Science in the News

Using existing media sources to help students navigate socio-scientific issues

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Many have argued for a more holistic approach to scientific literacy that includes an understanding of science content along with the interactions science has with society and the use of science as a tool for social change (Valladares 2021). Socioscientific issues (SSI)–based instruction is a compelling method for helping students develop such functional scientific literacy (Herman et al. 2022; Zeidler and Sadler 2011). SSI are complex issues in society that have deep connections to science and/or technology (Sadler et al. 2004). As such, students must consider multiple perspectives and ideas to navigate the complexity of the real world (Owens et al. 2021), thus promoting scientific thinking and high-quality decision-making (Ke et al. 2021; Zeidler and Sadler 2011). To help foster these skills and knowledge in students, we developed a way to promote robust scientific literacy with small modifications and additions to existing media sources. These edits result in educative modules that present students with an SSI to consider and reflect upon. In this article we describe the potential learning domains and outcomes associated with SSI and these modules.

Understanding of science

An understanding of science includes understanding how science works (i.e., the nature of science; NOS), how scientists communicate (i.e., scientific disciplinary literacy; SDL), as well as understanding science content. Each of these domains may help students develop a more holistic scientific literacy. For example, understanding NOS may promote appreciation for social justice issues (Hansson and Yacoubian 2020). SSI-based instruction has been shown to help students develop greater understanding of science. Sadler et al. (2016) found that SSI-based instruction can lead to learning of science content, whereas Eastwood et al. (2012), Herman et al. (2022), and Karisan and Zeidler (2017) demonstrated that SSI instruction is a useful tool in promoting NOS understanding.

Reasoning and metacognition

A well-rounded ability to think logically (reasoning) and to reflect on one's own thinking (metacognition) also contribute to holistic scientific literacy. Three domains fall under this category. The first is socioscientific reasoning, which asks individuals to consider multiple perspectives of SSI through a skeptical lens, recognizing the inherent complexity and ongoing inquiry of such issues (Sadler et al. 2007). Second, epistemological beliefs are beliefs about the certainty and justification of knowledge and are important in developing one's functional scientific literacy (Allchin 2022), dispositions toward learning (Kruse et al. 2022a), and research capabilities (Woodward and Cho 2020). These beliefs are connected to comprehension of difficult academic tasks (Schommer-Aikins and Hutter 2002), and Baytelman et al. (2020) found that individuals who had more sophisticated epistemological beliefs developed arguments of higher diversity and better quality. Third, science media literacy is another important aspect of high-quality reasoning and metacognition (Höttecke and Allchin 2020). Namdar et al. (2020) found a correlation between science teachers' media literacy and their reasoning regarding SSI.

Critical awareness

Developing critical awareness includes an understanding of the nature of technology (NOT) as well as critical consciousness. The NOT includes reflecting on questions such as "What is technology?" "What are the trade-offs of specific technologies?" and "How does technology affect how people think and act?" (Kruse et al. 2017; Pleasants et al. 2019). Although not much research has been done on the use of SSI to teach the NOT, Menke et al. (2022) found that inservice science teachers drew heavily from the NOT when considering SSI and recognized that most, if not all, SSI are heavily connected to technology and thus to NOT ideas. Waight et al. (2022) noted the importance of adding critical consciousness to understanding NOT. Critical consciousness describes how people learn to critically analyze the social conditions of marginalized and/or oppressed groups in society and how they try to change such social conditions (Watts et al. 2011). Given the role that social structures and conditions often play in SSI, SSI education may serve as a useful avenue for engaging in critical consciousness within the science classroom (Ottander and Simon 2021).

Guidelines for developing modules

We use an interrupted story approach (Abrams and Wandersee 1995) to help students think more deeply about each of the domains described here. To do this, we collect media articles about SSI related to content we are teaching in class. We use texts that include multiple perspectives and discuss complex aspects of the issue. Sometimes we find a single text that covers these criteria or we use multiple texts to create a narrative reflecting the complexity of the issue from multiple perspectives. Once the narrative is complete, we look for places within the text that demonstrate key ideas about the three learning domains. We typically find segments or paragraphs that demonstrate connections to these learning outcomes.

To leverage these readings and encourage greater student attention to particular passages, we insert written questions to help students wrestle with particular ideas. Unfortunately, students often misinterpret learning experiences to reinforce their preconceptions (Kruse et al. 2022b; Tao 2003). To guide students' thinking, we typically use specific and convergent questions. Specific questions draw students' attention to particular ideas and have demonstrated better ability to guide student thinking (Kruse et al. 2022c). Convergent questions point students in a particular direction or way of thinking, whereas divergent questions allow for multiple ideas to be introduced. Convergent questions help students move toward intended instructional outcomes, and divergent questions serve well for formative or summative assessment purposes (Voss et al. 2022). By inserting specific convergent questions into the text, we can draw students' attention to a particular idea and help them make the intended sense of that idea. For example, one specific and convergent question we ask to help students wrestle with the nature of technology is "How does this passage show that there is often unseen infrastructure that goes into using and maintaining technology?"

Developing a learning module

One of the modules we created focused on biofuels. We found that articles about biofuels tend to mention financial incentives or laws created by the government. These passages offer a real-world example of politics impacting science and technology, a key aspect of both NOS and NOT. We also want students to think about communicating the way scientists do. Therefore, when students are presented with a scientific diagram, we ask them, "In what ways does this diagram help you understand the process that is happening? In what ways is the diagram limited?" We follow that question by asking, "Why might scientists want to communicate with diagrams and not just words?"

Following is an excerpt (Service 2022, para. 28) with one of our bulleted questions added in bold. Some of these curricular materials are only two pages long, but others can be more than six pages long.

> Changes could be coming nationwide. Last year, U.S. House members introduced two bills to support SAFs. One would grant fuel producers a $1.50 tax credit for each gallon of SAF blended into aviation fuel as long as it cut greenhouse gas emissions by at least 50% compared with fossil jet fuel; in October, Biden praised the bill. The other would authorize up to $1 billion to support SAF plant construction and require EPA to create a national LCFS-like program for aviation fuels. Related bills have advanced in the Senate. So far, however, these bills remain stalled in Congress.
>
> - **The government currently has a large impact on science and technology. What might be some of the pros and cons of this impact?**

More example questions for each learning outcome are provided in Table 1. Additional examples for middle and high school use are available at this link: https://k12science.wordpress.com/socioscientific-literacy-resources. We discuss implementation of such materials in the next section.

Considerations for implementation

When implementing these modules in a classroom, it is important to remember that these activities are opportunities for discussion and reflection on key disciplines related to functional scientific literacy, and there are not necessarily right answers or opinions. Thus, we focus on providing students with time to read and discuss the embedded questions in small groups and move toward whole-class discussion, encouraging students to recognize the complexity of the issue and consider multiple perspectives. When working with emergent bilinguals, we typically read the text out loud and have even created a translated version of the article when appropriate. Reading the text out loud also supports students who may have reading difficulties. Another strategy to consider is using Newsela to find articles at various reading levels. Finally, we ask students to summarize

TABLE 1

Example questions for each learning domain.

Understanding of Science	Science Content	How might conservation of mass help you make sense of the pollution generated by a gasoline engine?
	Nature of Science	The government currently has a large impact on science and technology. What might be some pros and cons of this impact?
	Scientific Disciplinary Literacy	Why might scientists want to communicate using diagrams and images and not just words?
Reasoning and Metacognition	Socioscientific Reasoning	Why might considering multiple perspectives help you make more informed decisions about socioscientific issues?
	Epistemological Beliefs	How does this passage demonstrate that knowledge is complex?
	Science Media Literacy	Many people often think bias inherently makes an article wrong or misleading. Why might that not always be the case?
Critical Awareness	Nature of Technology	In what ways has reliance on air travel shaped our thinking and actions as a society?
	Critical Consciousness	The article notes that low-income families and students of color bear the brunt of pollution. In what ways has the wider society contributed to this situation?

the main points of the article to create a shared understanding of the text before discussing the embedded questions.

When we implement these modules, they take roughly an hour if students read through the entire passage and answer each question in depth, but this can be shortened or lengthened based on time restraints and the ideas you want to discuss. We generally have students read through the article until they get to the first set of bulleted and bolded questions. As groups reach this point, we encourage them to start talking in their small groups. This approach means that quick readers can move forward while slower readers have some extended time. As students read and discuss, we walk around and listen to group conversations and ask probing questions when necessary. After students have discussed with their groups, we ask them to share their ideas with the class. When beginning the whole-class discussions, we often remind students that we are not looking for "right" ideas and that playing devil's advocate is encouraged, as long as the contrary positions are introduced respectfully. As the discussion unfolds, we sometimes add key ideas to the whiteboard to document the ongoing conversation.

If students do not bring up ideas that we want them to, we typically ask more targeted questions. For example, when we discuss trade-offs and limitations of technology, students often discuss surface-level trade-offs, such as poor battery life, frequency of repair, or ease of use. We typically want students to think of more inherent limitations and trade-offs, so we might ask, "A lot of the limitations you brought up are things that could potentially be fixed through innovation. What are some limitations or trade-offs that are there no matter how good the technology gets?" After students have discussed the topic in depth, we ask them to read the next section and the process is repeated.

Because we know students are likely to disagree, we typically preface discussion by telling students disagreement is expected but that we disagree with and target ideas, not people. During a disagreement, we typically let students debate among themselves with some input from ourselves as long as students are disagreeing respectfully. This approach may help build student autonomy and argumentation and promote democratic practices. If time allows, we sometimes interrupt with other questions to get students to consider other perspectives or ideas, or we might ask students to reflect on the process of disagreement and debate. An example question is "I noticed that we seem to be disagreeing on this point. What do you think leaders in our communities do when they disagree strongly? Or perhaps what do you think leaders *should* do when they disagree?"

Assessing student thinking

Typically, we do not assess students on these modules. Instead, we use the modules as an extension of student learning or to help students make connections to real-world issues. When we do assess students' thinking related to SSI, we have used the embedded questions as the assessment. When reviewing students' responses, we categorize them into four categories:

1. student provides accurate and detailed response,
2. student provides vague but accurate response,
3. student did not answer the question as intended or their answer was irrelevant to the question at hand, and
4. the student demonstrated a misconception about the learning domain that the question targets.

Table 2 provides sample responses for each category described above. Even though we do not typically convert these categories into grades, we gain deeper insight into student thinking.

TABLE 2

Example responses to "Why is it important to consider the consensus of the scientific community rather than any single study?"

CATEGORY	RESPONSE
Accurate and detailed	… because consensus of the scientific community means there is/was repeatability in a study. Repeatability leads to consistency and consistency leads to reliance. A single study could merely be a fluke, but also, does not reflect accurate data if/when no other parameters and perspectives were considered or included.
Vague but accurate	…because gauging a whole community is much more valuable than considering a single study that is probably more focused on one person or one type of person.
Irrelevant answer	I rode the bus a lot. I never smelt diesel inside the bus. To me, that seems like an error in the engine or gas lines and not a problem with every bus.
Misconception	Their information may not be biased. Community unlike companies who look for ways of making money share just the facts and not other biased information.

Conclusions

These modules can be tied to a variety of content standards. For example, the biofuels module was created for a chemistry classroom during a unit on chemical reactions addressing the following *NGSS* standards (NGSS Lead States 2013): HS-PS1-4 (*Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total* *bond energy*) and HS-PS1-2 (*Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties)*.

Science content alone is not the totality of functional scientific literacy, we do not want to lose sight of the importance of understanding fundamental science ideas. Too many students learn science ideas in isolation and do not learn how to navigate the complex media, ethical, and social landscapes that surround many scientific issues. The strategies discussed in this article are simple but powerful ways to introduce deeper and more functional scientific literacy so students are better prepared to engage in scientific civic discourse.

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