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Socioscientific Issues: Theory and Practice

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Abstract

Drawing upon recent research, this article reviews the theory underlying the use of socioscientific issues (SSI) in science education. We begin with a definition and rationale for SSI and note the importance of SSI for advancing functional scientific literacy. We then examine the various roles of context, teachers, and students in SSI lessons as well as the importance of classroom discourse, including sociomoral discourse, argumentation, discussion, and debate. Finally, we discuss how SSI units, which encourage evidence-based decisionmaking and compromise, can improve critical thinking, contribute to character education, and provide an interesting context for teaching required science content.

Introduction to Socioscientific Issues

Definition

Socioscientific issues (SSI) involve the deliberate use of scientific topics that require students to engage in dialogue, discussion, and debate. They are usually controversial in nature but have the added element of requiring a degree of moral reasoning or the evaluation of ethical concerns in the process of arriving at decisions regarding possible resolution of those issues. The intent is that such issues are personally meaningful and engaging to students, require the use of evidence-based reasoning, and provide a context for understanding scientific information (Sadler, 2004a; Zeidler, 2003). This paper describes the theoretical model for using SSI in the classroom, while our companion article, which will be published in the summer issue of this journal, describes practical examples of SSI use in a 5th-grade classroom.

Rationale

Of course, the idea of teaching via controversial topics and more recently, SSI has been recognized in the international science education community and by the national documents of many countries in one form or another (Kolstø, 2006; Levinson, 2006; Ratcliffe & Grace, 2003; Ratcliffe, Harris, & McWhirter, 2004; Zeidler & Keefer, 2003). However, missing from most science classrooms are engaging activities that focus on contemporary social issues that require scientific knowledge for informed decisionmaking. While certain scientific principles require specific instruction, the development of pedagogical models dealing with contemporary issues in general, and SSI in particular, must necessarily include students' active participation in developing argumentation skills, the ability to differentiate science from nonscience issues, and the recognition of reliable evidence and data.

Two central presuppositions of the SSI framework that provided a rationale and direction for how the learning process unfolded informed our approach. First, our selection of many moral and ethical scenarios throughout the academic year had to do with our recognition that students' interests, more times than not, are not isomorphic with our educational objectives. Generally, students tend not to think about the structure of the cell, the periodic table, or the laws of thermodynamics. Students do not typically think about any topic that is not personally relevant. This begs the question, "What is personally relevant to students?" Phrased differently, "What do students think about?" The answers, so it seems, are not surprising. Generally, students think about themselves, whatever affects them personally, and what other people think. We do not imply this represents the sum total of their world, but it is a good starting place to get their attention. Second, our framework has suggested that contextualized argumentation in science education may be understood as an instance of education for citizenship. It follows that it is essential to present the humanistic face of scientific decisions about moral and ethical issues, and the arguments and evidence used to arrive at those decisions. Separating the learning of the content of science from consideration of its application and its implications is an artificial divorce (Sadler & Zeidler, 2005; Zeidler & Sadler, 2008b).

Distinction from Science, Technology, and Society

It is important to note that the SSI framework goes "above and beyond" past notions (at least how typically practiced) of science, technology, and society (STS) education. While STS education emphasizes the interrelationships among science, technology, and society, it seems to lack a theoretical framework that informs teachers and those involved in program development of pedagogical strategies that acknowledge the social development of children's identity as part and parcel with the curriculum. We have stated previously that "Socioscientific Issues, then, is a broader term that subsumes all that STS has to offer, while also considering the ethical dimensions of science, the moral reasoning of the child, and the emotional development of the student" (Zeidler, Walker, Ackett, & Simmons, 2002, p. 344). The SSI framework, as my colleagues and I have conceptualized it, is informed by developmental and sociological research that acknowledges the epistemological growth of the child and the development of character (Zeidler & Sadler, 2008a; Zeidler, Sadler, Simmons, & Howes, 2005).

SSI and Scientific Literacy

A conceptual SSI model of "functional scientific literacy" has been suggested elsewhere (Zeidler, 2007; Zeidler & Keefer, 2003; Zeidler et al., 2005). The theoretical framework was proposed both because of its utility in addressing SSI in terms of the psychological, social, and emotive growth of the child and its flexible sensitivity to multiple perspectives of science education research as it relates to scientific literacy (SL). In this conceptualization, functional SL, in contrast to more traditional notions of SL that are more technocratic in nature, is dynamically mediated by personal cognitive and moral developmental considerations. These considerations include factoring in character and cognitive and moral development and include the use of (but may not be limited to) cultural, discourse, case-based, and nature of science issues.

Our realization of functional SL lies in how these areas are orchestrated together with an eye toward providing developmental conditions necessary for the formation of responsible, evidence-based reflective judgment, conscience, and character. Hence, shaping students' epistemological belief systems may be a bit of a novel consideration in contemporary science education practice, but it is central to the advancement of an SSI approach to science education. Other researchers have acknowledged the connection between SSI and SL (Aikenhead, 2006; Pouliot, 2008). As the three examples in the companion piece will show, Pouliot (2008) strikes a chord in this regard that obviously resonates with us.

It is now commonplace in science education that the study of SSI by students constitutes a prime avenue for fostering SL of a kind that will prompt young people to familiarize themselves with science in action, to develop their capacity for evaluating the information made available to them on a daily basis, to make decisions concerning controversial sociotechnical issues, and to take part in debates and discussion on sociotechnical controversies of concern to them (Pouliot, 2008, p. 545).

SSI and Pedagogy

Role of the Context (SSI Context)

Teachers looking to the Web for SSI fodder may recognize that Internet and issues-based learning activities can also be an invaluable resource in terms of exposing students to diverse perspectives on current scientific reports and claims. Again, current research can suggest important ideas to inform practice. With scaffolded learning interfaces (e.g., Walker & Zeidler, 2007), students can spend their time reading and evaluating the multiple perspectives of a given socioscientific issue instead of "surfing" through a plethora of sometimes misleading information. Of course, this requires that teachers invest the time upfront to find both reliable as well as potentially unsound sources of scientific data and perspectives, so students may be confronted with mixed evidence and learn to assess the validity of varied claims and data.

Role of the Teacher

While encouraging students to consider evidence-based alternative arguments is of primary importance, it is equally important that teachers who are interested in using debate or discussion-focused activities also consider the match between their own pedagogical expectations and the theory base guiding the research. For example, a teacher engaged in SSI would need to rely on research and current information about a given topic to better direct classroom debates through various lines of questioning (e.g., epistemological, issue-specific, role reversal, and moral reasoning probes). The importance of exposing students to discursive activities in the science classroom cannot be overstated if our goal is to increase SL. Putting together an SSI module does not simply mean selecting a scenario where science or technology can "save the day."

Role of the Students

Moving SSI from theory to practice is essential in contemporary classrooms. Science education that includes SSI offers unique opportunities to challenge

students' moral reasoning and, in the process, presents concepts that seem to make sense because of the relevance and individual interest. Consistently, we have found that the main competition to understanding and coherence are core beliefs, pseudoscience, and lack of personal experience in moral decision-making (Zeidler, Sadler, Applebaum, & Callahan, 2009). The challenge to science teachers is to allow students to discredit their own belief system by having opportunities to formulate new perspectives. Our experiences have allowed us to identify several areas that are potentially problematic for students when engaging in SSI. Student impediments to success tend to include moral (core) beliefs, scientific misconceptions, lack of personal experiences, lack of content knowledge, underutilized scientific reasoning skills, and emotional maturity. In presenting this list, we do not mean to dissuade teachers from attempting an SSI approach. In fact, it is our position that insofar as students have such impediments, that we have a responsibility to provide them with opportunities to challenge their personal belief systems about the social and natural world in order to make connections. As the examples in the companion piece will show, the moral component of SSI is what triggers the students' need for more (content) information, critical thinking, constructive argumentation, and compromise.

SSI and Classroom Discourse

Sociomoral Discourse

Sociomoral discourse is a central necessity when issues of inquiry, discourse, argumentation, and decisionmaking become a focal point in an SSI classroom. It occurs when one student's reasoning influences that of another, and, in return, a reciprocal relationship is forged. Such transactive discussions have been described in the literature (e.g., Berkowitz, 1997; Berkowitz, Oser, & Althof, 1987; Zeidler & Keefer, 2003) and have proven to enhance the quality of reasoning by providing varied viewpoints that require the use of counterpositions, evidence, and just solutions over the course of development. Students are apt to experience dissonance when ideas or evidence are presented that do not immediately fit into their past experiences. The dissonance compels students to negotiate, resolve conflicts, and enhance the quality of their own arguments.

Argumentation and Debate

The inclusion of argumentation and debate in the science classroom is a rising area of interest among science educators just as issues of social controversy in science are proliferating with the advancements of technology. Although there are a number of useful approaches to assessing student discourse (Bell & Linn, 2000; Sadler, 2004b; Zeidler, 2003), much work needs to be done in developing effective pedagogical approaches that pay particular attention to elementary, middle, and high school students' conceptual understanding of science content knowledge and the structure and function of sound argument. Using argumentation and debate, however, is a useful means to engage thinking and reasoning processes, and to mirror the discourse practices used in real life in the advancement of intellectual and scientific knowledge. For the purposes of the classroom practice, a focus on tolerance, mutual respect, and sensitivity must be modeled and expected.

Discussion

Productive debate and argumentation is not always practical or even possible in every educational setting, particularly for educators with little experience managing it. Teachers may first consider guided discussions rather than debate. Such discussions can allow educators to address controversial socioscientific topics in a more controlled manner, which may be especially helpful in certain contexts. The unit involving the harp seal hunt in the companion piece, which can provoke strong emotions in children and adults, is a good example. Practicing by having a discussion before attempting a debate may also help both the teacher and the students to incorporate the behaviors that will ultimately make argumentation more productive.

Critical Thinking

Whether business, politics, or both motivate concerned citizens, calls for increased SL typically include a plea for the education system to produce students who are critical thinkers. One of the benefits of including an SSI curriculum is that the discussion and debate of controversial socioscientific issues necessitates that students develop many of the skills and dispositions associated with critical thinking. The core creative thinking skills of analysis, inference, explanation, evaluation, interpretation, and self-regulation (Facione, 2007) will all be encouraged by SSI units as will the dispositions associated with them. Incorporating SSI can therefore help to produce students who are truth-seeking, open-minded, analytical, systematic, judicious, and increasingly confident in their reasoning.

SSI and the Context for Evidence-Based Decisions

Integrating Science Content

Our working assumption within the SSI framework is that SSI units of study afford the context for students to understand, through carefully crafted experiences, that scientific knowledge is theory-laden and socially and culturally constructed. The extent to which students internalize this depends, of course, on their developmental readiness. The process of experiencing science "in the making" would look different across varied grade levels. However, our central approach remains essentially the same regardless of grade level. Appendix A reflects the teacher's role by illustrating the pedagogical relationships between the teacher and the students in the SSI discourse. The teacher's role becomes secondary (but not less important) in relation to the SSI, which provides the social context for understanding scientific content, and the inquiry methods and reasoning skills students bring to bear on working their way through the issues. The teacher must learn to direct, prod, orchestrate, and facilitate, but it is clearly the students' engagement in the issue that is of central importance.

Cross-Curricular Connections

One of the advantages of an SSI curriculum, particularly at the elementary level, is that it lends itself to interdisciplinary connections. Many educators feel there is not enough time for science in elementary grades. However, a carefully designed SSI topic can involve a mix of reading skills, science content, social

studies, mathematics, and art, as well as providing students (and their teacher) with real experience involving moral reasoning, epistemological development, and peer debate. As students get older, their education becomes increasingly focused and insulated, a process many believe reduces the overall effectiveness of science education. SSI units encourage the integration of scientific and nonscientific disciplines rather than their separation, which helps provide students with real, believable context. That context, in turn, provides motivation to learn science content by making it seem more relevant and interesting.

SSI and Character

We have made the argument elsewhere that moral education and its related forms of character education presupposes the formation of conscience (Zeidler & Sadler, 2008a). By this we mean that in the process of cultivating scientifically literate citizens, our aim is to foster the formation of a collective social conscience. The goal is to instill the desire to consistently hold one's actions up for internal scrutiny (i.e., reflective reasoning), which is a fundamental feature of conscience. By participating in carefully designed, socially responsible activities, students will hopefully develop or have reinforced such qualities as reliability, trustworthiness, dependability, altruism, and compassion. SSI education requires contextualized argumentation; we recognize that this provides an opportunity to practice education for citizenship. Democratic group decisionmaking, facilitating understanding, fostering human values and caring, and nurturing emotional intelligence are central in an SSI classroom and recognized as building blocks of character (Berkowitz & Grych, 2000; Wellington, 2004). It is noteworthy that approaches emphasizing character have been shown to have a direct impact on academic achievement (Benninga, Berkowitz, Kuehn, & Smith, 2003; Berkowitz, Battistich, & Bier, 2008).

Our recent research has shown that teaching within the context of socioscientific issues can increase students' moral sensitivity, thus contributing to overall moral development (Fowler, Zeidler, & Sadler, 2009). Students have been shown to recognize and be concerned with the lives, health, and well-being of other people (Sadler, 2004b). However, the effectiveness of this is related to the type of SSI used. The exact nature of how the context of the SSI influences moral sensitivity needs further study if SSI are going to be used as a pedagogical tool in the science classroom.

Summary

Science teacher education is primarily concerned with providing viable frameworks that teachers can utilize to engage students in the activity of science and develop meaningful (functional) notions of scientific literacy. For preservice and practicing teachers, the realization that science education for many (most) students has included years of indoctrination, dogmatism, or authoritarianism is a sobering epiphany. However, there is no place in science and, therefore, no place in science education for the protection of concepts and theories from criticism. The challenge for science teachers is to allow students to have personal experiences that do not immediately negate their belief systems; rather, the aim is to provide the conditions necessary to enable the development of a personal epistemology through continued exposure to, and interaction with, the nature of science and SSI. The use of argumentation and relevant SSI as a framework for science class

curricula is essential for enabling scientific concepts to enter students' individual belief systems.

The fatal flaw held by many teachers is their own pedagogical belief that concepts can be taught using sufficient explanations and tidy analogies that will then magically alter students' core beliefs. The use of SSI strategies challenges students to reevaluate their prior understandings, providing an opportunity for them to restructure their conceptual understanding of subject matter through personal experiences and social discourse.

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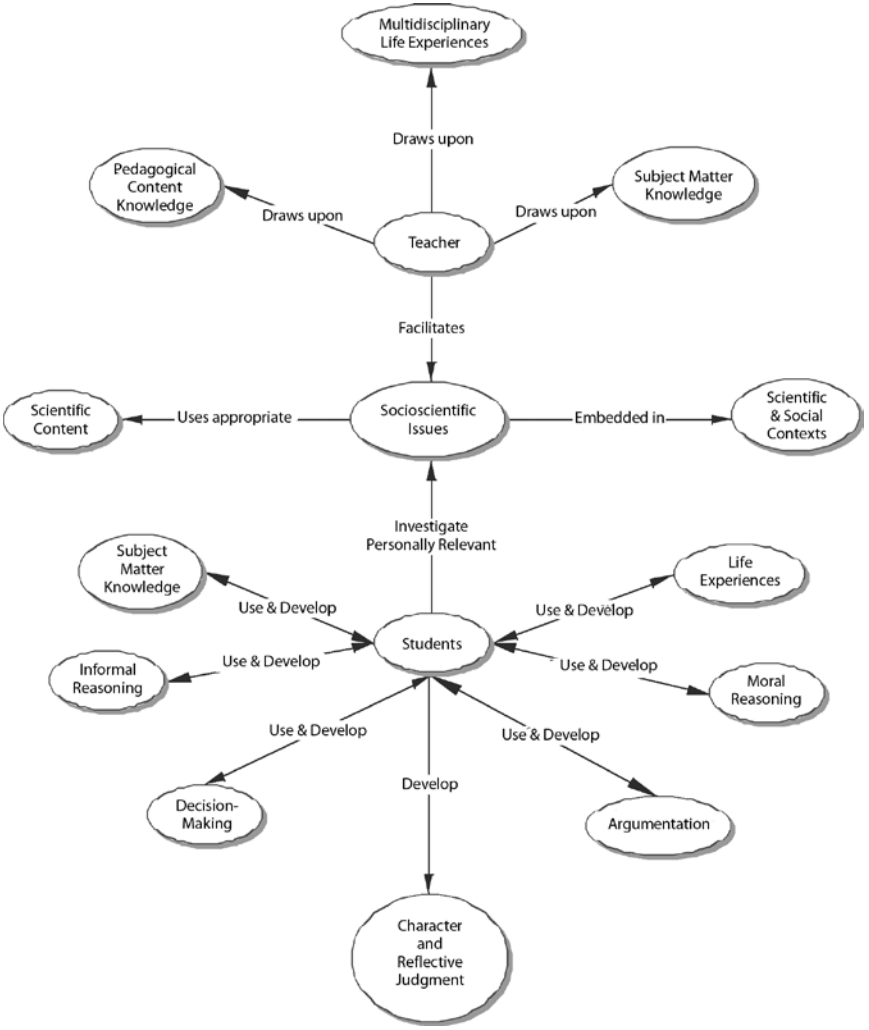
Appendix A

Pedagogical Relationships Between Teacher and Students' SSI Discourse



Taken from Zeidler et al. (2009)

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