Using a Socioscientific Issues Approach in an Undergraduate Environmental Science Course

By Mark H. Newton

A perennial goal of science educators is to develop functional scientific literacy in their students, especially those who will not become professional scientists. This article provides an example of implementing a socioscientific issues approach in an undergraduate environmental science course that enables students to develop the knowledge, reasoning, and skills requisite for resolving complex issues in a sustainable manner for people and the environment now and in the future. This example incorporates an interdisciplinary approach by leveraging traditional laboratory investigations and information from outside of science proper to facilitate a deeper and more nuanced understanding of gray wolves returning to Northern California.

Science educators continually seek innovative pedagogical approaches that move beyond scientific canon to help students develop the ability to take positions and make decisions about science-related issues. This search for new approaches represents a philosophical shift toward developing functional scientific literacy that encourages individuals to consider scientific and sociocultural knowledge when forming solutions to complex issues connected with science (Zeidler et al., 2005). To support this functional scientific literacy, undergraduate science courses for nonscience majors should provide opportunities for students to develop knowledge and reasoning skills that they can apply to discussions of contentious issues. One suggested method is to implement a socioscientific issues (SSI) approach, which is interdisciplinary and relies on scientific and nonscientific dimensions (e.g., emotive reasoning, perspective taking) to foster a more nuanced understanding of the issue and promote changes in behaviors (Herman, 2017; Newton, 2016; Zeidler et al., 2019). In this approach, instruction centers around a relevant and interesting science-connected social issue that has several possible solutions. Successful SSIs provide context and meaning for science content that engages students and can address a range of science topics.

There are three considerations for an instructor to keep in mind when selecting an SSI. First, the issue must be complex, with multiple potential outcomes. Second, the issue should be a socially relevant, real-world problem that engages students. Finally, students must have opportunities to consider scientific data and ethical concerns for those affected by the issue by applying the following socioscientific reasoning (SSR) skills: recognizing the inherent complexity of SSIs; examining the issues from multiple perspectives; appreciating that SSIs are subject to ongoing inquiry; exhibiting skepticism when presented with potentially biased information; and recognizing the affordances and limitations of science (Sadler et al., 2007; Zeidler & Nichols, 2009; Zeidler et al., 2019). Ultimately, SSI instruction aims to help students develop the requisite skills to take a position on an issue and make informed decisions by analyzing, synthesizing, and evaluating data from various sources while also applying moral reasoning to consider the ethical implications of various outcomes.

Once an instructor selects an SSI, he or she must make intentional pedagogical decisions to sequence experiences to maximize learning. First, an introductory experience must occur early in the unit to allow students to encounter the SSI in a manner that enables them to identify the associated scientific ideas and societal issues. Next, the instructor should scaffold experiences, allowing students to develop a deeper understanding of the scientific concepts associated with the issue and cultivate the SSR skills associated with the societal aspects of the SSI. The culminating activity in an SSI approach should give students the chance to synthesize the scientific knowledge, engage in SSR, and present the synthesis in a product (e.g., debate, poster, paper). Throughout the unit, the instructor must support students’ deconstruction of the experiences and explicitly connect the experiences and the SSI (Sadler et al., 2016).

This article provides an example of integrating an SSI approach into an undergraduate environmental science course designed for future science educators. A more detailed account of the outcomes of this course have been researched and appear in Herman and colleagues (2021). This unit was implemented in an environmental science content course for preservice elementary and middle school teachers.
consisting of 24 students (21 female, 3 male). Two overarching objectives existed for the course:
1. Introduce environmental science concepts included in the state and national science standards.
2. Integrate research-based pedagogical approaches to teaching environmental science.

Appendix A provides a summary of how the course was organized to align with an SSI approach, the content covered, and the SSR that was developed.

**Wolves in California as an SSI**

The topic of gray wolves returning to California serves as an ideal SSI to address in a course. The complex history of the existence, eradication, and return of the wolves means there are multiple conflicting resolutions. Developing a management plan requires weighing scientific and social implications, all of which provide opportunities for students to develop the knowledge and skills necessary to form a sophisticated and nuanced understanding of the issue.

The gray wolf is native to California and was exterminated from the state in the 1920s. However, in 2011, a male wolf (OR7) entered California after being dispersed by his natal pack in Oregon. Descendants of OR7 established the Shasta Pack, California’s first known modern pack, in 2015. Since 2015, three other packs have been identified in Northern California (California Department of Fish and Wildlife, 2023). Shortly after the packs established their presence in California, potential conflicts were reported between wolves and livestock, with the first confirmed depredation occurring in October 2017 on a ranch near the university. The students in this study attended (California Department of Fish and Wildlife, 2023).

The interaction between wolves and domesticated animals has created a contentious situation among conservation groups, livestock producers, scientists, and state agencies. This issue is problematic because gray wolves are protected under California law and can only be killed under specific circumstances. As such, nonlethal tools such as fladry and radio-activated guard devices have been implemented in several locations within known wolf territories, with varying levels of success (California Department of Fish and Wildlife, 2023). Additionally, the negative symbolism associated with wolves in many cultures has generated fear in some humans despite the fact that wolves rarely pose a direct threat to human beings (California Department of Fish and Wildlife, 2023). When viewed in its entirety, the issue’s overlap of the ecological importance of wolves, the financial impact of livestock protection and loss, the legislation of wolf management, and the cultural role of wolves has led to a complicated, and often emotional, conflict for California residents. For wolves to be managed in a sustainable manner, individuals must consider the scientific, economic, cultural, ethical, and political implications of any potential solution.

**Introducing the SSI**

The SSI must be introduced early in the unit to engage students and provide relevance for course experiences. During the first class session for this unit, the instructor began class by showing students three video segments about wolves returning to California: a news report from a local television station about a new litter of wolf pups photographed on trail cameras, propaganda from the state cattlemen’s association, and propaganda from a wildlife advocacy group. Students independently noted statements they found important about the issue.

After watching the videos, students self-identified their initial opinions of how wolves should be managed in California on a scale of 1 (“The only good wolf is a dead wolf.”) to 5 (“Wolves should not be managed in any form.”). The instructor asked volunteers to justify their positions. This conversation revealed which scientific and sociocultural information students relied on to form their opinions, as well as potential stakeholders who would be affected by wolves returning to the area. After the discussion, the instructor introduced the SSI project and the culminating activity. Lab groups were also assigned one of the following perspectives to represent in the culminating activity: sheep or cattle ranchers, wildlife biologists or scientists, indigenous people, state fish and wildlife agents, ecotourism companies, and wildlife advocates.

**Embedding the issue into scaffolded learning experiences**

Consistent with an SSI approach, much of the unit involved providing students with experiences that facilitated the development of the SSR skills discussed earlier, while also helping them develop a conceptual understanding of the science content (see Online Appendix A) and sociocultural aspects of the issue. Based on the initial discussion of the videos used to introduce the issue, students recognized that there was an abundance of information to consider. Furthermore, students acknowledged feeling unsure of where to start addressing the issue.

To assist students, the initial scaffolding activity took queues from Peel and colleagues’ (2018) work on SSI professional development for practicing teachers. Students collectively identified questions that would need to be answered to form a management plan. The instructor labeled the questions as either political, scientific, economic, cultural, or moral/ethical (see Figures 1 through 5). These questions formed the foundation for developing the culminating activity project and helped demonstrate the relevance of the content to future studies to be addressed in
the SSI unit. Furthermore, students received additional resources (e.g., news articles, documents from stakeholders) via the university’s course management system that served as a starting point for addressing the sociocultural questions. Finally, the instructor announced that experts from various stakeholder groups (i.e., a wildlife ecologist, a sheep rancher, a wildlife advocate) would share their perspectives on the issue with the class. The decision to include guest speakers stems from previous research on place-based SSI courses, which supports the notion that rich learning environments and authentic interactions with stakeholders are perceived to be impactful to students (Herman et al., 2018; Herman et al., 2019; Newton, 2016). Prior to the speakers’ presentations, the instructor met individually with each of them to ensure they understood the SSI approach and would anticipate students asking probing questions and challenging the stakeholders’ positions. Stakeholders were encouraged to speak honestly about their opinions on the issue because the project involved having students analyze information for potential biases.

Over the next 3 weeks, students engaged in a series of laboratory activities to develop a deeper understanding of science concepts (see Online Appendix A). Throughout each activity, the instructor frequently posed open-ended questions to students that required them to connect the science concepts under investigation with the issue of wolf management. For example, after investigating the niche breadth and overlap of various local plants, students applied these same concepts in terms of wolves and other apex predators in an ecosystem. Additionally, the instructor explicitly ended each postlaboratory discussion by soliciting students’ connections between the activities and the wolf management issue, as was the case after students participated in two different population estimation experiences (quadrant method and capture-recapture). Students weighed the pros and cons of these approaches, including social issues such as cost and impact on the surrounding community, for estimating wolf populations. This discussion led to students having a better understanding of population numbers reported by the state.

A more detailed exemplar, the first lab of the unit focused on primary productivity and the flow of energy through an ecosystem. The overarching purpose of this lab was to introduce the concepts of produc-
ers, consumers, and trophic levels via measurement of oxygen concentrations in water to calculate the net primary productivity of aquatic producers. Students exposed one set of aquatic plants to sunlight while keeping a second group in total darkness. This lab provided students with a concrete example of energy lost to respiration and an understanding that the net productivity of the plants was less than the gross productivity. This experience allowed students to explore the notion that some energy is lost at each trophic level and is not available for the next trophic level (e.g., primary consumers to secondary consumers). The discussion that followed focused on the impact of reintroducing wolves on existing trophic levels, specifically how the absence and return of consumers might affect the flow of energy in an ecosystem. This discussion also covered the effects of wolves on various groups and scaffolded instruction seamlessly into the next laboratory investigation and the first guest speaker (see Appendix A).

Prior to hearing from the first guest speaker, students generated questions that someone from their assigned perspective might ask a restorative ecologist. The restorative ecologist shared her experiences studying wolf reintroduction in Yellowstone National Park and the wolves’ impact on the ecosystem; she spoke specifically about her work refuting the notion of trophic cascade and the importance of aspen trees for the ecosystem. A question-and-answer period followed the presentation, with student-generated questions driving the discussion. The themes of these questions centered around the impact of wolves on an ecosystem and non-lethal measures that could be taken to discourage wolves from hunting in particular areas.

This laboratory activity, coupled with interactions with a restorative ecologist and the associated classroom discourse, facilitated the development of several of the SSR skills vital to functional scientific literacy. For example, students needed to consider the information presented by the guest speaker through the lens of their assigned perspective, a process linked with promoting perspective-taking (Herman et al., 2021; Kahn & Zeidler, 2016). Students also considered the affordances and limitations of science as they pondered their laboratory results and the restorative ecologist’s interpretation of her data in Yellowstone National Park. Additionally, students considered potential biases the restorative ecologist might have had that influenced her interpretation of the data and her position on wolf management. All of this information demonstrated the issue’s complexity for the students.

As a result of the scaffolded instructional design, students’ SSR skills became more developed and permeated their culminating project, as well as their reflections on the experience, as seen in the student statements in Figure 6. One such statement references information shared between two stakeholders regarding details about trophic cascade. The students received conflicting scientific information regarding trophic cascade, which
FIGURE 6
Sample student responses to questions after town council activity.

Student 1: Learning about the effects of wolves that I wouldn’t have typically thought of was very eye-opening for me. For example, learning that a wolf’s presence can stress out livestock and affect their weight and growth was an effect I hadn’t considered. Learning about these important details that have a huge impact on some people’s lives made me more understanding of different perspectives. I am not directly impacted by wolves entering California, so before learning about the topic, it was easy for me to see it in black and white. Hearing from people who are directly impacted and involved makes it difficult to judge them only for their opinions about wolves instead of seeing them as people who want what’s best for their families and investments.

Student 2: I truly changed my opinions on wolves being introduced to California during the guest speaking days. Both [the ecologist] and [the rancher] presented very strong evidence about both trophic cascades and the ability to coexist while consistently communicating with biologists and ecologists.

Student 3: I did not have a position on wolves since I was not familiarized with this subject; furthermore, before this project I did not know that California had two packs of wolves that had returned to the state. I literally learned about wolves for the first time from a rancher’s perspective but as I was listening to the different perspectives and management plans proposed by the different groups from every table, I gained a deeper understanding on the subject. I came up to the conclusion that we need to find ways to coexist with wolves and with one another regardless of our points of views on different subjects.

required them to critique each source for bias and reliability. Furthermore, the conflicting information prompted new questions about the science and meant students needed to conduct more research on trophic cascade. Ultimately, the iterative nature of the course design allowed students to apply their developing knowledge and skills to deepen their understanding of the issue.

Culminating activity: Town council debate
A culminating activity provides an opportunity for students to engage in SSR while also demonstrating their synthesis of the information collected throughout the SSI experience. The culminating activity for this unit was a town council–style debate in which each lab group presented a wolf management plan from their perspective they were assigned on the first day of the unit.

Each lab group made a 10- to 12-minute presentation, which was followed by a questioning period; they also wrote a 10- to 15-page management plan. One student from each group was randomly selected to serve as a “council member” the week prior to presentations to ensure groups could properly prepare. A round of 2-minute rebuttals occurred after all groups had presented and the town council had exhausted its questions. The town council was sequestered in a separate room and tasked with deciding on a management plan. Their options included selecting one group’s plan in its entirety or selecting portions of various plans. The council then returned from their deliberations and announced their plan and their reasoning for the decision. Ultimately, the town council elected to merge parts of multiple proposals to create a just and fair compromise.

Outcomes of the SSI approach
As a final reflective exercise, students answered questions on the following topics after completing the town council activity:
• How they would describe any aspects of the unit that influenced their perspective-taking abilities
• What aspect of the unit they found particularly challenging (excluding group work)

The student responses shown in Figure 6 exemplify the types of responses the questions elicited.

These responses characterize how students overwhelmingly reported gaining a greater understanding of the complexity of the issue after completing the unit. Additionally, students acknowledged the need to consider competing claims (e.g., restorative ecologist vs. rancher). Perhaps most important, students expressed sympathy for stakeholders and the need to consider various perspectives when attempting to find solutions to contentious issues.

Broader impacts
The extant SSI literature frequently provides theoretical explanations for designing SSI units in courses (see Herman et al., 2018). Furthermore, the literature has demonstrated that carefully designed SSI instruction can be an effective approach for strengthening content knowledge (Sadler & Zeidler, 2005), an understanding of the nature of science (Herman et al., 2019), and many other skills (e.g., Dawson & Carson, 2020; Hsu & Lin, 2017) for students of varying ages. What is often missing from the research is a detailed account of the design of the learning experience and the instructor’s intentional decisions that facilitate effective instruction.

This article provides a practical guide for designing and implementing SSI in an undergraduate science course for nonscience majors that addresses course objectives and helps develop individuals who are capable of resolving complex science-related issues. Students reported a deeper understanding of the content and the social considerations associated with
the issue, and they demonstrated the reasoning skills necessary for functional scientific literacy. These outcomes are particularly valuable if a goal of undergraduate nonmajor science courses is to develop students who will not become professional scientists but will play a crucial role in resolving contentious local and global issues in the future.

References

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