledge of environmental issues, almost half of the students reported learning about the existence of these issues through the media including special TV reports, movies, news, and billboards. Roughly 52% stated that their K-12 experience did not include any reference to or extensive education about environmental issues. Others reported learning about these issues in their K-12 education, but added that the discussions of such issues were limited, occasional, and merely superficial. For example, many of these students indicated that the K-12 environmental education focused primarily on recycling.

> I learned about some environmental issues in biology as discussed above. In my K-12 experience I remember doing small experiments to see the effects of pollution. For example, in junior high school we looked at the effects of oil in water. Simple experiments like these were the extent to my experience with learning about environmental issues. I don't ever remember learning about environmental issues outside of the school setting. (Sue)

The comparison group's responses on the post interview were similar to their initial responses. They noted that no major changes had occurred in their level of environmental literacy throughout the semester since no discussion of such issues had taken place in the course. However, the treatment group's responses were indicative of considerable changes in their knowledge of environmental issues as a result of the course. As the following student responses indicate, participants reported learning about more issues and gaining a more in-depth and extensive understanding of these issues. Some even mentioned the specifics of the issues they had learned about in the course.

> I have a better and more extensive knowledge about environmental issues now. In talking about waste management, for example, we obviously discussed the environmental impact of landfills. Because landfills leech toxins into the groundwater, this affects nearby plants and aquatic animals who need this water to survive. It also affects humans who drink water and also eat crops and animals which may contain the toxins. We also talked about food webs and how every living thing depends on the other living things to thrive. Some other topics discussed included water conservation and global warming. (Karen)

Others made references to learning about environmental issues at the national and local level rather than only on a broad global level.

> I am much more knowledgeable about environmental issues now. One area that I have really learned about is the effects of destroying land to build highways, homes and shopping centers. The effects on the environment are shocking. After taking this course I am more familiar with environmental issues in [State] and the United States. (Casey)

They further added that the course resulted in a greater awareness of the consequences of their actions, a realization of what they had taken for granted, and an increasing desire to take actions to resolve such issues.

> I think I am more knowledgeable now about environmental issues than I was at the beginning of the semester. Prior to taking this course, there was a part of me which knew about environmental issues but I didn't make it a daily concern or thought. In the duration of this course, I was forced to become knowledgeable

about environmental issues and I think that was a good thing. I now give my actions a second thought, such as if I recycle the lunch I'm throwing away or if I should leave the water running when I brush my teeth. I still have quite a bit of knowledge to gain when it comes to environmental issues but I do feel like I have gained enough knowledge to cause me to stop and think about my actions in day to day life and how they will effect the environment. (Brianna)

Perceived skills.

At the beginning of the semester, all participants, when asked about their perceived skills regarding environmental issues, stated that they possessed very little or no such skills. Many explained that their skills were inadequate and not extensive for large-scale resolution of environmental issues. For many, their lack of knowledge of such issues was intricately connected with their lack of skills. They explained that if they lacked the necessary knowledge of such issues, they would not be able to possess or exercise skills related to such issues either.

At this time, I do not feel I have all the information I should on the environment and therefore, I'm not sure I have all the skills. Knowledge is key and when I attain that knowledge in college hopefully, and then I can help my future students learn about the environment and how to keep it healthy. (Sam)

A few further clarified that their K-12 environmental education was limited to superficial learning of issues but felt concurrently threatened by and helpless in the dealing with such issues.

When I was taught about these issues, I remember being taught in a way that just bombards one with too much information at once. STS issues also tend to have an underlying tone of panic, fear, and helplessness. For example, the water supply is supposedly running out faster than oil supplies, how does one approach such information without fear or panic or feelings of helplessness? I feel that I do not have the skills, or ability to help resolve these problems. (Kim)

During the post interviews, students from the comparison group continued to express a lack of skills in this regard and still viewed that as a result of their lack of knowledge. Students from the treatment group, however, reported a major enhancement of their skills and were able to read about and analyze issues and had gained knowledge to expand on their ideas.

I think this course has greatly improved my skills in identifying, analyzing, and resolving these issues. I am definitely aware of what I need to do as a citizen to make a mark in correcting these problems, and I plan on doing everything in my power to do so. I am also knowledgeable about the issues, which is the first step in taking action. I am also able to write letters and inform people of the public's opinion on certain matters. Although I do not have the authority to hold town meetings, I can attend them. (Sarah)

Some mentioned that the course provided an atmosphere in which they learned to think independently and perceived themselves as equipped with the necessary skills to be able to attempt issue resolution on their own rather than feeling helpless.

Now, I believe that I actually can make a difference and have the skills to help resolve these issues. I feel this way because we spent the whole semester learning about such issues and we were introduced to a variety of different ways we can resolve those issues. For example, I learned about forms of persuasion, consumer action, political action, and physical action. (Tina)

Personal action history.

Students from both groups were asked if they had ever taken any action in alleviating environmental issues. The majority of the participants reported not taking any major actions in the past. A few stated one or two steps they had undertaken, but these were limited to occasional recycling, picking up litter, and saving energy by turning off extra lights. When asked what had prompted them to take such actions, they mentioned that they felt they were doing their part in saving the world for future generations. Two of the participants reported taking action in the past because it was part of a course requirement (Tina) or as a member of an environment club at school (Sue).

At the end of the semester, participants from the comparison group reported that their activities had remained the same throughout the semester. They reported either not taking any action or continuing the types of actions such as recycling and picking up of litter that they had previously done. In the treatment group, some students reported taking major actions during the semester while the majority mentioned they took less extensive ones or indicated a willingness to take action of some degree in the near future as a result of gaining more knowledge about such issues in the course. Thinking about these issues and taking small steps to alleviate them had become a greater part of their everyday thinking and living. Some even began advertising and promoting such actions on campus during the semester as illustrated in this interview excerpt.

> This past semester a group of members in my sorority started a recycling position in our house that will be passed on to new members each year. We are currently the recycling chairs for the position and we posted recycling posters above trashcans and recycling bins. We also talked to our president about removing Styrofoam use from the kitchens and she accepted the recycling committee positions to remain an elected position for new members each year. I feel that the recycling issue was something that is highly overlooked in [our town] and more specifically the Greek community. We decided that a good action would be to try and combat the recycling problem. (Elizabeth)

When questioned specifically about reasons that have encouraged them to take more actions, they referred to a greater awareness of the major problems and the consequences of human action that the course had opened their eyes to. They reported thinking about the issues more often and feeling some guilt about their activities or lack of positive actions.

> This class really made me want to take a stand and do something. I believe that oftentimes people do not realize that they are harming the environment, like when they throw things away where they go. Just because you throw something away doesn't mean it is gone. Also, I think that people do not realize that their actions have consequences because it might not directly affect them – their actions might affect people hundreds of years later. Today we are generating so much garbage and generating it in ways that are wasteful. When we talked about the landfill that closed in Monroe County, as well as when the guest speaker came in, were things that contributed to my willingness to take action and hopefully make a difference. (Elizabeth)

This course has helped me to see myself, an individual, in the bigger picture: 'Am I part of the problem or am I part of the solution?' I think that once you are informed of these issues, that it becomes almost impossible to continue living as you did when you were ignorant of them (the issues) and the consequences. Knowledge is powerful in that there is this voice that pleads with you to make the best choice and to ignore that voice is to deny your own knowledge. (Sue)

STS views

Quantitative analysis.

The results of the MANOVA revealed a significant main effect on STS Views Sub Scores F (4, 88) = 24.26, p < .001 (η^2 = .52, Power = 1.00) and a significant interaction on STS Views Sub Scores by Group, F (4, 88) = 24.61, p < .001 (η^2 = .53, Power = 1.00). The results of the repeated measure ANOVA on Total STS Views revealed significant main effects & interaction by Group for Total STS Views score and each of the four sub-scores. Post-hoc analyses consisting of two independent sample *t*-tests and two dependent sample *t*-tests revealed two significant findings: (1) the Experimental Group Posttest means were greater than the Experimental Group Pretest means, and (2) the Experimental Group Posttest mean was greater than the Comparison Group means which are summarized in Table 2.

Qualitative analysis.

The pre and post interview data related to participants' perceptions and attitudes toward STS issues were analyzed qualitatively to provide further support for the quantitative data discussed above. The qualitative data will be presented in three categories: 1) pre-service teachers' belief about the importance of understanding STS issues, 2) their personal knowledge and interest in understanding STS issues, and 3) their perceived skills to investigate, evaluate, and resolve STS issues.

Belief about the importance of understanding STS issues.

All participants initially felt that having an understanding of STS issues is extremely important; however, the responses and reasoning were simplistic and general. For example, one student (Sarah) stated, "I think it is very important because understanding the problems will possibly lead to solutions, and hopefully they will get resolved." Other students, such as Melissa, responded by restating STS as described in the question and added that they had no further knowledge of such issues to even pass judgment on whether they are important.

> Understanding of STS issues is important because it will take into consideration science, technological and societal factors and how they all relate and interact with environmental concerns. I am not, however, in a good position at this time since I am very limited in the knowledge I have regarding STS issues. (Melissa)

There were a number of students who stated that understanding of STS issues is critical in order to "resolve these issues and improve the quality of life for future generations." (Sue)

Table 2. Pre and post PSTSI STS views total and sub-scales scores

	Experimental Group (Pretest)		**Experimental Group (Posttest)**		**Comparison Group (Posttest)**	
	M	**SD**	**M**	**SD**	**M**	**SD**
STS Views Q1: Belief about importance of understanding STS issues	2.33	1.00	3.65	0.53	2.31	1.04
STS Views Q2: Personal interest in understanding STS issues	2.06	0.81	3.27	0.71	1.89	0.89
STS Views Q3: Belief about personal skills to investigate & evaluate STS issues	1.58	0.87	3.23	0.63	1.67	0.88
STS Views Q4: Beliefs about personal skills to help resolve STS issues	1.33	0.78	2.83	0.78	1.38	0.81
Total STS View	7.31	2.58	12.98	1.828	7.24	2.87

As with the environmental literacy questions discussed in the last section, the responses of the comparison group participants did not change by the end of the semester. However, the responses of the treatment group participants became notably more specific and referred to a need to possess knowledge in order to be able to take the subsequent steps of analyzing and attempting issue resolution. Knowledge was viewed as a first step to the resolution of such issues. Students also referred to the necessity of having knowledge of such issues in order to make more informed decisions as responsible citizens with a community. It was only during the post interviews that the students suggested the concept of responsible and informed decision making, which was a key component of class projects, activities, and discussions.

> I think it is important to have an understanding of STS issues. Having an understanding means one knows all the aspects of the issue and can list pros and cons for each possible action that can be taken relating to the issue. By knowing this, one can help explain the issue to others, and also make an informed decision about how the issue should be handled. Once an understanding is developed, it is important that people take action towards resolving STS and environmental issues. Many of these are issues which affect our everyday lives—such as water conservation. Certain dry areas of the country like Arizona have used up most of the water from their water table, and now have little left to irrigate land, fill swimming pools, and even take showers/wash dishes/drink. Obviously, in instances like this a solution for rationing needs to be reached. (Karen)

Knowledge about and personal interest in STS issues.

When asked about their own personal interest and knowledge of STS issues, participants from both groups initially reported not having any knowledge or having very general and broad knowledge of such issues. Some only understood that such issues somehow related to society, science, and technology. Others misunderstood these issues and thought that any social issue, such as poverty, terrorism, wars, domestic violence, and child abuse could be categorized as STS issues. For example, one student hesitantly categorized the issues of battered women or poverty as STS issues. A few students, such as Beth incorrectly viewed STS as a *tool* to address other issues: "I think STS helps to address environmental issues. However, I don't know any details about how they deal with these issues or what the issues are."

Students in both groups responded similarly when asked about contributing factors for their knowledge or lack of knowledge for both STS and environmental issues.. The media was an outlet for information for some while school was the source of information or encounter with such issues for several other students. However, those who had encountered STS issues at school commented that such issues were not referred to as STS issues in school and were simply covered like any other topic. Many of these students reported that the coverage in school was limited or missing.

By the end of the semester, the treatment group's responses had changed dramatically. The levels of knowledge and personal interest in STS issues were noticeably greater. Students reported having a real, in-depth knowledge of these issues and feeling affected by them in their daily lives. They were also able to identify and allude to specific examples of STS issues in their post interviews, whereas in the beginning of the semester, they only knew STS issues in a broad manner.

> Since the beginning of the course, I have broadened my knowledge about STS issues. At the beginning of the year, the only thing that I knew was that STS literally stood for science-technology-and societal issues. I had no idea what the issues were, what signified an issue, or how they affected my life. Now, I feel as though I have a lot of knowledge regarding the topic, and could identify an STS issue that I have not yet learned about. A great example of this is, my knowledge about specific issues. Before the school year I understood that pollution was an issue, but I did not understand the extent. After our unit on garbage and disposal I know the both sides of the issue, how it affects my life as well as the lives of others, what I do to contribute, and what I can do to prevent it. (Brea)

Perceived skills regarding environmental issues.

When asked about whether they believe they possess the skills to identify, analyze, and resolve STS issues, participants responded in a similar fashion as they did to the question about perceived skills with regard to environmental issues (see discussion above). Many felt that they did not possess such skills or that their skills were limited. They also viewed knowledge about STS issues as a stepping-stone to gaining the skills to deal with such issues. By the end of the semester, participants in the treatment group perceived that they possessed the necessary skills. As with other questions, students' responses about their perceived skills became more specific in the post interview. They were able to refer to specific skills they had learned about or felt are necessary in dealing with STS issues, whereas in the beginning of the semester, they referred to skills in general terms and were not even aware of the type of skills necessary.

> I've learned through the course how to take action on these issues when it comes to the classroom. For instance, have your students make presentations to other classrooms and students to get the knowledge out there. Or you can have the classroom write a letter together to a representative about an issue. It just takes creativity and passion when it comes to taking steps to resolve issues. Before this course, I'm not sure I would have thought about how to solve these issues. I think a part of me felt like they were just too big of issues and the efforts of one little person wasn't going to make a big difference. However, I now understand how wrong that is and if everyone thinks they are too small to make a difference, nothing will ever change and will, in fact, get worse. (Melissa)

STS Teaching Views

Quantitative Analysis.

The results of the MANOVA revealed that a significant main effect on STS Teaching Views Sub Scores F (4, 88) = 8.34, $p < .001$ ($\eta^2 = .28$, Power = 1.00) and a significant interaction on STS Teaching Views Sub Scores by Group, F (4, 88) = 13.16, $p < .001$ ($\eta^2 = .37$, Power = 1.00). The results of the repeated measure ANOVA on Total STS Teaching Views revealed significant main effects & interaction by Group for Total STS Teaching Views score and each of the four sub-scores. Post-hoc analyses consisting of two independent sample *t*-tests and two dependent sample *t*-tests revealed two significant findings: (1) the Experimental Group Post-test means were greater than the Experimental Group Pre-test means, and (2) the Experimental Group Post-test mean was greater than the Comparison Group means which are summarized in Table 3.

Table 3. Pre and post PSTSI STS teaching views total and sub-scales scores

	Experimental Group (Pretest)		Experimental Group (Posttest)		Comparison Group (Posttest)	
	M	SD	M	SD	M	SD
STS Teaching Q1: Belief about importance of elementary students' understanding of STS issues	2.83	0.72	*3.69*	*0.51*	*2.67*	*0.93*
STS Views Q2: Willing to teach elementary school students about STS issues?	2.69	0.66	3.58	0.54	2.51	0.90
STS Views Q3: belief about ability to teach elementary school students to investigate & evaluate STS issues	2.38	0.76	3.42	0.68	2.09	0.87
STS Views Q4: Belief about ability to teach elementary school students to resolve STS issues	2.18	0.61	3.19	0.76	2.00	0.93
TOTAL STS Teaching Views	9.28	3.20	13.88	2.15	7.24	2.87

Qualitative analysis.

The qualitative data will be presented in three categories: 1) pre-service teachers' belief about the importance of teaching STS issues, 2) their willingness to teach STS issues, and 3) their perceived confidence or ability to teach STS issues.

Importance of teaching STS issues.

During the pre-interviews, all participants expressed that it is important to teach STS issues even though some did not believe they had an understanding of such issues themselves. They viewed the teaching of such issues as important in altering the quality of life for future generations. However, the responses that they provided were general and broad and just discussed the importance of teaching such issues without going into the specific details of why and how such teaching should occur.

> I believe that teaching elementary school students to become knowledgeable about STS and environmental issues is very important. We should all be very aware about the world around us. The children in my classroom could change the world, if I spark their interest in these issues! (Sam)

By the end of the semester, responses from comparison group participants had not changed. Responses from the treatment group participants indicated a change in their ideas about the importance of teaching such issues. Treatment participants, in their post interview responses, referred to how little they knew about STS issues early in the semester and how they could not accurately make judgments regarding the importance of teaching such issues. However, after the completion of the course, their responses were more detailed and involved description of their beliefs about the teaching of such issues to young children. Many emphasized teaching children beyond the content and giving them the opportunity to think critically and grow into responsible adults. They argued that children, beginning at a very early age, should be given opportunities to learn about these issues and given the tools to identify, analyze, and resolve such issues even if they begin with small steps at that age. Gaining this knowledge and the necessary skills will allow children to grow into older children and adults who are able to think critically about such issues and make informed decisions about them. The following responses are indicative of this viewpoint.

> Before this course, I would not have thought about bringing STS and environmental issues into the classroom, especially with young children. But now it only makes sense to me to use these issues in the classroom because these

> students are the future and how they view the environment is going to determine how they treat the environment. I also think it is important to teach children about STS issues because unlike other methods of teaching science, it gives students the chance to learn and make a real difference in the world. I think the learning will be enhanced by the students feeling like what they are learning is something that affects everything and everyone around them. By teaching children about these issues and asking them to take a personal interest in what they are learning, they will have the willingness to want to investigate STS issues because they will realize how important these issues are in their lives. (Melissa)

Some talked extensively about the nature of young children and how they are more susceptible to learning and taking actions.

> By adulthood people are usually set in their ways of thinking and their lifestyle. Yet, it seems that children are more inclined to change. Therefore, it is important to teach elementary students to seek out knowledge about STS and environmental issues, because if a teacher is able to help cultivate a genuine interest and concern in children for such issues it is more likely it will become a lifetime habit. I have seen the importance of teaching students to be knowledgeable in elementary school through this course. For example, during the course our instructor presented a unit on waste management. By the end of the unit the class viewed recycling and waste management as a valid issue and suggested solutions to alleviate the problems. Yet, the instructor noted that students still threw paper, bottles, and other recyclables away in the trash in his very classroom. The students' beliefs were in conflict with their actions. I think things like this happen because of several reasons, but one of them is that my peers and I have been raised with beliefs and values that do not promote thinking about how our actions now will affect us later. We understand the concepts, but we do not apply them to our lives and we do not worry about what our actions today mean for tomorrow. (Kim)

Willingness to teach STS issues.

Similar pre-interview responses were given for this question as the previous question. Responses were general and reflected students' lack of knowledge of these issues. For many, it seemed as though they simply thought that STS must be a good thing to teach, and, therefore, expressed willingness to teach it in their future elementary classrooms. By the end of the semester, however, the treatment group participants not only indicated great willingness to teach such issues but also provided ample reasoning for their willingness to do so. Many discussed different aspects of the class that prepared them, and, therefore, gave them the tools to teach STS. They also expressed a greater willingness to teach these issues because they had become interested in such issues as a result of the course.

> In the beginning of the semester, I was skeptical on how important it was to incorporate STS issues into the curriculum. However, I now see its an excellent way to teach science to children because it's something relevant to the world around them and it will make them feel like they can make a difference in the world they live in. It is a great way of teaching science because it is real life and relevant to the students lives. Rather than having students learn about things from the textbook, have them engage in something that is happening now and something they can have a voice in. (Beth)

At the beginning, many did not feel they had the knowledge, and, hence, the confidence to teach such issues and they were less willing to even try. But, by the end of the semester, they felt more knowledgeable, and, therefore, more confident and willing to teach such issues.

> I think that I have always thought students should understand these issues. This course has helped me to see with greater clarity the importance of understanding and having the skills to resolve STS and environmental issues. I will teach my students about these issues because to not teach them about them is to ignore an essential part of their lives. Students need to find out what issues interest and concern them and to go from there. When students see how they are connected to and affected by such issues I think they will be moved to learn about them and to take action when necessary and possible. (Kim)

Confidence in teaching STS issues.

A question that closely relates to pre-service teachers' willingness to teach STS issues is one about their perceived confidence and ability in teaching such issues. Many began the semester uninformed about these issues, and, therefore, lacked the confidence to teach them to elementary students. However, upon completion of the course, the treatment participants explained that the course had given them a greater confidence to incorporate such issues into their teaching curriculum.

> I believe I can teach elementary school students how to resolve issues. A teacher can encourage students to create letters to people they know, hang up bulletin boards, create videos, or set up web pages which can be read by others. I can also teach students to develop environmentally conscious lifestyles. For example, I can teach them to conserve water when washing their hands, by demonstrating and utilizing these procedures in my own classroom. Another example would be to have a class compost pile or a recycling bin to show students examples of actions they can take, and get them in the habit of doing these things. I could also have the kids make something out of recycled items for a class project. (Karen, post-interview)

> Of course, at the beginning of the semester this would have not been attainable for me. Having no idea of what these were, I would not be able to teach children how to resolve the issues. Now, I have the confidence to mention STS actions to children and to also give them enough knowledge where they feel comfortable brainstorming their own ideas for actions. By having debates and writing the 10 day unit on an STS issue I feel that I have the tools I need to teach students how to resolve STS issues. So yes, I do feel that elementary school students are able to learn and retain this information. (Katy, post-interview)

DISCUSSION AND IMPLICATIONS

The quantitative and qualitative data, discussed in the previous section, indicated that a semester long STS intervention, such as the one employed in the treatment sections, can influence elementary pre-service teachers' level of environmental literacy and their perceptions and attitude toward STS issues and the teaching of such issues. The results also indicated a relationship among instruction using an STS issue related curriculum, pre-service teachers' environmental literacy, attitudes, and perceptions toward STS issues, and pre-service teachers' attitudes and perceptions toward teaching STS/environmental issues to elementary students. The treatment group participants correlated the increase in their level of environmental and STS literacy to their enhanced skills to identify, analyze, and resolve these issues, which in turn made them more motivated, confident, and willing to take action and teach their students about such issues. Therefore, it could be inferred that the utilization of such curricula may also have positive outcomes with pre-service teachers in other teacher education programs.

The National Science Teachers' Association (NSTA, 2010) has recommended that a portion of the school science curriculum be dedicated to STS issue instruction. Moreover, the Next Generation of Science Standards (NGSS) emphasize the need for an appropriate use of scientific principles and processes in making personal decisions and encourage engaging students intelligently in public discussions about scientific and technological concerns (NRC, 2013). The positive results of this study indicate that an appropriately designed STS/environmental issue program which involves pre-service teachers in identifying, analyzing, investigating, evaluating, and planning for the resolution of STS/environmental issues does improve the use of these process skills in pre-service teachers. As suggested previously, an STS centered curriculum must focus on elevating students' level of knowledge, skills, and action by actively involving them in their own learning. Students need to be a central part of the learning process. An STS curriculum for pre-service teachers must include a variety of readings, discussions, debates, inquiry activities, projects, unit synthesis, peer teaching and debriefing, and other such measures that spark student interest and grant them a greater sense of ownership of the issues.

Moreover, over the years, researchers and educators have indicated that there were not enough teachers with the required skills to bring students to a high level of responsible citizenship in an environmental dimension (Stapp, 1974; Ramsey & Hungerford, 1989; Disinger, 1993; McKeon-Ice et al., 1995). Such skills are important tools needed by pre-service teachers in order to go beyond teaching STS/environmental issues at just the knowledge level. In this study, the pre-service teachers who completed an STS issue oriented program attributed greater importance to STS/environmental issues and indicated greater interest in such issues than other pre-service teachers. More importantly, the pre-service teachers who experienced an STS issue oriented program believed that they possessed a higher level of skill to teach STS/environmental issue investigation and evaluation to elementary students than their counterparts who did not experience the program. They also believed that they were more competent at teaching STS/environmental issue resolution to elementary students than their counterparts. A critical relationship between teacher beliefs and decisions to implement science education reform efforts has been documented (Czerniak, Lumpe, & Haney, 1999; Czerniak & Lumpe, 1996; Haney, Czerniak, & Lumpe, 1996; Lumpe, et al., 1998). Haney, Czerniak, and Lumpe (1996) determined that teacher beliefs are significant indicators of the behaviors that will be present in the classroom. If this is the case, we can be hopeful that pre-service teachers undergoing such STS oriented courses and experiencing growth in their beliefs and attitudes can translate that into positive action within their future classrooms.

The STS focused curriculum was designed to help pre-service teachers acquire skills that will enable them to become responsible citizens in society and teach STS issues to elementary students. Bybee (1987) reported that teachers believed it was important to teach STS issues to elementary students, but very little of it was being taught. More needs to be done in order to prepare teachers to teach students about STS issues.

Prior research (e.g. Lane, Wilke, Champeau and Sivek, 1995) has indicated several key points. Many teachers lack any EE or STS training during their pre-service teacher programs. They further suggest that teachers who have pre-service EE/STS training have significantly more positive responses than the teachers who did not have pre-service EE/STS training with regards to perceived competencies in EE teaching, attitudes toward EE teaching, and class time for teaching EE/STS. Therefore, it is highly recommended that more teachers be given training in EE/STS instruction prior to certification, and practicing teachers should be encouraged and given the opportunity to take EE/STS courses and teaching methods.

In light of the findings, it is strongly recommended that pre-service teacher be given the opportunity to participate in an STS-based teaching and learning experience . This can only be possible if teacher education programs include STS issues curriculum or other components of the same nature in their curricula. These could be in the form of science courses, electives, or as part of science methods or science education seminar courses. It is further recommended that pre-service teachers receiving instruction in STS issues curriculum be given encouragement by their instructors and school administration to utilize the skills they will acquire during their training. When these pre-service teachers enter the profession as novices, they should be assigned appropriate mentors and supported by the school administration. This support will help them overcome any fear of utilizing newly acquired skills to teach elementary students. Such a support system can be in the form of additional training in classroom management skills, planned refresher courses or in-service training, peer coaching, team teaching, and opportunities to participate in professional conferences.

Nevertheless, it is noteworthy that the simple inclusion of STS or similar curricula in the methods classes or the teacher education programs will not necessarily result in pre-service teachers' conceptual change and their embracing such instructional approaches in their own classrooms. We need to identify pre-service teachers' perceptions of STS that they bring to science methods courses and attempt to determine how these perceptions are formed and how they are reinforced or modified during the semester. Therefore, it is imperative that teacher preparation programs develop strategies for helping students reflect on their own and their peers' perspectives. By allowing pre-service teachers the opportunity to reflect and focus on their own views and classroom actions relating to learning and teaching, teacher education programs can gain better insight into the kinds of experiences these programs must include in order to promote issue oriented inquiry based teaching (Simmons et al. 1999). Therefore, the educators need to go beyond asking students to reflect on their beliefs about STS by challenging them in a non-threatening manner so that they are willing to seriously consider alternative points of view. These include opportunities such as appropriate and relevant field placements, reading, discussions, and conferences with faculty that encourage students to explore their beliefs (Goodman 1988).

IMPLICATIONS FOR FUTURE RESEARCH

In 1993, Yager and Tamir called attention to the fact that although the STS approach had been gaining support among science educators, little empirical support for this approach could be found in the literature. Three decades later, there is still a need for further research focusing on STS education and environmental literacy, and in particular, the preparation of teachers to adopt STS instruction (Amirshokoohi, 2010; Jamuluddin, 1990; McKeown-Ice, Brayton, & May, 1995). Although the current study and a few others (e.g. Amirshokoohi, 2009; Jamuluddin, 1990; Ngwidibah, 1997) have attempted to answer some questions in this regard, there is still a great need to fill this gap in the literature.

The current study can be expanded upon in several ways to address other unanswered questions in this area. First, this study concentrated on beliefs and attitudes of pre-service teachers at one particular university in the Midwest. The pre-service participant population was homogeneous in terms of gender and races as most were white females in their second or third year of the program. The results of this study can be even more generalizable if the study is repeated at several other institutions in different regions of the nation and if the pre-service teacher participant population is drawn from a more diverse group that includes more males and students of different races and backgrounds. Greater sample size will also increase the generalizability of the results.

A subsequent study can investigate the correlation between participants' environmental literacy, and beliefs and attitudes about STS issues and STS instruction and their demographics. For example, the correlation between the communities (urban, rural, suburban) that participants grew up in and their environmental literacy should be explored to shed light on possible differences in their initial environmental literacy and their susceptibility to changes as a result of the course. If the study is repeated at other institutions with a more diverse population, similar correlations could be explored as related to other factors such as race or gender.

The current study examined the extent to which pre-service teachers' environmental literacy and perceptions and attitude toward STS issues and instruction changed as a result of an STS focused science methods course. The change that was investigated involved changes between their initial and final positions. It would be beneficial to explore points of transition throughout the semester-long instruction to identify factors and/or instances within the course that may be deemed instrumental in stimulating such changes. This type of study will indicate the growth and development of pre-service teachers throughout the semester as opposed to the comparison of initial and final attitudes and perceptions.

Finally, it will be necessary to do follow up studies involving the same participants to track their classroom actions during their student teaching and initial years of teaching. Such follow up studies would illuminate whether changes in perceptions and attitudes necessarily translate into appropriate actions and behaviors. Studies exploring elementary pre-service teachers' environmental literacy and attitudes toward STS issues and instruction are very rare but even more scarce are studies following these prospective teachers into their future classrooms to investigate how their classroom actions and behaviors are influenced by their levels of environmental literacy or attitudes toward STS issues and instruction. These studies can further examine factors that might enable or hinder the translation of teachers' beliefs into appropriate classroom action (i.e. time, school administrator support, mentoring, and funding). Therefore, such studies will be crucial in filling the gap in the literature.

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