


A Case Study of Elementary Pre-Service Teachers Experiencing an STS-Based Science Methods Course

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ABSTRACT

Incorporating STS-based instruction in K-12, particularly, elementary classrooms, is contingent upon proper preparation of a teaching force that understands STS issues and is well equipped to focus instruction on such issues. It is, therefore, imperative that teacher beliefs, attitude, and understanding of STS issues and STS-focused instruction are considered and addressed during teacher education programs and particularly methods courses. The purpose of the current case study was to examine a small group of elementary pre-service teachers' experiences and reflection on the STS component of a science methods course, pre and post environmental literacy, views and attitude toward STS issues and instruction, and how their experiences influenced their views and attitudes. The results of this study are promising and allow us to examine the experiences and perceptions of individual students. All five participants who began the course with minimal knowledge of STS issues and little to no confidence or willingness to teach about STS issues, ended the course with a greater understanding of STS issues, skills to deal with and teach STS issues, and willingness to take action and incorporate STS-based instruction. The study's participants suggested that multiple aspects of the exploratory and STS-focused course allowed for them to rethink some of their previous ideas, gain a deep understanding of STS issues, and become equipped to take action and also incorporate STS-based instruction into their future classrooms.

Keywords: STS education, science methods course, pre-service teachers

INTRODUCTION

Over the past few decades, science education reform documents have emphasized the importance of pertinent and socially contextualized science instruction, which focus on the real-world interconnection of science and technology with societal issues (NGSS, 2013; NRC, 1996, 2011; NSTA, 2010). The adoption of the science, technology, and society (STS) framework of science education has long been promoted as a means of contextualizing science instruction (Aikenhead, 2003; Yager et al., 2006).

The STS framework focuses on the introduction of science concepts in the context of contentious societal issues, many of which are environmental issues that are closely linked with science and technology. Prior research studies (e.g. Bennett et al., 2007; Hungerford & Volk, 1990; Pedretti & Nazir, 2011; van Eijck & Roth, 2013; Yager, 2007) have documented the numerous benefits of STS-based instruction. Such benefits include: enhancing students' understanding of science concepts and the relevancy of science in their lives and society at large; improving their achievement, creativity, and critical

thinking skills; empowering them to make informed responsible decisions; and providing them opportunities to interact with their peers, school, and community as well as applying their understanding to real world situation.

Incorporating STS-based instruction in K-12, particularly, elementary classrooms, is contingent upon proper preparation of a teaching force that understands STS issues and is well equipped to focus instruction on such issues. It is, therefore, imperative that teacher views, perceptions, and understanding of STS issues and STS-focused instruction are considered and addressed during teacher education programs and particularly methods courses.

Equally important is the need for research exploring teachers' beliefs, attitude, understanding, and willingness to adopt STS-based instruction as well as the possible ways in which STS-focused methods courses and professional development opportunities may shape and influence teachers' affective and cognitive domains as well as their decisions with respect to STS-focused instructional practices.

LITERATURE REVIEW

STS related studies that focus on teachers fall under two main categories. The first group of studies focuses on the existing beliefs, understanding, and self-efficacy of teachers with respect to STS and STS-based instruction. This category is further divided into those focusing on pre-service teachers and current in-service teachers. Many studies in this category focus on secondary science pre-service and in-service teachers, both within the United States (e.g. Nashon et al., 2008; Pedersen & Totten, 2001) and other countries (e.g. Bettencourt et al., 2011; Mansour, 2010). Studies focusing on existing perceptions of elementary pre-service teachers, particularly in the United States, are few in number (e.g., Amirshokoohi, 2010; Amirshokoohi & Jubilan, 2018; Pedersen & Turkmen, 2005). Findings from these studies have indicated low levels of environmental literacy and personal interest in STS issues and STS-based instruction among U.S. elementary pre-service teachers (Amirshokoohi, 2010, 2016), most of whom identified school and media as primary sources of information on environmental and societal issues (Amirshokoohi, 2010; Pedersen & Turkmen, 2005).

The second category of studies focuses on the impact of teacher preparation courses and programs as well as professional development on pre- and in-service teachers' attitude, understanding, beliefs, and self-efficacy. The majority of the studies in this category, many of which have been conducted outside of the U.S., focus on courses for secondary science pre-service teachers (e.g., Dass, 2005; Pedretti et al., 2008) with only a few studies focusing on the impact of courses on elementary pre-service teachers (e.g., Amirshokoohi, 2016; Henning & King, 2005). With the exception of a small number of studies, most of the interventions implemented in courses both for elementary and secondary pre-service teachers have been brief or excluded experiential opportunities with STS. Similarly, most of the studies focusing on the impact of STS-based courses tend to be quantitative studies that focus on aggregate changes as opposed to individual or small group changes.

A naturalistic inquiry by Pedretti et al. (2008) examined Canadian secondary science student teachers' responses to a case of STSE (science, technology, society, & environment) through the use of questionnaires, reflective writing, and interviews. They found that, although the participating pre-service teachers expressed confidence and motivation about teaching STSE, they also indicated decreased likelihood of teaching these perspectives during their early years of teaching. Factors such as participants' perceived lack of control and autonomy, a need for support and sense of belonging, and perceived lack of expertise were identified as possible reasons for low inclination to adopt such instructional approach early in their teaching career. Amirshokoohi (2016) conducted a mixed methods study to examine the impact of STS-focused methods courses on elementary pre-service teachers' environmental literacy and views toward STS issues and STS instruction. The study's quantitative and qualitative results indicated significant improvement in environmental literacy and perceptions toward STS and STS instruction in the pre-service teachers enrolled in the sections of the course that had a strong STS component. The positive results of that study

Table 1. Participant information

Participant	Year in program	Community
Beth	3	Rural
Cathy	3	Suburban
Mary	4	Suburban
Rachel	4	Urban
Tom	4	Suburban

prompted us to embark on a related study exploring the impact of such courses for elementary pre-service teachers. The purpose of the current case study was to examine a small group of elementary pre-service teachers' experiences and reflection on the STS component of a science methods course, pre and post environmental literacy, views and perceptions toward STS issues and instruction, and how their experiences influenced their views and perceptions.

METHOD

In this study, we decided to utilize a case study approach (Creswell, 2013) to examine the experiences and reflections of a small group of elementary pre-service teachers (cases) enrolled in an STS-based science methods course taught by the first author at a Northeastern private university. The case study approach allowed for examination of individual cases' knowledge and perceptions about STS issues and STS-based instruction before and after the STS-focused component of the course. More specifically, a cross-case analysis method (Yin, 2009) was employed to compare the cases, explore possible connections among the discrete cases, develop inferences about their experiences and perceptions both individually and across the cases, as well as delineate possible factors that may have contributed to the outcomes of the cases.

Case Selection

The five participants, or cases, will be identified by the pseudonyms Beth, Cathy, Mary, Rachel, and Tom (**Table 1**). Their selection, from the 22 students enrolled in the course and 19 who had signed the IRB consent form and agreed to participate in a larger related study, was based on best representation of the demographics of the course section in terms of gender, year in the program, and type of community they grew up in. The class consisted of two male and twenty female students, 15 third and seven fourth year students, and four rural, four urban, and fourteen suburban students. The five cases selected included four female and one male student. Three were third year students and two were completing their final year in the program. Cathy, Mary, and Tom grew up in suburban communities, Rachel in urban, and Beth in a rural community and near her grandparents' farm.

Context

Students enrolled in the early childhood and elementary education program at this institution are required to take a science methods course after having completed a science content course and a general instructional design course. The course instructor (first author) employed an inquiry-based, hands-on/minds-on approach grounded in the constructivist philosophy of learning and instruction. Students participated

in various forms of investigative and explorative inquiries such as individual, team, and whole-class activities, discussions, viewing and discussion of films/videos, reflections, lesson plan writings, role-playing, debates and simulations, and issue centered projects. The last component of the course, which spanned three weeks, focused on contextualizing constructivist inquiry-based science instruction around STS issues and the significance of teaching in a way that highlights the interconnection between science, technology, and society. The instructor's focus of instruction was on

- 1) making connections between science concepts and everyday life as well as applying their understanding,
- 2) development of critical thinking skills, and
- 3) fostering sensitivity and positive attitude toward STS and STS teaching.

Most of the class time was devoted to simulating the three components of STS instruction: issue identification, issue analysis, and issue resolution, in a manner consistent with the 5E learning cycle model of inquiry-based instruction taught and promoted throughout most of the course. The instructor simulated the beginning of an STS unit focused on waste, with an engaging introduction consisting of a news clip about a controversial plan to build a proposed landfill in the community and community members' reactions to the plan, which was followed by a class discussion and the identification of the STS issue of focus. The next phase, issue analysis, which should consist of a series of exploration phase interspersed with explanation (discussion) phases addressing the various concepts to be addressed in the unit, was partially simulated and fully laid out in a unit plan format for students to examine and discuss. At the end of the issue analysis component, we simulated a townhall meeting where students presented arguments from the viewpoints of different stakeholders such as farmers, city planners, environmentalists, the average citizen, etc. and debated the issue before putting it to a city council vote. Finally, we discussed the need for classroom students to take action and apply their understanding of the concepts and the issue at hand as part of the issue resolution component of the STS framework. As a class, the simulated unit was discussed thoroughly within the context of the STS framework and additional readings and analysis tasks were completed in order to enhance students' understanding and comfort level with this type of planning. As a culminating assignment for the course, students worked in teams of three-four to create a two-week unit revolving around an STS issue of their choice. During the last week of class, teams presented their STS issues and units as well as microteaching a portion of their unit.

Data Collection and Analysis

As part of this qualitative case study, we collected and examined multiple sources of descriptive and interpretive data in order to allow for data triangulation and formulating generalizations within and across the cases. The data gathered included participants' written reflections as well as written responses on tasks and assignments completed during the STS-focused component of the course and pre and post interviews with each participant in order to further identify their perceptions and experiences. As part of the initial and final written reflection tasks and the pre and post interviews,

the participating pre-service teachers were asked to reflect on their awareness of and interest in STS issues, extent to which they believe an understanding of STS issues and teaching students about such issues is important, extent to which they believe they possess the skills to investigate, evaluate, and resolve STS issues, and their willingness and ability to teach elementary students about STS issues along with how to investigate, evaluate, and resolve them. The initial interviews were conducted approximately a week prior to the first STS-focused session and the final interview occurred at the end of the semester, approximately one week after the completion of the final course project which focused on STS instruction. Each interview, conducted by the second author, lasted approximately 15-20 minutes and was designed in a semi-structured manner focusing on the items discussed above. All the interviews were tape-recorded and transcribed for analysis.

The first two authors analyzed all sources of data independently for each individual. We began by analyzing the pre data, including the initial reflections, written responses to assignments, and the initial interview responses. We then cross checked our analysis by comparing our observations and proceeded to perform a cross-case analysis to determine commonalities and differences among the different cases and formulate generalizations within and across the cases (Stake, 1995). We repeated the same process using the later reflections and written responses as well as the post interview data to examine possible changes in each case and determine commonalities and differences among the cases as well as possible factors that may have been responsible for their experiences and perceptions.

RESULTS

The findings will be presented for the major categories of environmental literacy and knowledge of STS issues, views toward STS issues, views toward STS instruction, and course experiences leading to changes.

Environmental Literacy & Knowledge of STS Issues

Pre-methods course

At the beginning of the semester, all five pre-service teachers reported having similar knowledge and awareness of environmental issues. None of them recognized what STS issues would be, and when given a description of STS, were only able to name a few generally known environmental issues such as pollution, deforestation, and global warming. Cathy and Beth even included issues such as domestic abuse and wars which are not STS issues since these do not involve the interconnection of science, technology, and society. In connection to their initial lack of awareness of STS and environmental issues, they all indicated possessing inadequate skills to deal with such issues.

All of them indicated the role of the media, such as movies or the news, for providing them limited and sporadic exposure to the mentioned issues. Mary and Tom stated that their K-12 experience did not include any reference to or extensive education about environmental issues. Rachel, Beth, and Cathy indicated being exposed to some environmental issues

during their K-12 education; however, they added that the discussions of such issues were limited, occasional, and merely superficial with the main focus being on recycling. Beth was the only participant who mentioned personal exposure to topics such as the use of pesticides and animal growth hormones because of her experiences at her grandfather's farm, but she did not view them as "issues."

Early on, participants were asked if they had ever taken any action in alleviating environmental issues. Most stated having undertaken only sporadic and limited actions such as picking up litter or avoiding littering (mentioned by all five participants), occasional recycling (mentioned by Beth, Rachel, and Tom), and saving energy by turning off extra lights (mentioned by all five participants). 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.

Post-methods course

By the end of the semester, all five pre-service teachers reported learning about more STS and environmental issues and gaining a more in-depth and extensive understanding of these issues. Mary, Tom, and Rachel made references to learning about environmental issues at the local and national level, such as river pollution and local waste management, rather than only on a broad global level such as rainforest destruction. Furthermore, all participants added that the course had resulted in a greater awareness of the consequences of their actions, a realization of what they had previously taken for granted, and an increasing desire to take actions to resolve such issues. Beth, for example, discussed how the use of pesticides on the farm, which she initially viewed as just a regular part of farming, may be problematic and lead to a number of issues which would require attention. Finally, all participants, particularly, Beth, Rachel, and Tom, indicated becoming cognizant of the controversial, complex, and multifaceted nature of STS issues because of the number of stakeholders involved. In the following excerpt, Rachel discussed her increased knowledge of STS/environmental issues:

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 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.

Similarly, Beth discussed very specific issues such as the water shortage in areas such as California and Arizona which she had researched for her mini unit plan.

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, & even take

showers/wash dishes/drink. Obviously, in instances like this a solution for rationing needs to be reached.

Tom also indicated being able to identify several STS issues.

I feel I'm more aware of STS issues now. For example, STS issues are about our population and our overconsuming habits. As humans, we overconsume and create a large amount of waste. Reusing, reducing and recycling are actions that humans can take to help reduce our amount of waste. I have learned that issues such as this have contexts that involve the lives of human and/or animals within the environment. I have learned about other STS issues such as endangered species, cloning, killing animals for sport, oil spills, and water pollution.

By the end of the course, along with increased knowledge of STS and environmental issues, the participants also suggested feeling more equipped with analysis, critical thinking, and communication skills necessary to understand such issues. They indicated that the course had provided them an opportunity to learn and become equipped to think on their own and felt an improvement in their ability to read about and analyze issues, think critically, as well as communicate about and attempt to resolve issues rather than 'feeling helpless in the face of such issues'. As with other questions, students' responses about their perceived skills became more specific by the end of the semester. 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.

Furthermore, at the completion of the course, the participating pre-service teachers mentioned that thinking about STS issues and taking small steps to alleviate them had become a greater part of their everyday thinking and living. They reported increased levels of self-reflection on their everyday activities and choices made. Although they were not able to embark on any large-scale action during the course of the semester, they all mentioned taking small steps on a more consistent and regular basis and being more interested in taking actions and informing others in the future. For example, Cathy had started a small-scale recycling center in her residence hall. Beth was interested in finding out more about the farming methods used in her community. What was evident was that the increased knowledge and skills that were linked with increased action or willingness to take action. For example, Rachel reflected on the significance of knowledge and thinking about the impact of one's actions:

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.

Views about STS Issues & STS-Based Instruction

Pre-methods course

As discussed in the previous section, the five participants initially lacked awareness about STS issues which was consequently reflected in their views and perceptions of STS issues. They were uncertain about the importance of understanding and teaching such issues. Although most mentioned that “they must be important because they seem to have to do with society”, these pre-service teachers were not able to provide specific reasoning as to why and how such issues should be taught or their willingness to teach such issues in their future classroom. They all indicated a willingness to teach STS issues due to the perceived connection to society; however, they were unable to provide an explanation as to how they would do so or specific reasons for doing so in terms of connections to curriculum and classroom instruction. Most of them clearly indicated a lack of comfort and confidence in their ability to implement STS curricula in their future classrooms as a result of their lack of awareness and in-depth understanding of STS-based instruction and STS issues. While Tom and Rachel indicated that they could, perhaps, feel confident if they learned about such issues, the other three participants indicated a complete lack of confidence in their ability to teach STS issues.

Post-methods course

By the end of the semester, the participants’ responses 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.

As a consequence of their increased awareness of STS issues, the participants’ post views toward STS and STS instruction were very favorable. All participants discussed the importance of understanding and teaching such issues and provided specific and detailed reasons for doing so. They all mentioned the importance of going beyond the content and allowing students to think critically and be provided tools to analyze and resolve such issues and become responsible citizens. They communicated feeling a sense of responsibility toward their students and the world at large which they suggested had led to increased willingness to teach STS issues. For instance, Tom who was initially not certain about the importance of STS instruction eventually realized the need for it in order to develop socially responsible population who cares about the environment and the world around them. He, like others, also indicated more willingness to teach using the STS framework because they felt more equipped to do so and saw it as an effective and relevant way to teach science and capture student’s attention and curiosity. Participants such as Tom and Beth, argued that children, beginning at a very early age, should be given opportunities to learn about these issues and be provided with the tools to identify, analyze, and resolve such issues even if they begin with small steps at that age. The following excerpt from Tom’s reflection is 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.

Beth’s comment, for example, highlights the participants’ views about young children being more inclined to change than adults and how that should serve as one of the reasons for educators to focus their attention on teaching about such issues to younger students so that they can gain interest and knowledge about such issues.

By adulthood, people are usually set in their ways of thinking and their lifestyle. Yet, it seems that children are more inclined to change. So, 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.

Mary commented on the efficacy of the STS approach in making learning relevant, enjoyable, and self-empowering for students:

If I can get my students to understand the problems in our environment & how we, as a society, are creating those problems, they will be more likely to take an interest and make a difference. At first, I was skeptical about how important it was to incorporate STS issues into the curriculum. However, I now see it 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 have they engage in something that is happening now and something they can have a voice in.

All of them discussed ending the course with a strong sense of empowerment and excitement in being able to design STS-based instruction and ultimately make a difference in students’ learning and life beyond school. They expressed a greater willingness to teach about STS issues because they had become interested in such issues themselves as a result of the course.

They provided ample specific examples of how they plan to implement STS instruction in their classroom. Here in Cathy’s

response to an interview question, we see several examples such as creating a compost pile in school, having students write letters to inform others, and planting trees on school grounds.

I believe I can definitely teach elementary school students how to think about and address 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. This can even be practiced at school by planting trees around the school area or creating a compost pile from leftover cafeteria scraps.

A summary of the five cases' pre and post methods course views toward STS issues and instruction is included in **Table 2**.

Course Experiences

The five participants highlighted the importance of the way in which the course was set up and the effectiveness of various course components. The course readings, activities, and discussions allowed Rachel and others to gain awareness of a myriad of STS issues, and, therefore, be more willing to inform others.

I have learned about the sides of many issues including the construction of the new road, nutrition in schools, global warming, waste management, endangered species, water conservation, the use of fossil fuels, oil transportation and clean-up of spills. Because I know more about the issues, this increases my willingness to inform others on the issues, as I feel I have more facts to offer to the students.

During the STS-focused sections of the course, thematic modules focusing on local landfill and highway construction issues (among others) were incorporated as contexts for the simulation of STS instruction. The following excerpt from Cathy's reflection, echoes all five participants' sentiments about the significance of the use of such real-life scenarios and modules in opening their eyes to what was going on around them and encouraging them to inform and educate others.

This class has also taught me the magnitude of the problems our society faces. For example, when I saw the map that showed how many landfills were still left open, I was appalled; we are quickly running out of space. This helped me to further see the importance of telling others about the issues so they can also help in resolving them.

The course culminated in an STS research project and 10-day STS-focused unit plan that the students worked on in teams. The five participants were each in different teams and

focused their units on different STS topics, such as childhood obesity, water pollution, waste, and loss of biodiversity. However, they all discussed how the project allowed them to gain a better understanding of the STS issue they researched and practice creating instructional units focused on STS issues, such as the healthy food choices unit developed by Beth and her team.

Children love candy, pizza, and other junk foods, but do not understand their implications. In this 10-day unit, students will become familiar with the issue of healthy vs. unhealthy foods. Eating habits start at a young age, and this unit will increase the awareness of eating healthy, as well as the consequences for eating unhealthy food. This unit is designed to counteract the unhealthy food provided by schools, parents, and teachers.

DISCUSSION AND CONCLUSION

This cross-case analysis study aimed to explore the experiences and perceptions of STS issues and STS-based instruction of a small number of elementary pre-service teachers who were enrolled in an elementary science methods course focused on STS-based instruction. The findings of the current study mirror some of the general trends witnessed in the earlier mixed methods studies focusing on aggregate data from larger groups of students (e.g., Amirshokoohi, 2010, 2016). The results of this study are promising and allow us to examine the experiences and perceptions of individual students. Previous studies focusing on U.S. elementary pre-service teachers' existing views and understanding of STS issues and STS-based instruction (Amirshokoohi, 2010; Pederson & Turkman, 2005) have indicated low levels of environmental literacy, knowledge of STS issues, and personal interest in STS issues and STS-based instruction. Similarly, in this study, all five participants began the course with minimal knowledge of STS issues and little to no confidence or willingness to teach about STS issues. In line with previous studies focusing on the impact of teacher preparation courses and professional development, most of which focused on secondary teachers and were quantitative in nature (Amirshokoohi, 2016; Dass, 2005; Henning & King, 2005; Pedretti et al., 2008) the findings of this study were also encouraging. All participants ended the course with a greater understanding of STS issues, skills to deal with and teach STS issues, and willingness to take action and incorporate STS-based instruction. The study's participants suggested that multiple aspects of the exploratory and STS-focused course allowed for them to rethink some of their previous ideas, gain a deep understanding of STS issues, and become equipped to take action and also incorporate STS-based instruction into their future classrooms.

Furthermore, the findings of this study highlight the interconnection among pre-service teachers' level of knowledge, perceptions, skills, willingness to take action, and inclination to incorporate STS-focused instruction in their classrooms. A similar finding was reported in an earlier larger scale mixed-method study (Amirshokoohi, 2016), but the current cross case study highlighted that regardless of their

Table 2. Summary of pre- & post-methods course views toward STS issues & instruction

	Pre-methods course	Post-methods course	Sample post-methods course excerpts
Importance of understanding & teaching STS issues	<ul style="list-style-type: none"> Uncertain about importance of understanding & teaching STS issues Unable to provide specific reasoning for why & how STS issues should be taught 	<ul style="list-style-type: none"> All discussed importance of understanding & teaching STS issues Provided specific & detailed reasons All mentioned importance of going beyond content & allowing students to think critically & analyze & resolve such issues Importance of developing responsible citizens. 	<p>Tom: <i>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.</i></p> <p>Beth: <i>By adulthood, people are usually set in their ways of thinking and their lifestyle. Yet, it seems that children are more inclined to change. So, 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></p> <p>Mary: <i>If I can get my students to understand the problems in our environment and how we, as a society, are creating those problems, they will be more likely to take an interest and make a difference. At first, I was skeptical about how important it was to incorporate STS issues into the curriculum. However, I now see it 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 have they engage in something that is happening now and something they can have a voice in.</i></p> <p>Cathy: <i>I believe I can definitely teach elementary school students how to think about and address 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. This can even be practiced at school by planting trees around the school area or creating a compost pile from leftover cafeteria scraps.</i></p>
Willingness to teach STS issues	<ul style="list-style-type: none"> Unable to provide specific explanation about: Reasons for teaching STS issues How they would teach STS issues 	<ul style="list-style-type: none"> Communicated feeling a sense of responsibility toward students and the world at large Increased willingness to teach STS issues Found STS curriculum as effective & relevant way to teach science & capture student's attention & curiosity. 	
Confidence to teach STS issues	<ul style="list-style-type: none"> Tom & Rachel indicated possible comfort with teaching about STS issues if provided preparation Others expressed lack of comfort & confidence in ability to implement STS curriculum 	<ul style="list-style-type: none"> Greater sense of confidence & comfort Felt more equipped 	

gender, year in the program, or type of community they were raised in, these elementary preservice teachers gained a better understanding of STS issues and STS-focused instruction, their perceptions about such issues and teaching them in the classroom improved as well as their willingness and comfort level in incorporating STS issues into their teaching.

Although the case study only focused on a small number of participants, their shared experiences in the course and evolution of understanding, perceptions, and confidence toward STS issues and STS-based instruction is promising for pre-service teachers experiencing similar methods courses. Their shared opinions about course specific components that

they found beneficial and effective also shed light on factors and components that must be considered when incorporating an STS component into methods courses for pre-service teachers. Such courses should include firsthand experiences, readings, discussions, projects, unit development and microteaching in order to enhance pre-service teachers' understanding, perceptions, confidence, willingness to adopt STS instructional framework. Considering previous studies that have documented a connection among pre and in-service teachers' perceptions, understanding, and implementation of science education reform efforts (e.g., Amirshokoohi, 2016; Czerniak et al., 1999), the findings of this study may provide

further confidence that STS-focused methods courses may eventually result in the translation of such perceptions into STS-based instructional practices in their future classrooms.

Implications

Proper preparation of a teaching force that understands STS issues and is well equipped to focus instruction on such issues is a necessary requirement for ensuring the incorporation of STS-based instruction in K-12, particularly elementary classrooms. To properly prepare future teachers, it is important their views, perceptions, and understanding of STS issues and STS-focused instruction are considered and addressed during teacher education programs and particularly methods courses. The course components highlighted above should be considered for methods courses in order to enhance preservice teachers' understanding of STS issues and STS-based instruction and improve their confidence and willingness to adopt such instructional approach in their future classrooms.

It is equally important to engage in research exploring teachers' beliefs, attitude, understanding, and willingness to adopt STS-based instruction as well as the possible ways in which STS-focused methods courses and professional development opportunities may shape and influence teachers' affective and cognitive domains as well as their decisions with respect to STS-focused instructional practices. Studies focusing on the impact of teacher preparation courses and programs as well as professional development on pre- and in-service teachers' understanding, views, and self-efficacy with respect to STS issues and instruction have mainly concentrated on secondary science pre-service teachers and have been conducted mostly outside of the United States. There is a need for more studies focusing on elementary pre-service teachers, particularly in the United States, and their experiences in STS-based courses and programs. Most previous studies have explored short-term interventions or ones excluding experiential learning. Findings of this study indicate the significance of incorporating key course components discussed above to enrich elementary pre-service teachers' experience and influence their knowledge and perceptions. Future studies focusing on elementary pre-service teachers from different demographic backgrounds and enrolled in different types of institutions and teacher preparation programs are necessary to allow for comparison in terms of experiences and outcomes and further generalization of the findings. Furthermore, future studies examining the teaching behaviors of pre-service teachers who experience STS-based courses and programs is necessary to determine the extent of the translation of perceptions and knowledge into tangible classroom pedagogical practice. It would also be necessary to explore possible factors impeding or enhancing their ability and willingness to incorporate STS-based instruction in their classrooms.

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