Controversial issues in the science classroom

Teaching students how to consider some of the most difficult science issues of our time will better prepare them to be scientifically literate citizens.

By David C. Owens, Troy D. Sadler, and Dana L. Zeidler

As the nation's political divide widens and becomes more toxic to civil discourse, the role of science in public debates becomes increasingly suspect. On a wide range of hot-button issues — from the use of stem cells in research to debates about emissions standards and climate change — partisan advocates tend to stake out their positions along ideological lines, with little or no grounding in scientific evidence. And to the extent that they do bring science into their arguments, their reasoning is often wittingly or unwittingly fallacious.

Whatever one's political stance or party affiliation, it may be tempting to argue that it's the other side that distorts and rejects scientific evidence. Given, for example, the reluctance of most conservatives to acknowledge the evidence concerning anthropogenic climate change, and given the Environmental Protection Agency's recent decision to allow chlorpyrifos pesticide to remain on the market (even though the EPA's own scientists

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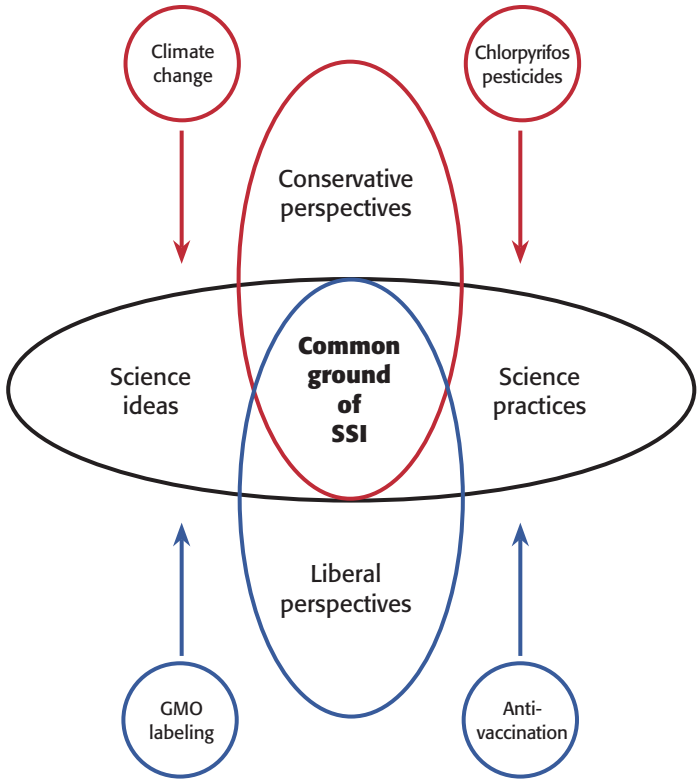
FIGURE 1.
The Common Ground model of SSI



have concluded that it is dangerous to human health), one might conclude that right-learning partisans are responsible for the assault on scientific reasoning. Equally disconnected from science, however, are positions that originated from the left (Berezow & Campbell, 2012), such as the refusal of many parents to vaccinate their children and the movement to put warning labels on all foods that contain genetically modified organisms. We suggest, therefore, that the rejection or inappropriate use of scientific evidence is not strictly a partisan problem. Rather, it resides at the level of the individual.

Of course, while evidence-based perspectives are essential to making sound public policy decisions, these are not the only perspectives that matter. The thorniest controversies often revolve around *socioscientific* issues, which require citizens and policy makers to make arguments that draw upon scientific evidence while also addressing morality, ethics, economics, and the like.

For example, liberals may be skeptical of GMOs not just because of safety concerns but also because they fear Monsanto's monopolization of the agricultural sector, while conservatives may argue that the regulation of GMOs represents governmental overreach. No matter which perspective one takes, it is a brute scientific fact that GMOs enable more food to be grown on less land and with fewer fertilizers and less water — all requisite to keep an exploding population from going hungry. But while the facts are indispensable to an informed understanding of these issues, any attempts at their resolution must integrate social, economic, and political perspectives, among others (Sadler, 2009).

Given that formal opportunities for individuals to learn about, discuss, and debate socioscientific issues begin to wane after high school, it is imperative that students are provided ample opportunity to do so throughout the formative years of K-12 education. This includes opportunities to seek out trustworthy information, develop positions concerning controversial issues, practice defending those positions using scientific evidence, and respectfully evaluate alternative positions held by others.

A socioscientific issues approach

When teachers employ a socioscientific issues (or SSI) approach to classroom instruction, they engage students in developing and evaluating arguments about challenging problems of public importance. Though several solutions may seem plausible, none is likely to benefit all stakeholders equally, and a scientific understanding alone is unlikely to result in the successful resolution of the issue. Science does, however, offer an understanding of the natural world that everyone can similarly access through practices that include the systematic collection and analysis of data and the replication of studies, thus serving as a nonpartisan "common ground" that all students can share and that can provide a basis for agreement.

Figure 1 highlights how an evidence-based understanding derived from scientific practices can inform both conservative and liberal perspectives, providing a starting point from which individuals from both sides of the aisle can begin to negotiate contentious issues and move toward a common understanding. Practicing science in such a manner can help prepare students for the responsibilities of democratic citizenship while strengthening their content knowledge, helping them see both the benefits and limitations of scientific inquiry (Reiss, 2003), and giving them opportunities to practice robust argumentation and develop reflective judgment (Zeidler, 2014).

The SSI approach has been codified through an instructional framework that helps teachers and curriculum designers consider key elements for enacting SSI as learning experiences. The model includes three phases (Figure 2). In the first phase, students "encounter" (or are introduced to) an issue. In the second — which comprises the bulk of the teaching and learning — students study the social and scientific components undergirding the issue. And in

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the third, students attempt to reach a resolution of the controversy. These phases are discussed in detail below.

#1. Encounter the issue.
In this phase, students develop an awareness of the issue, including the relevant scientific content as well as the social and political conflicts associated with it. For example, a teacher might begin an SSI unit focused on the labeling of GMOs by providing students with familiar items from the grocery store and asking them to identify those that are or are not genetically modified. The teacher might show a short video of people in a resource-deprived area who are able to survive because of drought-resistant crops, followed by a perspective from individuals who consider the practice of genetic modification to be unethical. Students could then be introduced to DNA and its important role in genetic engineering as well as some of the social issues that might make banning GMOs a challenge.

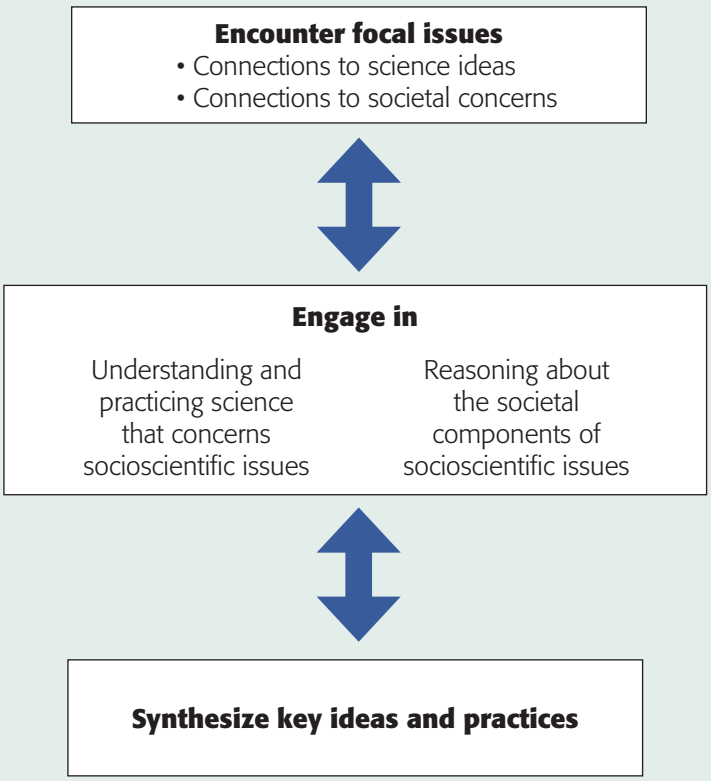
#2. Study the science and engage in reasoning.
Students then learn about the science and explore the underlying social components of the SSI. For example, when studying GMOs, students might learn about inheritance and variation of traits, and engage in science practices such as creating models that explain the similarities and differences between genetic engineering and traditional breeding. To tackle the social components of the GMO issue, students might explore the perspectives of various stakeholders — such as farmers, corporations, and individuals who depend on GMOs — and look for contradictions or instances of bias in "scientific" accounts.

#3. Synthesize key ideas and practices.
In the final phase, students reflect on how their own perspectives have changed by engaging in science learning and socioscientific reasoning about the issue. Often, this involves a culminating activity such as a debate about the safety of GMOs or the creation of a policy statement that requires a synthesis of scientific ideas and practices with consideration of the issue's social components.

Implementing SSI-oriented instruction

Introducing students to relevant and contentious issues, helping them contextualize science ideas and practices toward the resolution of those issues, and tasking them with creating effective arguments and evaluating those of their peers is critical for promoting the kind of civil discourse that democracy

FIGURE 2.
The SSI Teaching and Learning model



Source: Sadler, T.D., Foulk, J.A., & Friedrichsen, P.J. (2017). Evolution of a model for socioscientific issue teaching and learning. *International Journal of Education in Mathematics, Science, and Technology, 5.*

Socioscientific issues vs. traditional science instruction

Less emphasis on . . .	More emphasis on . . .
Discussing science in isolation	Discussing science concepts and understanding in the context of personal and social issues
Working alone	Collaborating with a group that simulates the work of a scientific community or represents authentic groups found in society
Acquiring scientific information	Acquiring conceptual understanding and applying information and conceptual understanding in making and evaluating personal, social, and global decisions
Closed questions with one correct answer	Open-ended questions that require students to explain phenomena or take positions backed by evidence
Multiple choice assessments	Authentic assessments

Source: Wilmes, S. & Howarth, J. (2009). Using issues-based science in the classroom. *The Science Teacher, 76* (7), 24.

requires, but it can be a daunting task for teachers. Traditional science education has generally focused on dispensing established and secure knowledge while relegating controversial or ethical topics to the sidelines (Hodson, 2003). Doing so enables teachers to avoid conflict with students, parents, and other stakeholders by removing controversial issues from the curriculum and keeping their own ethical perspectives to themselves. Yet, these topics that teachers deem too controversial to teach are precisely the kinds of issues that are most relevant to students' lives and to the development of democratic citizenship (McGinnis & Simmons, 1999). Avoiding such issues obscures the nature of science and leaves students to their own devices as to how they reconcile a value-free understanding of science with the value-laden realities of SSIs (Zeidler & Sadler, 2008).

Every scientific advancement introduces new ethical dilemmas that must be examined from scientific and moral standpoints.

Including contentious issues and discussion of values and ethics in classroom settings does not have to be a difficult or risky business for teachers. For example, Friedrichsen and colleagues (2016) describe an SSI learning experience in which students begin their investigation by exploring their own personal values that may interact with the issue. Allchin (1999) suggests that a value-laden classroom discussion might include reflection on the values inherent to the scientific enterprise itself. Researchers bring their personal values with them into any scientific investigation. Those personal values may create or constrain the types of questions they ask, the observations they make, and the conclusions they draw. However, a scientist's personal values need not be obstacles to the scientific enterprise — rather, a variety of perspectives is critical to identifying preconceptions in research, serving as a hallmark for the peer review process that advances science. Furthermore, every scientific advancement introduces new ethical dilemmas that must be examined from scientific and moral standpoints. For example, a discussion of emerging STEM cell technologies would be incomplete without mention of the moral commitments that might be diametrically opposed to such advancement. Thus, normalizing the discussion of ethics and values first by addressing those inherent to the nature of science itself can open the door to discussing the ethics and values of SSI that may be more sensitive or contentious.

Perhaps most important to the inclusion of controversial issues to guide formal instruction is that teachers and students together establish and main-

tain a learning environment in which all individuals involved feel safe and demonstrate respect for one another (Presley et al., 2013). Learning should be active and defined by interaction and collaboration, so that oppositional ideas can be discussed in light of supporting science and include the multiplicity of perspectives that inform the complex nature of SSI. Most important, the teacher and students must toe a fine line between productive, revealing discussion and statements that might be perceived as hurtful.

In our own work, we have documented how experienced teachers successfully enact issue-based teaching (Owens & Sadler, 2018; Zeidler, Applebaum, & Sadler, 2011). One strategy for establishing classroom communities that support productive discourse is to engage students in thoughtful questioning and critique of emerging ideas related to science concepts. As students gain experience with asking their peers difficult questions and publicly adjudicating different interpretations of laboratory results or scientific models, they begin to understand that questions, critique, and even disagreement, when shared respectfully, can lead to productive discourse and learning. Having had opportunities to challenge one another's emerging scientific ideas, students are better prepared for more value-laden discussions around the social dimensions of SSI.

No matter what side of the partisan fence one resides on concerning any contentious issue, the evaluation of well-sourced scientific evidence is a starting point for reaching common ground. However, without consideration of the multiple cultural, societal, and personal perspectives that contribute to the contentious nature of those issues, the successful resolution of any of them becomes unlikely. An SSI approach to instruction not only contributes to students' understanding of the science concepts that undergird these issues but also positions students to recognize and evaluate the various societal components that must be addressed when attempting to resolve them. If schools expect to promote civil discourse that begins to bridge the partisan divide concerning contemporary contentious scientific issues, we suggest that engaging learners in the thoughtful negotiation of SSI can be a useful and effective pedagogical approach.

The rejection or inappropriate use of scientific evidence is not strictly a partisan problem.

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