Pathways to Considering Social Dimensions within SSI

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Abstract

Socio-scientific teaching and learning (SSI-TL) framework is a guide for developing an instructional approach to SSI-focused pedagogy. Despite the potential benefits of SSI-TL, teachers often struggle to implement this approach in their classrooms (Sadler et al., 2006; Saunders and Rennie, 2016; Zangori et al., 2018), and one of the most prominent reasons for this struggle is science teacher concerns and hesitation associated with incorporating social dimensions into their instruction. The purpose of this paper is to provide science teacher educators with tools to help teachers better manage the social dynamics with an issues-based approach. In doing so, we suggest an expansion of the SSI-TL framework such that it more explicitly highlights pathways for focusing on social dimensions of SSI within science learning environments. These pathways emerged as a result of a joint effort with 9 high school science teachers as they developed a unit around COVID-19; however, the pathways support science teachers as they implement science learning experiences that provide opportunities to negotiate social dynamics across most SSI, not only COVID-19. The pathways include systems modeling, connecting analysis to positions, media literacy, and social justice. We present how following each pathway integrates the social dimension of the focal issue, an example from the COVID-19 unit, and future considerations for science teacher educators as they help classroom teachers adopt an SSI approach.

Introduction

Socio-scientific issues (SSI) are complex, controversial problems with significant connections to science concepts but are primarily concerned with societal ideas. SSI highlight the interdependence of science and society for the benefit of developing potential solutions to society's most threatening issues rooted in scientific understanding (e.g., climate change, viral pandemics, antibiotic resistance). Although scientific proficiency is necessary to engage in SSI meaningfully, this understanding alone is not sufficient to render sustainable, fulfilling solutions; a deeper grasp of societal impact is key to appreciating the full magnitude of socio-scientific issues.

Many classroom teachers have positively acknowledged the possible benefits of using an SSI-based approach (Sadler et al., 2006; Saunders & Rennie, 2013), and the literature surrounding SSI-based instruction features resources for picking issues, constructing an SSI pedagogy, and structuring classroom dynamics (Bayram-Jacobs et al., 2019; Eastwood et al., 2012; Hancock et al., 2019; Lee & Yang, 2019). However, despite holding favorable perceptions of SSI and the resources available, researchers have identified that many teachers struggle to incorporate SSI beyond superficial context (Foulk et al., 2020). Teachers report struggling to integrate the social dimensions of SSI into their curriculum designs. In response to this need, this paper addresses this concern by establishing four pedagogical pathways for integrating the social dimensions within an SSI instructional approach.

A Model for SSI Teaching and Learning

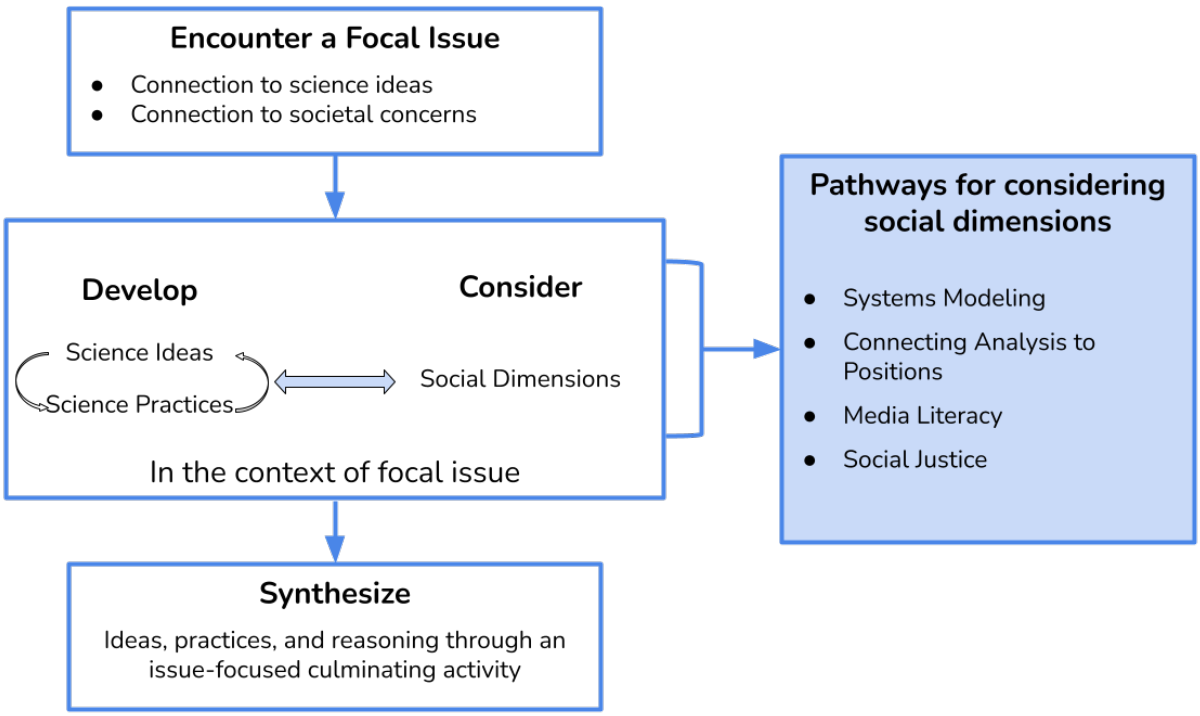
The SSI Teaching and Learning (SSI-TL) framework presents teachers with a guide for developing an instructional approach to SSI-focused pedagogy (Foulk et al., 2020; Hancock et al., 2019; Sadler et al., 2017). This framework was developed iteratively through a series of

design-based research studies which involved multiple rounds of teacher review and input (Sadler et al., 2017). SSI-TL identifies three distinct phases of instruction as it is carried out over a curricular unit. It highlights elements specific to science content while emphasizing the need to incorporate the societal dimensions of the issue being considered.

The left side of Figure 1 presents the SSI-TL as it stands now. First, students encounter a compelling focal issue, such as the COVID-19 pandemic, climate change, antibiotic resistance, or oil drilling, to set the context for learning and promote student engagement and motivation. The focal issue is the curricular anchor that contextualizes the following two phases. In the second phase, students explore the disciplinary core ideas (defined by the *Next Generation Science Standards*) needed to understand the focal issue (NRC, 2012). These ideas are developed with opportunities to engage with science and engineering practices such as modeling, argumentation, data analysis and interpretation, and explanation. Simultaneously, the framework suggests science ideas and practices develop in concert with considering the social dimensions of the focal issue. In the final phase, students have an opportunity to synthesize their perspectives on the social dilemma, new scientific understandings, and research and evidence in a culminating activity that is sharable with their classmates or a broader audience. This three-phase approach to SSI instruction provides multiple opportunities for learners to consider the complex dynamics at work within the focal issue (Hancock et al., 2019). Despite the potential benefits of SSI-TL, teachers often struggle to implement this approach in their classrooms (Sadler et al., 2006; Saunders and Rennie, 2016; Zangori et al., 2018), and one of the most prominent reasons for this struggle is science teacher concerns and hesitation associated with incorporating social dimensions into their instruction. The purpose of this paper is to provide science teacher educators with tools to help teachers better manage the social dynamics with an issues-based

approach. In doing so, we suggest an expansion of the SSI-TL framework such that it more explicitly highlights pathways for focusing on social dimensions of SSI within science learning environments. The right side of Figure 1 reflects our additions.

Figure 1: SSI-TL Framework



This expansion of the SSI-TL leverages teachers' discretionary autonomy in determining the best approaches for composing an SSI learning sequence. Huizinga and colleagues (2014) determined that teachers have more successful SSI implementation when they are involved in the curriculum design process; therefore, by offering pathways for considering the social dimensions, we hope to empower teachers to feel more confident in managing the social dynamics of SSI in their curriculum designs. The pathways are systems mapping, connecting analysis to positions, media literacy, and social justice. As pathways for considering the social dimensions of SSI, each approach offers a way for learners to engage in social considerations

that are challenging for teachers to incorporate in their science classrooms. These pathways are explored more thoroughly in the following sections.

Context

This paper emerged as the result of a research project in which we worked with science teachers to develop an SSI unit centered around COVID-19. We invited nine high school science teachers to participate in a professional development (PD) experience that included a two-day session in Spring 2020 (just as COVID-19 began to spread in the US) and a four-day workshop in July 2020 (as schools were planning for instruction in the 2020-2021 school year). Collaborative curriculum design served as an overarching frame for the PD experience (Huizinga et al., 2014). During the workshops, classroom teachers co-designed an SSI-based unit following the SSI-TL, which centered around the COVID-19 pandemic, to be used in their classrooms during the 2020-2021 school year (and beyond). Teachers were given autonomy on curricular decisions while the research team served as facilitators and resources for SSI teaching. During the 2020-2021 school year, seven teachers implemented the SSI unit in their science classrooms and participated in follow-up interviews. During that time, the research team refined and organized the instructional activities developed during the PD to prepare them for dissemination to the broader community. During this process, and with the help of teacher feedback, the researchers identified pathways to support science teachers as they implement science learning experiences that provide opportunities to negotiate social dynamics across most SSI, not only COVID-19.

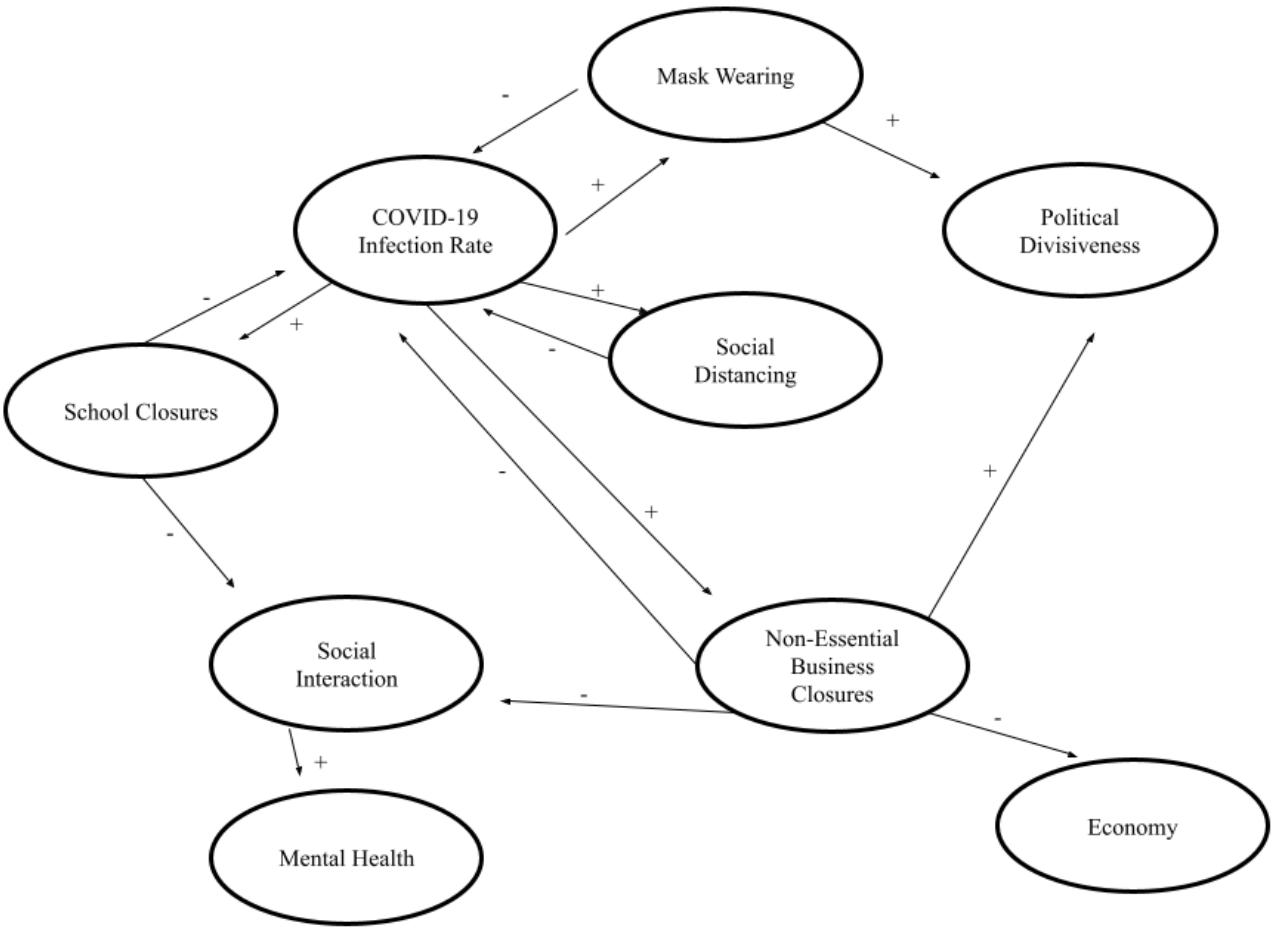
Pathways to Consider Social Dimensions

SSI teaching is dependent on students exploring scientific and social dimensions of an issue. In this section, we detail how each of the four pathways serve as a method to engage learners in considering the social dimensions of SSI.

Systems Mapping

Systems thinking is a broader term used to describe epistemic habits that allow for predicting, modifying, and engaging with complex systems (Ke et al., 2020; Sadler et al., 2007). "Systems" are identified by NGSS as a crosscutting concept; systems thinking is an analysis that allows for identifying patterns, cause and effect relationships, and grasping the magnitude of the system and potential solutions or outcomes (NRC, 2012). A systems map is a type of model that engages students in systems thinking while investigating the complex social and scientific elements of SSI. Because socio-scientific issues have implications in society and science, there are dimensions of the model that are not strictly scientific in nature. It is a tool to help better understand the dynamics of the science and social components of SSI from a systems thinking perspective. For example, Figure 2 illustrates the social and scientific elements of a specific SSI, COVID-19, in a systems map. By making visible the connections among elements of an issue, the systems map encourages analyses of how elements affect one another in direct and indirect ways. As Figure 2 demonstrates, these elements relate to policy, economics, cultural norms, and scientific evidence.

Figure 2: COVID-19 Infection Rate Systems Map



An advantage of using systems mapping as a form of modeling is that it allows for a more comprehensive analysis of all of the dimensions socio-scientific issues present. In the systems map depicting the ramifications of COVID-19 (see Figure 2), there are scientific components such as wearing masks and social distancing, and there are social impacts such as economic implications and limited social interaction. Another advantage of using a systems map is that it is a type of scientific model. As a science and engineering practice identified by NGSS, scientific modeling is a critical practice involving identifying forces at work and analyzing their relationships. A key feature of scientific modeling is the possibility and necessity of revising the original model; therefore, as learners develop their scientific awareness, there should be

opportunities to return to original systems maps, make revisions, and add evidence to support claims. As learners build and revise their models, they examine the social, political, behavioral, and scientific components that teachers have reported struggling to integrate with the content, making it an opportunity for learners to consider the interconnectedness of science, people, organizations, government, and culture in society. This type of activity highlights the inherent complexity of SSI and prepares learners to begin engaging in productive epistemic habits such as considering the social dimensions of the issue.

Connecting Data to Positions

Data analysis is typically understood as a strategy for systematically analyzing scientific data; however, in science classrooms, analysis can extend to other forms of data that can inform positions and perspectives. Investigating different types of data through analytic tools, such as graphical interpretation, visualization, or statistical analysis, develops an evidence-based understanding of social trends, economic factors, and political forces at play within the focal issue. By examining different positions and data sources, learners are exposed to diverse perspectives. A key feature of SSI is that there are typically multiple approaches for resolutions; however, this does not mean all perspectives are equally tenable. By engaging in diverse data analysis and interpretation, learners are pushed to engage with issues beyond a personal framework to recognize the substantive challenges present in any solution strategy.

One example of this type of analysis is to investigate how government responses to SSI impact social factors such as health, education, infrastructure, and economic opportunities. For instance, national responses to COVID-19 varied significantly across the world. By providing students an opportunity to analyze COVID-19 data from multiple countries, interpret the data in relation to their government policies, and form personal opinions about policy implementation

and infection rate, students are prompted to think critically about the government's role in responding to natural disasters and the resulting consequences of government action or inaction. This activity requires learners to view the issue from multiple perspectives by considering implications for public safety, economic repercussions, and political interests when implementing any national policy. Developing such analysis skills in a political context opens the discussion of questioning stakeholders, thinking critically about government action, and using evidence to drive decision-making. This type of critical thinking exercise supports learners as they examine social and scientific dynamics of SSI from the national level down to personal responsibility. Through engaging with diverse types of data, learners are exposed to opportunities to negotiate the social implications using scientific evidence to develop a personal position.

Media Literacy

SSI are frequently reported on in the media through traditional venues and social media outlets. Because of their contemporary relevance, accessing information about SSI and considering how SSI are represented through media is essential for negotiating SSI in the modern world. Therefore, SSI teaching should incorporate opportunities for learners to build skills associated with accessing reliable information about SSI through media. However, media does not divide issues in terms of disciplines, making it interdisciplinary by nature. Therefore, media literacy skills are a set of skills that allow students to explore and interpret media messages which address multiple dimensions of issues, positioning media literacy as a constructive pathway for considering social dynamics within SSI.

The value of media literacy is largely uncontested in the science education community; however, a framework for engaging in media literacy skills and practices within the science

classroom context presents more challenges (Bautista and Batchelor, 2020; Dani et al., 2010; Sperry, 2012). This challenge is exacerbated by the equivocal nature of media literacy skills because there is no one way to practice media literacy. We recommend characterizing media literacy in science classrooms through defining media literacy and the associated conventions, recognizing common pitfalls, and practicing using the tools to develop these skills. In doing so, learners are exposed to opportunities to generate and evaluate different positions pertaining to the issue.

SSI predicates scientific issues as civic ones. Therefore, using media literacy abilities to analyze and think critically about media texts informs participation through public discourse. By foregrounding media literacy, educators empower learners to circumvent the influences of misinformation campaigns and media bias to allow for responsible citizenship participation. By providing the skills to access SSI through media, media literacy is one way in which SSI bridges science learning to lived experiences.

Social Justice

In addition to media literacy, SSI bridge school environments to students' lived experiences through significant social justice implications. For example, climate change is arguably the most prominent SSI on the planet, with impacts being experienced across the globe, and yet, the most profound and damaging impacts are on marginalized communities. Science educators who choose to engage in culturally relevant pedagogy (CRP) recognize their role in bridging the gap between science concepts and the lives of their students (Ladson-Billings, 2009). Understanding scientific principles is required to fully recognize the discrepant struggles SSI present across race, class, gender, and/or other identifying lines in society. CRP as a teaching philosophy uses the skills and knowledge constructions acquired in school to help learners better

understand their position in society and the context for why that is. As a pathway for considering the social dimensions, appealing to a justice-oriented perspective opens the classroom up as a space to investigate, question, debate, and change established systems that contribute to patterns of injustice. Furthermore, the ability to critically assess social, political, and economic structures for inequities using scientific principles informs reasoning skills necessary in civic participation.

To leverage social justice as a pathway for integrating the social dimensions of SSI into the classroom, students need opportunities to investigate the systemic barriers, advantages, and incentives alongside their peers. Examples of ways to accomplish this can be through case studies or participating in activities that intentionally promote civic participation, such as letter writing. The method of engaging in social justice is less important than the conversations and positions that are developed through this pathway. For example, using a case study that details the challenges a family can face when accessing a COVID-19 testing site can take the form of storyboarding or a mock town hall meeting. The conversations surrounding systemic racism, socioeconomic status, trust of institutions, and access to resources are essential to consider the social implications inherent within the issue.

Conclusion

Socio-scientific learning experiences should present students with opportunities that challenge them to construct balanced positions, which include scientific understandings with the social implications; together, the two inform future citizenry. While the SSI-TL framework provides an overarching guide for organizing an SSI unit, as it stands now, it fails to guide teachers in ways to engage students in considering the social dimensions of the issues. Incorporating systems mapping, connecting analysis to positions, media literacy, and social justice into the SSI-TL as pathways for considering the social dimensions creates space for

negotiating the dynamic relationship between scientific understanding and societal complexities. As an identified challenge of SSI pedagogy, the social dimensions are made visible and approachable through systems modeling, data and policy analysis, media literacy, and social justice. Teachers can utilize these pathways to bridge the gap between scientific competency and the social implications.

As we consider the implications of this work, we are interested in using the expanded SSI-TL in our future work with K-12 teachers. We think this expanded framework supports science teacher educators to help teachers better incorporate societal considerations into their SSI units. We believe it would be productive to use this framework in teacher education settings as well as in-service opportunities to make sense of and embrace this approach as a meaningful tool for student learning. The expanded SSI-TL highlights pathways for focusing on social dimensions of SSI within science learning environments.

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