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STEM Education Course: Enhancing K-12 Teachers' Cultural Awareness Through Reflections of Socioscientific Issues

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Abstract: This study applied the Socioscientific Issues (SSI) framework to explore how elementary teachers navigate STEM curriculum and apply SSI following a STEM certification endorsement course. Analysis revealed a number of themes regarding shifts in teachers' perceived cultural practices, indicating a substantial shift in focus for these teachers in teaching science.

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Introduction

Much of the responsibility for preparing students to be integral and functioning members of local and global communities depends on teachers. Teaching Science, Technology, Engineering, and Mathematics (STEM) subjects in the context of Socio-Scientific Issues (SSI) instruction can educate and prepare students to develop as citizens capable of considering, evaluating and negotiating the complex STEM-based issues intertwined with personal beliefs, knowledge, culture, and politics (Kahn & Zeidler, 2016). SSI instruction has been identified as an avenue for developing students' "character and values as global citizens" (Lee, Yoo, Choi, Kim, Krajcik, Herman, & Zeidler, 2013, p. 2079). Examples of SSI instructional topics that have been implemented in K-12 classrooms include: climate change, global warming, energy resources, environmental pollution, nutrition, and smoking and cancer (Anagun & Muhammet, 2010; Saad, Baharon & Mokhsein, 2017). These lessons allow teachers to engage students in discussions of SSI and, in turn, foster students' ability to solve problems, evaluate information, make decisions based on valid and reliable evidence, and welcome and negotiate multiple perspectives (Zeidler, D.L, 2016). The SSI framework "focuses specifically on empowering students to consider how science-based issues and the decisions made concerning them reflect, in part, the moral principles and qualities of virtue that encompass their own lives, as well as the physical and social world around them" (Ziedler et al., 2005, p. 360).

However, preparing and helping teachers to implement SSI instruction in STEM subjects is challenging, particularly for those with limited knowledge and experience in teaching through inquiry and engineering design-oriented classroom strategies (Macalalag & Parker, 2016; Peterson, Crow & Macalalag, 2016). Many educators approach teaching SSI topics using lenses such as personal beliefs and biases, which may not be supported by empirical evidence (Parr, 2013). According to Anagun and Muhammet (2010), the majority of pre-service teachers in their study were unaware of how to implement and felt unprepared to teach SSI in the classroom. Moreover, while most pre-service teachers recognized the value of introducing young children to SSI, they themselves had limited knowledge of SSI and tended to gravitate only to those topics and issues promoted by the media. In another study conducted by Espeja and Lagaron (2015), preservice teachers who were preparing to teach in elementary schools had simplistic and limited knowledge of SSI and it was challenging for them to implement SSI activities in their classrooms.

In our study, the SSI framework provided lens for exploring and understanding how 24 preservice and inservice teachers navigated STEM curriculum to incorporate SSI into their classroom practice. In particular, the following questions guided our inquiry: (a) In what ways, if any, do practicing elementary teachers' notions of SSI change before and after completion of the STEM and Society course? (b) To what extent do practicing elementary teachers' change their intention to implement SSI in their lessons and classroom instruction?

Literature Review

Our research study is founded in the SSI framework described by Zeidler, Sadler, Simmons, and Howes (2005). The SSI framework explores the importance of student engagement in culturally relevant scientific issues on the development of scientific literacy and understanding, as well as morality and ethics. The authors break down the development of this cognitive and ethical scientific literacy into four component parts, nature of science issues, classroom discourse issues, cultural issues, and case-based issues. Students' understanding and application of the nature of science influences how they make evidence based decisions to address preconceived notions regarding SSI. This is done through the development of a more scientific discourse involving the construction of arguments and socially constructed knowledge through discourse about specific, culturally relevant SSI cases (Ziedler et al., 2005).

These components converge to allow students to develop a functional scientific literacy, in which students find agency to make informed scientific decisions and understand and influence the world around them. In a study conducted with fourth grade students, SSI lessons assisted students in developing their critical thinking skills while engaging in discourses regarding the local and global environmental issues (Burek, 2012). In another study with high school students, SSI instruction supported development of better understandings of scientific theories and the Nature of Science. It also provided opportunities for students to improve their ability to evaluate claims and make arguments based on evidence (Pinzino, 2012). Finally, in a study conducted with undergraduate students, the SSI approach to teaching enhanced students' abilities to improve their explanations and decisions toward environmental issues (Zobi, 2014).

Several research studies have shown the successes and challenges of preparing and helping teachers to incorporate the SSI framework into their STEM lessons. Saunders and Rennie, (2011) showed that teachers often lacked the confidence and support to address issues related to SSI classroom implementation. Most pre-service and inservice teachers saw the value of teaching through SSI, but do not have the knowledge and pedagogy to implement it in their classrooms (Anagun & Muhammet, 2010; Parr, 2013). The preservice teachers' initial ideas of SSI were simplistic and limited, in most cases only referring to ideas or issues that did not include the complex nature of SSI such as discourse around uncertainty and competing arguments (Espeja & Lagaron, 2015). However, it was also shown that undergraduate education methods courses and professional development can support teachers in learning how to incorporate SSI instruction (Espeja & Lagaron, 2015; Parr, 2013). In the response to the call of Kahn and Zeidler (2016) to study the impact of science teachers' facilitation of SSI, we conducted a research study with 24 pre-service and in-service teachers enrolled in a graduate STEM course. We provide the methods of our study below.

Methodology

Research Setting, Context, and Participants

Our study was conducted during the 3-credit, graduate-level course, ED697 STEM and Society, taught by the first author for about 45 hours for five weeks in summer of 2016. To address some of the challenges in the globalization of STEM Education, our study aimed to investigate teachers' pedagogical content knowledge in a STEM and Society: Global Field Study course. The STEM and Society course is a graduate interdisciplinary problem-based course designed to introduce teachers to the synergistic and symbiotic relationships between society and the environment.

This is an interdisciplinary inquiry- and problem-based course designed to introduce teachers to the synergistic and symbiotic relationships among society, STEM disciplines and the environment. Specifically, the course objectives were to: (a) collect, synthesize and describe human's use, benefit and dependency on water, (b) identify and analyze the human activities and practices that can help or harm the environment, (c) calculate and estimate energy and water demands, (d) analyze population growth, (e) analyze the synergistic relationship between society and the environment, (f) compare and contrast the role of the environment in the evolution of STEM fields and green technologies, and (g) write and reflect on units or lessons that promote the study of society and the environment. Teachers in this course studied and discussed the varying perspectives toward the socio-scientific issues including the mystery of missing bees, the drought in California, the development of wind farms in Massachusetts, the population growth, human impact to the environment, renewable energy and sustainability, and the environmental contributions to health and civilization. Teachers read materials available online and evaluated and argued based on the claims and evidence from these readings. They also had opportunities to adapt, redesign or develop lessons that emphasized environmental education for K-12 students. The articles and guide questions for teachers appear in Appendix A.

In addition to the study of selected cases in SSI, teachers conducted hands-on explorations using Engineering is Elementary modules that have environmental education and sustainability themes: (a) Water, Water Everywhere: Designing Water Filters, (b) A Slick Solution: Cleaning an Oil Spill, (c) The Best of Bugs: Designing Hand Pollinators, (d) Catching the Wind: Designing Sails and Windmills, and (e) Now You're Cooking: Designing Solar Ovens. As an assignment, our teachers designed units and lessons to describe how they plan to implement and teach their students about SSI and environmental education concepts.

Finally, teachers conducted field studies in Philadelphia and Sicily, Italy, which included a visit to a local arboretum and urban farm where they educate students on the importance of clean water and using local produce. They visited a water treatment facility and wastewater treatment plant where they learned about the process of cleaning the wastewater and treating the water from the river before distributing it to the city for human consumption and usage. Moreover, our group of teachers interviewed engineers about the electrical energy distribution and consumption in Sicily while visiting a solar energy and hydroelectric power facilities. They also had a chance to trek a volcano with a volcanologist and survey a coastal marine preservation area with a marine biologist. These classroom activities, discussions, and field explorations helped teachers to assess, at the local, national and international levels, how geo-ecological environments give rise to distinct STEM fields, careers, economies, and technologies and to articulate these concepts into current K-12 STEM education.

The participants in this study included 24 pre-service and in-service teachers. Of the 24 participants, 15 teachers had ten or more years of teaching experience, while nine teachers had nine or fewer years of teaching. At the time of this study, he majority of participating teachers (N=14) taught in elementary schools, two taught science in middle schools, one was a part-time lecturer of chemistry, two were mathematics specialists, one was a technology specialists, and four were pre-service teachers. The teachers had varying backgrounds, with a majority (N=11) having degrees in early childhood and elementary education. Others reported previous degrees or certifications in literacy, marketing and communications, math, history, psychology, chemistry, biology, Spanish, and the Arts.

Data

In order to answer our research questions, we analyzed: (a) the transcripts of audio recorded responses to initial conceptions questions regarding pre-existing knowledge and practices for SSI and (b) the photo journals and reflections compiled over their various experiences throughout the course. For the initial conceptions transcripts, teachers were asked to address two prompts: (1) describe lessons, instructional activities, or projects that you have done in your classroom or school that taught students about SSI, society, and/or the environment, (2) identify the learning outcomes of these lessons or activities in terms of students' knowledge and experiences. We asked the teachers to answer these prompts individually, to discuss their answers with another teacher, and to record their conversations. The survey instrument and examples of teachers' answers to each prompt are provided in Appendix A. In addition, teachers were asked to complete and submit a photo journal of environmental education fieldwork in Philadelphia and in Sicily. The following topics guided the teachers in their reflections of the field studies: functional scientific literacy of SSI (Nature of Science, classroom discourse issues, cultural issues, and case-based issues), environmental education and society, STEM (engineering focus) and society. They also provided photos and explanations of their photos to support their reflections. The photo journal assignment is included in Appendix B.

Data Analysis

Our data analyses followed the *quantitative analysis of qualitative data* as described by Chi (1997). Our coding proceeded through an iterative process of application to the data set and refinement of the codes to capture relevant emerging themes in the data (Merriam, 1998). The initial codes were developed and examples were identified by the first two authors. Codes were developed and utilized to analyze teachers' initial conception transcripts and photo journals. Four broad themes emerged from our analyses: (a) reason for teaching SSI, (b) STEM content, (c) reducing carbon dioxide (CO2), and (d) teaching SSI. For this paper, we focused our analysis and report on *STEM content* and *teaching SSI*. The first and third authors, double-coded 50% of the papers with

88% agreement for the initial conceptions and 83% agreement for the photo journal assignment. Any disagreements that occurred were discussed and negotiated. However, only agreed upon codes were included in this study. The remainder of the data was analyzed by one of the authors. We then conducted a quantitative analysis of qualitative data to find frequencies, changes and/or patterns in our codes (Chi, 1997). Examples are provided for each theme in the results and appendix.

The theme *STEM content* referred to the teachers' STEM knowledge that they described during and after the course. Given the focus of our course and research, we created two sub-categories for the STEM content that was described by teachers that included: (a) connections between science and engineering and (b) knowledge of STEM concepts and processes. Within the sub-category *connections between science and engineering*, we identified instances in which teachers described occurrences in the natural environment or nature and when teachers connected nature to technology or engineering design (e.g., birds and airplanes, or duck flippers and scuba diving fins); while the sub-category *teachers' knowledge of STEM concepts and processes* referred to their knowledge of science and engineering prior to and during the field studies and excursions.

We defined our second theme, *teaching SSI*, as instances when teachers mentioned students' engagement and learning such as activities outside of the classroom and in the natural environment, the use of technology, and self-directed learning. We created two categories within the theme of *teaching SSI*: (a) real world examples of SSI, and (b) importance of STEM education in schools. The *real world examples of SSI* category refers to teaching SSI that are relevant to society and to students' lives, which is based on students' prior knowledge and experiences, cultural background and interests. We created the *importance of STEM education* category to describe the methods of teaching that pertains to: (a) motivating students to learn STEM concepts and practices, (b) preparing students for the future, (c) various pedagogy of teaching STEM subjects, (d) teaching by observing nature, (e) learning about STEM content, and (f) learning about cultural practices that are connected to STEM such as the environment and sustainability. We provided our codes and categories as well as examples from our analyses in Appendix C.

Results

STEM Content

Our analyses revealed changes in teachers' notions of SSI and their ideas for lesson implementations. In particular, with regards to the theme *STEM Content* and its categories, teachers' responses to the initial conceptions prompts showed roughly eight percent mentioned *connections between science and engineering* (N=2), and nearly 60 percent mentioned *teachers' knowledge of STEM concepts and processes* (N=14). In comparison, more teachers mentioned the *STEM Content* categories in their photo journals (N=9 and N=21, respectively). As an example of *connections between science and engineering*, Ms. Garcia described connecting the transportation of seeds in nature and engineering design in her photo journal. "After learning about how seeds can be transported in nature, we were asked to engineer a way for a seed to either float, fly, hitchhike or spring. Dorothy's design included a raft and a sail, while mine utilized a piece of cork for buoyancy. David created a spring-loaded mechanism from a safety pin. Peter used Velcro, an invention inspired by nature, to get his seed to hang on."

We also found shifts in our second category, the *teachers' knowledge of STEM concepts and processes.* While over half of the teachers mentioned STEM concepts and practices in their initial conceptions transcripts, this code was identified in nearly all of the teachers' photo journals and the examples within the photo journals indicated a more specific and detailed understanding of STEM content that they hoped to integrate into their teaching. The following is an example of *teachers' knowledge of STEM concepts and processes* from Ms. Davis' photo journal which described the engineering content she learned during her field excursion to the Philadelphia Wastewater Treatment Plant. "After the wastewater treatment process, water is returned to the Delaware River fishable, cleanable, and cleaner than the current water in the river. Because of this, the river is currently the cleanest it has been in 100 years! We also discussed new challenges for the future as water treatment technology has to evolve to handle prescription medication that enters our water supply."

Teaching SSI

In addition to STEM content, we also saw changes in teachers' intention to incorporate SSI in their lessons and classroom instruction. With regards to the theme *teaching SSI* and its categories, nearly 70 percent of teachers mentioned *real world examples of SSI* in their responses to the initial conceptions prompts (N=16), and approximately 91.7 percent mentioned the category *importance of STEM education in schools* (N=22). In comparison, all of the teachers mentioned the category *real world examples of SSI* in their photo journals, whereas 70.8 percent of teachers mentioned the *importance of STEM education in schools* category (N=17). This represents a shift in teacher focus from simply identifying the importance of SSI, to recognizing this importance and exploring avenues for implementation.

For the sub-categories of *importance of STEM education*, 41.7 percent of the teachers described in their initial conceptions transcripts teaching practices to *motivate their students to learn STEM concepts and practices* (N=11), and 8.3 percent mentioned *preparing students for the future* (N=2). In comparison, more teachers described in their photo journals *motivating their students to learn STEM concepts and practices* as well as *preparing students for the future* (N=13 and N=5, respectively). The following is an example of the sub-category *motivate their students to learn STEM concepts and practices* from Mr. Martinez' photo journal. "This struck me as we arrived at Morris Arboretum. To me this looks like the ultimate classroom. It has inspired me to get myself and students out of the four-walled classroom and out into the open spaces." As an example of teachers *preparing students for the future*, in his photo journal, Mr. Martinez, "Wanted the students to gain a stronger understanding of the world around them, environmentally or socially, working collaboratively, learning how to communicate, try to work together to find solutions to difficult problems that the world is facing, that they will be facing as they get older."

With regards to teachers who expressed *various pedagogy of teaching STEM subjects*, 8.3 percent mentioned *learning about students' prior knowledge and assessment* in response to the initial conceptions prompts (N=2), 12.5 percent *addressed how students collect data* (N=3), and 33.3 percent mentioned *engaging in an engineering design challenge* (N=8). We saw modest increases in all three teaching methods with regards to *various pedagogy of teach STEM subjects* (N=3, N=5, and N=9, respectively). As an example of *learning about students' prior knowledge and assessment*, Mr. Martinez described in his photo journal, "Our first activity at Project Learning Tree was to draw our idea of a tree. It exposed what parts of the tree we noticed and considered important. Then, we went outside, looked at trees and did it all over again, discussing what we noticed. This lesson was a great example of how we should get students to express their current understanding and see how it changes after discussion and exploration." The following is an example of teachers *engaging in an engineering design challenge* from Ms. Coleman's photo journal which described ideas for building models of the earth's core or a volcano. "For younger children have them make models of the earth's core using Playdoh, clay or food stuffs (e.g. marshmallows, peanut butter, and chocolate chips). For older children use molded gelatin and/or thick corn syrup to represent molten lava under the earth's crust."

Moreover, 8.3 percent of teachers mentioned the sub-category *teaching by observing nature* in their initial conceptions transcripts (N=2), more than half mentioned *learning about STEM content* (N=16), and 20.8 percent mentioned the *learning about cultural practices that are connected to STEM* (N=5). In teachers' photo journals, we saw an increase in the sub-category *teaching by observing nature* (N=6). Conversely, a modest decrease was observed in *learning about STEM content* and *learning about cultural practices that are connected to STEM* (N=15 and N=3, respectively). In Mr. Moore's photo journal, he mentioned *teaching by observing nature*, in which he remarked how observing nature can be a part of teaching and a useful learning tool. "In an effort to go beyond simple memorization, we explored an activity in which each participant took on the role of a part of a tree. The interconnectedness of the features became readily apparent." As an example of the sub-category *learning about STEM content*, Ms. Wilson described in her initial conceptions transcripts how she would incorporate water scarcity in her lesson plan. "They are given a bag of pennies that represents how many gallons of water that country has per person, and then they're given a chart that indicates what a typical bath would be and... typical brushing your teeth or washing your hands, and they have to figure out whether their country has enough water to actually do these things daily or weekly." The changes in teachers' notions of SSI and intention to implement SSI and STEM in the classrooms appear in Appendix D.

Discussion and Implication

Research has linked student SSI Reasoning to ethical and scientific literacy development, yet, "more work remains to better understand how to leverage contextual and socio-cultural factors to maximize the pedagogical returns connected to situated learning" (Zeidler, Herman, Ruzek, Linder, & Lin, 2013, p. 252). The findings of this study regarding shifts in teachers perceived cultural practices and applications of SSI in their classrooms provides useful resources for developing STEM education programs and courses with research-based content and methods for introducing new contexts to elementary science teachers. While much pertinent research has been done in regard to SSI, means for preparing elementary teachers for addressing and leveraging these important, yet difficult, issues has not been fully illuminated. In response to the recommendations of Kahn and Zeidler (2016) to empirically assess the impact of programs that help science teachers, the findings from our study provide evidence to identify strengths and weaknesses of the teachers' shifts in understanding to both thinking and pedagogy as a result of their participation in this STEM course.

We identified a number of shifts in several of our findings. Building upon the findings of Espeja and Lagaron (2015) that fostered the development of teachers' understanding of SSI after attending a methods course, the teachers in our study showed a sophisticated understanding of STEM and SSI instruction after the course. In particular, they identified connections between science and engineering and demonstrated more detailed and specific understandings of STEM concepts and processes based on their experiences. The teachers identified examples of science and engineering based on observations of the natural world that they intended to incorporate into their classrooms. Contrary to the findings of Anagun and Muhammet (2010) that described teachers as unprepared to teach SSI, our study findings suggest that teachers showed potential to incorporate SSI in their classrooms. Their experiences and discussion of SSI within the course and field experiences provided them a template for integrating SSI into their own teaching. While initially a large portion of the teachers identified the importance of SSI in the classroom, following the course their focus shifted to actual implementation as opposed to simply identifying the need. Moreover, these examples became more focused following their field experiences, with teachers identifying specific aspects that were important to the lives of their students. While the difference in the number of codes for both *motivate their students to learn stem concepts* and *practices and preparing students for the future* were modest, it was evident that the quality of these codes had shifted. Again teachers understanding were more specific and detailed, providing detailed explanations of how they would implement these practices into their own classrooms.

The findings from this study are valuable to science education teacher educators and researchers, in that it can inform how SSI instruction can be used to better prepare in service elementary teachers to address the STEM learning needs of an increasingly diverse student body. The local and international field studies provided our teachers knowledge, experiences and evidence to discuss and compare the complex nature of SSI. While we recognize the limitation of a small sample size, we are not attempting to generalize our findings. Instead, our findings may be useful in informing similar programs in developing STEM educators to address difficult SSI issues in there courses. Better understandings of how teachers perceive cultural practice will allow instructors and researchers to develop programs to enhance teachers' cultural awareness and to better explore means of preparing elementary teachers to tackle difficult and culturally sensitive topics in relevant and meaningful ways.

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Appendix A

Reflections and Discussions about the Socio-Scientific Issues (SSI)

Instructions: Individual Reflection and Partner Discussions

1. Read the guide questions and write their answers on a piece of paper.
2. Read the articles and view the videos provided, which present a case in SSI.
3. Discuss your individual reflections with a partner and record their discussions using Voice Memos from iPhone.
4. Collect the individual reflection papers and submit the recorded voice memos to (first author).

Guide Questions:

1. What is(are) the issue(s)?
2. Identify and explain the claims or arguments presented in the articles and videos.
3. What can you say about these claims and arguments? (or evaluate the claims and arguments made in the articles).
4. What questions do you have or additional information you need in order to have a better understanding of the issue(s)?
5. To what extent do you think this/these issue(s) is/are relevant to your students?
6. In what ways can you engage your students to think about this/these issue(s)?

The Windmills

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Appendix B

Photo Documentation and Journal

As we conduct field excursions and studies in Philadelphia and Italy, I would like you and your partner to document your photos and write reflections on two or three of the following big ideas:

1. Functional Scientific Literacy of Socioscientific Issues
    a. Nature of science issues
    b. Classroom discourse issues
    c. Cultural issues
    d. Case-based issues
2. Environmental Education and Society
3. STEM (Engineering focus) and Society

Components:
1. Photos
2. For each photo, describe what you noticed, explain why you selected this photo and how it is connected to the big idea (Research Question 1)
3. For each photo, if possible, describe how you can bring the big idea to your classroom (Research Question 2)

Format:
1. Microsoft Word
2. Microsoft PowerPoint
3. Online

Appendix C

Codes and Examples

Connections between science and engineering: occurrences in the natural environment or nature and when teachers connected nature to technology or engineering design

"I do absolutely believe in site specific design and building (which way windows face to capture sun + wind) overhangs for shade, appropriate insulation to achieve as much passive heating and cooling as possible, + using local materials + reusing whenever possible: all the good stuff that LEED certification is working to create." (Ms. Gibson and Ms. Green, Photo Journal}

Knowledge of STEM concepts and processes: teachers' knowledge of science and engineering content prior to and during the field studies and excursion

"This French turbine at the Water Works has a horizontal wheel that was unaffected by the rising and lowering of the tides in the river. This engineering solution solved the problem of the previous water wheel that was unable to run during certain times of the day due to the tides." (Ms. Davis, Photo Journal)

Real world examples of SSI: socioscientific issues that are relevant to society and to students' lives, which is based on students' prior knowledge and experiences, cultural background and interests

"We were reminded of our trip to the Wastewater Treatment Plant with this exhibit that shows the "Journey of Your Flush." Helping students understand the process and the impact on the environment can help them develop a greater appreciation for our natural resources and how we impact the environment with everything we do." (Ms. Garcia, Photo Journal)

Motivating students to learn STEM concepts and practices: teachers' desire to stimulate student curiosity or excitement through out of school learning, informal teaching and learning, application of knowledge, or making learning experiences relevant to students
"So we had our own little aquaponics system in the classroom and the students had to graph the chemical changes to kind of see how the fish interact with the plants and how they both support and help each other. And then they actually took the plants home and used the basil, mint, and cilantro in their cooking."
(Ms. Green, Initial Conceptions)

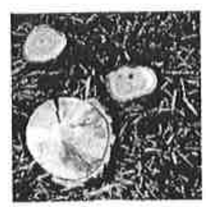
Preparing students for the future: to become scientifically literate citizens, with the goal of becoming stewards of the environment and engaging in social issues

"Plants and trees are a curriculum that is relevant to their personal experiences, is age appropriate and encourages intellectual development in order to understand science in a societal context. Our goal is to develop leaders who will care about their community and the future generations by being able to make reflective, scientifically literate decisions regarding issues they will confront," (Ms. Williams & Ms. Brown, Photo Journal)

Various pedagogy of teaching STEM subjects (a): Learning about students' prior knowledge and assessment (e.g., pre- and post- tests)
"Yeah, and scientifically, we were hoping the kids would take away a better understanding of ecosystems, thinking about habitat loss for different animals, like with the birds," (Mr. Moore, Initial Conceptions

Various pedagogy of teaching STEM subjects (b): addressing how students collect data

"By examining the number and sizes of the rings, as well as the other markings on the wood, we can tell a lot about a tree, its history, and the environment in which it grew. This activity gives students a chance to be investigators to piece together clues to the tree's story,"
(Ms. Garcia, Photo Journal)



Various pedagogy of teaching STEM subjects (c): engaging in an engineering design challenge
"I had my students create a solar oven for alternate energy. I had my students build their own solar ovens out of pizza boxes and different variables,"
(Ms. Sanders, Initial Conceptions)

Teaching by observing nature: Teachers' descriptions of nature and the environment, and how it is a part of their teaching

"Using a large number of various seeds and seed delivery systems that are found in nature the students are able to explore how nature spreads different species around. Some glide through the air, some float down a river, others grab on to whatever will carry them,"
(Mr. Moore, Photo Journal)

Learning about STEM content: how teachers planned to teach the STEM content in their classrooms (e.g., sources of water and energy, plants, integrated pest management)

"Although in class we read and discussed the "mystery of the missing bees," here the gardens teemed with the buzz from busy bees doing what they do best, pollinating flowers...This issue would be a great way to introduce different articles and have students read through them and come up with their own interpretations of the topic, similarly to what we did in class. Then have the students draw their own conclusions from the readings," (Ms. Bennett, Photo Journal)

Learning about cultural practices that are connected to STEM: teachers described the consideration of cultural practices and beliefs in teaching STEM subjects

"Italy had many different forms of transportation. People use smaller vehicles, electric vehicles, bikes and mopeds to get around. The students can design another form of transportation that will allow people to move from place to place in an eco friendly way," (Ms. Lopez, Photo Journal)

Appendix D

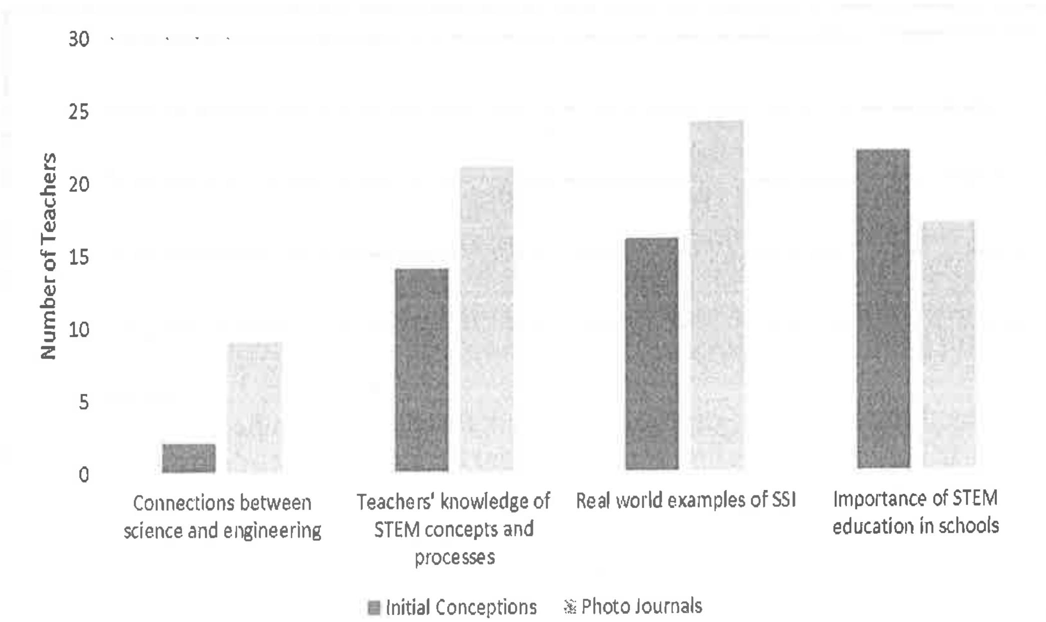


Table 1. Shifts in Teachers' STEM Content and Intent to Teach SSI

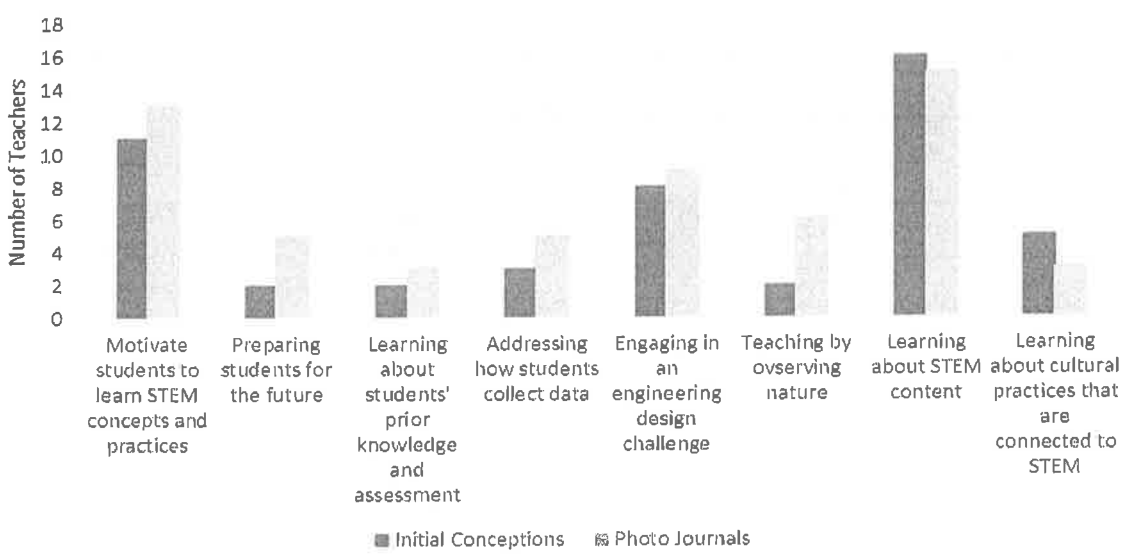


Table 2. Sub-Categories of Importance of STEM Education in Schools