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Engaging pre-service teachers enrolled in science methods course in teaching through social contextualization of science

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ABSTRACT

The recent global pandemic, the spread of artificial intelligence technology, and the constant threats of climate change are just examples of ways in which our lives and the issues we face are intricately linked with science and technology and highlight the need for improving our education system to allow for developing an informed and engaged citizenry. The preparation of teachers and successfully equipping them to plan and implement socially relevant and contextualized science lessons is a critical step in achieving this goal. In this article, I provide lucid and detailed account of my approach and describe possible ways of incorporating immersive and experiential learning opportunities within methods courses and teacher professional development to help pre and in-service teachers recognize the significance of socially contextualized science, and by extension STEM instruction, as well as prepare and support them in planning and implementing such an approach in their own classrooms. The components and examples discussed are suitable for elementary and secondary methods courses and professional development and would similarly be ideal and applicable for implementation in K-12 classrooms.

Keywords: pre-service teachers, science methods course, STS-based instruction, science/technology/society, social contextualization, teacher preparation

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INTRODUCTION

Teaching science in a social context, whereby the focus of instruction is on the real-world interconnection of science and technology with societal issues, has been heavily endorsed and promoted by the science education community and major reform documents (National Research Council [NRC], 2012; National Science Teachers Association [NSTA], 2010) as a means of achieving scientific literacy. Furthermore, it has been argued (Amirshokoohi et al., 2022) that the transformative vision of scientific literacy (Sjöström & Eilks, 2018), which focuses on critical global citizenship, aligns perfectly with the science, technology, and society (STS) framework of science education (Aikenhead, 2003; Yager et al., 2006) that was first advocated more than three decades ago and continues to be emphasized in important science education documents and initiatives such as the framework for K-12 science education (NRC, 2012) and the next generation science standards (NRC, 2012). STS framework, and the closely associated socio-scientific issues (SSIs) framework (Zeidler & Nichols, 2009) focus on "controversial, relevant, and authentic SSIs", which emphasize the interdependence of STS, as the "drivers for the curriculum" (Sjöström & Eilks, 2018). The literature on socially contextualized instruction has demonstrated numerous benefits including augmented student understanding of scientific concepts and its interconnection with society, enhancement of student creativity, critical thinking, and problem-solving skills; development of informed decision making; and increased opportunities for interactions with the community and application of scientific understanding (Amirshokoohi et al., 2022).

The adoption of a socially contextualized approach to teaching science requires a teaching force that is equipped with the necessary understanding, skills, and disposition. Yet, as highlighted by prior studies (e.g., Amirshokoohi, 2010; Amirshokoohi et al., 2022; Kazempour & Amirshokoohi, 2020; Turkmen & Pederson, 2005), one of the challenges we are confronted with in implementing such an approach is the low levels of environmental literacy and personal interest in STS issues and STS-based instruction among U.S. pre-service and in-service teachers, particularly those in early childhood and elementary education. Hence, a necessary step to ensure the implementation of socially relevant and contextualized K-12 science instruction, especially in the earlier grades, is teacher preparation and professional development focused on enhancing current and future teachers' understanding of science and technology interconnected societal issues as well as their inclination and ability to adopt STS-based science instruction.

Although the positive impact of professional development and methods courses on pre and in-service teachers' level of understanding, confidence, and willingness to embrace socially contextualized science instruction has been reported in multiple studies (Amirshokoohi, 2010; Amos et al., 2020; Autieri et al., 2016; Borgerding & Dagistan, 2018; Cohen et al., 2020; Forbes & Davis, 2008), publications providing details about course components and examples of specific pre-service teacher experiences in such courses are rare or non-existent. In this article, I aim to provide lucid and detailed account of my approach, including specific examples, which may provide inspiration or guide the incorporation of similar approach in more methods courses and professional development opportunities. The components and examples discussed below are ones I have incorporated in my elementary science methods courses as well as previously taught secondary science methods courses. The modules and examples that will be discussed could also be ideal and applicable for implementation in K-12 classrooms.

APPROACH TO INFUSING STS FRAMEWORK

Teaching an STS curriculum is not about discussing a social issue in each class session or devoting a small amount of time to reading about such issues. On the contrary, due to its inherently interdisciplinary nature, STS-based instructional framework involves integrating societal and technological issues, exploring the interwoven relationship of STS, and teaching science within the context of society and technology. Students should have the opportunity to witness the relevance of the science content in their own lives, exhibit more interest in the science content and take ownership in their own learning, hence making it more meaningful for them.

In preparing pre-service teachers in my science methods course, I focus on enabling students to feel connected to the world around them so that real-life societal problems, such as climate change, do not appear abstract and beyond their control. My goal is to enhance preservice teachers' awareness of societal and environmental issues and foster environmental sensitivity, positive attitude toward STS and STS teaching, and willingness to act in resolving such issues and informing future students to take similar steps (Amirshokoohi, 2010; Amirshokoohi et al., 2022; Autieri et al., 2016). I place considerable emphasis on teaching students *through* inquiry by simulating the teaching/learning process and creating an immersive learning environment in which students are active participants constructing their own meaning through recognizing their prior understanding and modifying it through first-hand experience and engaging in discussions with peers and the instructor. Furthermore, I focus on contextualizing the content and making it pertinent to students' lives and emphasizing the significance of contextualized and relevant teaching. The first several weeks of the course are devoted to actively exploring and discussing the nature of science, process of scientific inquiry, constructivism, the 5E learning cycle model of inquiry-based instruction, and the importance of contextualized and relevant learning. This is followed by at least multiple sessions in the latter part of the course devoted to the instruction of science in its social context and using an STS framework, which has long been ignored in teacher education programs.

Teaching STS Through Constructivism & Inquiry

The constructivist, inquiry-based approach utilized in my courses emphasizes the processes of inquiry and decision making by not only stressing the investigative nature of science and how it directly relates and applies to the students' lives, but also by exploring the relationship that exists between STS. The inquiry practices serve as the driving vehicle in my classroom. An STS issue-oriented classroom requires all students to learn by constructing their own knowledge and understanding through active exploration and reflection on ideas and content. Thus, students play a dynamic and fundamental role in my STS-focused classroom by constantly interacting with us and one another and engaging in various forms of investigative and explorative inquiries, team and class discussions, viewing and discussing contentious videoclips, unit and lesson planning, role-playing, debates, simulations, and issue centered projects as recommended by STS educators (Loving, 1991; Pedretti, 1996). Similarly, an STS approach demands an instructor who is not the center of knowledge or dispensing information. As an instructor, I embark on a joint venture with my students as they raise certain issues and passionately explore them along with possible solutions. As a guide or facilitator of their learning, I ask them provoking questions, set the stage for investigation, encourage communication among students in their own individual teams and as a class, and create an arena for opposing and divergent views and student resolution of issues.

In adopting a constructivist, inquiry-based approach to introducing preservice teachers to STS model, I extend beyond simply "doing" science and technology or merely "teaching" about STS framework. Hence, the learning becomes context bound, meaningful and relevant to students as they participate in problem solving inquiries and explorations. Consequently, the students' knowledge and scientific process skills, as well as their teaching skills, develop in the context of issues and problems drawn from their own environments.

STS Model Alignment With 5E Learning Cycle

Instead of lecturing or assigning readings about STS-based instruction, I involve students in multiple abbreviated experiential learning modules to simulate and discuss 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, as described in the following sections. It should be noted that the 'evaluation' component of the learning cycle would occur as diagnostic, formative, and summative assessments and is not specifically discussed below.

STS issue identification (engage)

The first component of an STS unit, *issue identification*, connects effectively with the '*engage*' stage of the learning cycle. The idea is to find an engaging and intriguing way to pique students' interest and curiosity and pose the problem or issue that will be the focus of the unit and discuss why it is even considered an STS issue. For instance, to begin an STS unit focused on waste, I simulate an engaging introduction by displaying an official 'memo' that informs town residents about plans to build a proposed landfill in the community to get the students to reflect individually as possible community members. I then present a brief video clip showing the community members' reactions to the controversial plan. This is followed by a class discussion in which students think about the various perspectives that would be held by different stakeholders and STS issue, 'should the landfill be built in or near the town,' is identified as the focus of the unit and the interconnections of STS are then discussed.

I always strive to focus on local issues as it is best if STS curriculum initially focuses on issues most relevant to and of interest to the students. In one of the simulated modules, the issue stemmed from an actual highway construction project, which had become controversial and garnered extensive attention and discussions on public radio stations and town hall meetings. The planned highway project would connect several cities across the state and run through numerous neighborhoods and natural environments that would be home to countless organisms; hence, resulting in the disruption and destruction of many local ecosystems and their inhabitant.

Similarly, I do another simulation focusing on the issue of 'deer population control', which is incredibly relevant to the students in our state. To capture students' attention, I begin by showing a couple of brief deer encounter video clips such as deer entering a school or running into a group of athletes during practice on the field. Afterward, students brainstorm everything that comes to their mind upon encountering the word "deer". I then present a brief video clip raising the issue of deer over-population in a local county and excerpts from several editorials, newspaper clips, and articles, focusing on the controversies surrounding deer population control in the area.

STS issue analysis (explore/explain)

Once an STS issue has been identified, the next phase, which makes up the bulk of any STS unit, is the full analysis of STS issue and the underlying science, technology, and engineering content as well as cross cutting themes and content in disciplines such as social studies, mathematics, and literacy. To fully understand an STS issue and be able to critically analyze various stakeholder claims, solve problems, and make informed decisions with full consideration of the possible tradeoff in every decision made, students must engage in a series of authentic and collaborative inquiry-based exploratory activities (explore phase), each of which is followed by teacher-facilitated class discussions and gradual formal introduction of relevant concepts (explain phase).

In an actual STS unit in the classroom, this may take days or weeks, depending on the issue, but in my courses, I simulate one or two examples, and then provide students with a full listing of other possible exploratory activities and concept introduction phases. For instance, in the 'deer population' module, I first brainstorm a listing of possible science and interdisciplinary concepts that would need to be understood in order to effectively address the issue. Sample concepts include: organisms and their needs (food, shelter, water, etc.); population growth in general and deer population in particular, factors impacting population growth; interdependence and relationship among organisms and with their environments; history of deer population fluctuations at the state and national levels; impacts of deer population growth on their environment such as overgrazing; history of the impact of humans on the environment; and possible ways to control deer population (pros and cons of different management options).

I simulate one or two exploratory activities, such as a food web activity and the Oh Deer! Population activity (Project WILD, 1992) interspersed with related post discussions and introductions of relevant concepts of flow of energy in ecosystems, trophic levels, food chain and food web, interdependence of organisms and the environment, population size and factors such as food, shelter, and water availability, predation and natural disasters that impact population size. Then, I provide students with a listing of possible exploratory activities, each to be followed by class discussion and concept introduction, that could be incorporated as part of the issue analysis component of the unit. These include mapping activities to analyze the spread of deer in the area, graphing tasks to analyze relationship between human and deer population in the area, data analysis tasks to explore deer related accidents, and exploratory activities to understand various deer population management options.

At the end of the issue analysis component, I simulate a mock public townhall meeting, where students present arguments and recommendations from the viewpoints of different stakeholders such as farmers, city planners, environmental advocates, government officials, and average citizens either supporting or opposing the deer population control. This is followed by a question and answer session and brief debate among stakeholders.

Issue resolution

The final component is 'STS issue resolution' during which students participate in several summative projects and assignments by applying their newly gained understanding and attempting to address and possibly resolve the issue. In the modules I simulate in my courses, I discuss possible issue resolution ideas and actions that could potentially be undertaken by classroom students. For instance, in the 'landfill' module, students normally propose writing letters to county officials providing evidence-based arguments against building the landfill and suggesting ways to deal with the existing waste issue using the content learned in the unit. In the 'deer population' module, I discuss possible actions such as writing newspaper articles, creating educational and informative webpages, blogs, videos, or social media stories, as well as creating pamphlets or posters to be presented to younger students or parents and families. The issue resolution component is critical in allowing students to extend their learning by taking actions that impact the world around them and instill in them a sense of self-empowerment.

CONNECTIONS, RELEVANCY, & REFLECTION

My aim is to make connections between science concepts and everyday life and encourage pre-service teachers to do the same. I recognize that applying school science to real world science may help resolve some of the current issues teachers encounter in the science classroom. One of the key issues in science education is bridging the gap between the abstract and the concrete. Students may gain more enduring and in-depth conceptual understanding if their learning experiences are connected to relevant societal issues. Therefore, I focus on course content that presents science as personally meaningful and socially relevant to students in conjunction with modeling and promoting socially contextualized science instructional approaches in the classroom.

Another clear and significant advantage of planning and implementing STS-based units is that it allows teachers to simultaneously address a multitude of science content standards, disciplinary core ideas, science and engineering practices, as well as cross cutting concepts (NGSS Lead States, 2013) that are critical dimensions of learning science. This is another dimension of 'connection' and allowing preservice teachers to experience how teaching science content should be done in a connected and cohesive manner rather than as random and isolated lessons addressing different standards in disjointed manner. For instance, the deer overpopulation unit could potentially address state and next generation science standards related to basic needs of living things, interdependence of living things and their dependence on the physical environment, cycles of matter and energy transfer, ecosystem dynamics and functioning, ways in which various types of technology are used to meet human needs, impact of technology on humans and the environment, along with pros and cons of possible solutions to scientific and technological challenges in society.

Furthermore, an effective STS-based plan integrates other subjects such as literacy, mathematics, and social studies and, thus, enables teachers to address standards across multiple subjects as opposed to teaching each subject in a disparate and siloed manner. In the case of the deer overpopulation unit, I discussed not only the interconnections of science with technology and engineering content and practices, but also with

(1) mathematics content and skills such as graphing, data analysis, problem solving, and patterns and trends,

(2) social studies content related to civics rights and responsibilities, conflict and resolution, leadership and public service, competent and responsible citizenships, understanding maps, and analyzing historical data and patterns, and

(3) literacy content and skills pertaining to reading text, persuasive writing, debate, and presentation.

Finally, it is important to allow pre-service teachers numerous opportunities of ongoing reflection throughout their experience about the significance of being informed about STS issues as citizens and teaching students about them. I incorporate team and class reflections and discussion on the 'how' and 'why' of the various stages of STS framework, the interdisciplinary and inquiry-based nature of STS planning, and connections among various science content as well as with other disciplines and real-life.

APPLICATION: PUTTING IT INTO PRACTICE

Once students have been introduced to STS model, I provide them an initial opportunity to apply their understanding and practice what they have learned by examining several practitioner articles that focus on teaching science in its social context. Working in teams, students analyze the lessons or units described in the articles to determine the extent of alignment with STS model and provide suggestions for improvement considering our discussions and first-hand experience with effective features and components of STS-based instruction. Each article is then discussed as a class, which allows for further reinforcement of key ideas about STS model.

As a final means of applying their newly gained understanding of effective science instruction, the culminating course assignment involves students working collaboratively in teams to create an inquiry and STS-based 10-to-15-day unit revolving around an STS issue of their choice. During the final course sessions, teams present their STS units, microteach a portion of it, and embark on collaborative and constructive discussions. Teams have the option of focusing on any STS issue on the local, national, or international level, but are encouraged to make it as relevant as possible to the students and their communities. Most teams concentrate on a local issue or scenario either within the school or the local community as the context of their unit or create hypothetical scenarios that could apply to any school or community. Below are sample STS issues that students typically focus on:

- Deforestation/logging–Should areas of a local forest be cleared to allow for business and residentials districts to be expanded?
- Pesticide usage–Should pesticide usage be banned statewide/countywide?
- Poor nutrition (i.e., childhood obesity) –Should the school cafeteria revamp its menu to serve healthy food options?
- Water shortage–Should the school make financial investment to implement water conservation plan?
- Energy waste–Should the school make considerable financial investment to implement an energy conservation plan?
- Solid waste–Should the city allow a waste management company to build a landfill within the city limits?
- Air pollution–Should the city make considerable financial investment to adopt a clean air policy and revamp its transportation system?

As part of the unit plan, teams are instructed to identify their STS issue, create a list of science and other interdisciplinary concepts and/or standards related to their theme, and then lay out their unit plan in a 5E learning cycle format with the three STS components labeled. For the 'issue identification' component, which includes the 'engage' stage, students are to describe the scenario or problem they will use to initiate the unit to pique student interest. For the 'issue analysis' component, students are to describe the 'explore' stages (activities to allow student exploration of concepts) and 'explain' stages (tools and resources such as books, children's cartoon episodes, online videos, and guest speakers to help formally address the concepts). For the 'issue resolution' component, teams discuss ways they plan to have students apply their knowledge and take action to resolve the issue. Lastly, they are asked to also incorporate 'evaluation' as diagnostic, formative, and summative assessments throughout the unit plan.

CONCLUSIONS

The recent global pandemic, the spread of artificial intelligence technology, and the constant threats of climate change are just examples of ways in which our lives and the issues we face are intricately linked with science and technology and highlight the need for improving our education system to allow for developing an informed and engaged citizenry (Kazempour & Amirshokoohi, 2020; Sjöström & Eilks, 2018). The preparation of teachers and successfully equipping them to plan and implement socially relevant and contextualized science lessons is a critical step in achieving this goal. In this article, I aimed to describe possible ways of incorporating immersive and experiential learning opportunities within methods courses and teacher professional development to help pre and in-service teachers recognize the significance of socially contextualized science, and by extension STEM instruction, as well as prepare and support them in planning and implementing such an approach in their own classrooms.

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