Chapter 11
A Socioscientific Issues Approach to Environmental Education

Benjamin C. Herman, Troy D. Sadler, Dana L. Zeidler, and Mark H. Newton

Abstract This chapter makes a case for applying a socioscientific issues (SSI) approach to environmental education (EE). We present a model for SSI-based teaching and learning that can be used for the development and implementation of EE learning experiences. The model highlights the significance of design elements, teacher attributes, learner experiences, classroom environment, and peripheral influences. We present a description of and results from an experiential environmental issues course as a means of showcasing an implementation example of the model for SSI-based for teaching and learning. The course features contentious environmental issues from the Greater Yellowstone Area with a particular focus on the reintroduction of wolves. The chapter also presents evidence related to how framing this EE course with an SSI approach led to student development of competencies including conceptualizing scientific claims, balancing ethical and cultural considerations, negotiating unintended consequences of proposed solutions, and engaging in socioscientific discourses.

B.C. Herman (✉)
Department of Learning Teaching & Curriculum, College of Education, University of Missouri, Columbia, MO 65211, USA
e-mail: hermanb@missouri.edu

T.D. Sadler
School of Education, University of North Carolina at Greensboro, Greensboro, NC 27412, USA
e-mail: tdsadler@uncg.edu

D.L. Zeidler
Department of Teaching and Learning, College of Education EDU105, University of South Florida, Tampa, FL 33620–5650, USA
e-mail: zeidler@usf.edu

M.H. Newton
Department of Science Education, College of Natural Sciences, California State University, Chico, CA 95929, USA
e-mail: mhnewton@csuchico.edu

G. Reis, J. Scott (eds.), *International Perspectives on the Theory and Practice of Environmental Education: A Reader*, Environmental Discourses in Science Education 3, https://doi.org/10.1007/978-3-319-67732-3_11

11.1 Environmental Education and Socioscientific Issues

There are numerous possible approaches to environmental education (EE). Teaching materials and learning exercises might project a strong environmental advocacy perspective, while other approaches might foreground scientific principles and processes (Duerden and Witt 2010). The science-first approach often assumes that if students are armed with scientific knowledge, then they will enact pro-environment decisions and behaviors (Ballantyne and Packer 1996). Other EE approaches emphasize affective (e.g., Pooley and O' Connor 2000), cultural, and social justice (e.g., Cole 2007) dimensions to promote pro-environmental dispositions.

Some learning experiences may focus on environmental health at a global level. These are congruent with the themes of "thinking globally" advocated by EE initiatives such as the UNESCO–UNEP International Environmental Education Programme (Gough 2013). Other approaches drive instruction through the exploration of a specific, local environmental problem and its impact on indigenous cultures. For instance, Anna Cole (2007) reflects about how her place-based EE curricula could have facilitated students to consider environmental and social justice topics such as the perspectives of various stakeholders (e.g., Native Americans, Hispanic ranchers) impacted by river ecosystem issues in northern New Mexico. Thus, EE may create opportunities for learners to connect personally with issues through field-based or place-based experiences, while others are more abstracted and presented in generalized terms (Kurdyavtsev et al. 2012). Whether intentional or tacit, pedagogical decisions carry with them a number of assumptions related to what ought to be valued, how people learn, what the outcomes of education should be, and how learners best engage with their environment.

For the past 15 years, members of our authorship team have collaborated through research, curriculum development, teacher education programs, and implementation efforts in authentic settings to develop, empirically explore, and theoretically justify the socioscientific issues (SSI) framework (Zeidler 2014). We see the SSI framework as a useful perspective and lens for approaching teaching and learning challenges in multiple contexts including EE (with science education and integrated science, technology, engineering, and math [STEM] education serving as other examples).

SSI represent ill-structured problems at the intersections of science and other aspects of society. They tend to be controversial; multi-faceted; subject to multiple, sometimes, contradictory perspectives; and connected to scientific concepts. Despite the necessary association between SSI and underlying science ideas, solutions for SSI are underdetermined by scientific data alone. SSI encompass a wide range of real-world issues including contentious environmental issues (CEI) such as climate change, hydrofracturing, and the introduction (or reintroduction) of flora and fauna into natural communities. SSI-based education leverages the compelling ethical nature of these issues, the significance of decisions regarding these issues, and the chance to connect learning opportunities to the lived experiences of students. In

terms of commitments most relevant to EE, the SSI framework presumes the following:

- Educating citizens capable of responsible citizenry (including environmental stewardship) requires development of conscience. By conscience, we refer to one's self-awareness, self-regulation, and explicit moral recognition of being an impactful component of a larger system.
- CEI (e.g., climate change, hydrofracturing, species reintroduction) are inherently challenging and cannot be solved through simple means.
- Learners require opportunities to explore complex problems, negotiate multiple solutions, and develop and justify their own perspectives.
- Understanding the science underlying CEI is necessary but not sufficient for resolving these problems.
- Opportunities to explicitly negotiate multiple dimensions of CEI (e.g., unequal impacts on diverse groups and the environment, ethical concerns, political and ideological dimensions) are critical for learning and fostering responsible scientific literacy, citizenship and environmental stewardship.

In summary, we propose that SSI-based education provides an ideal pathway to help people conceptualize and respond to the various facets (e.g., scientific, social, political, and ethical) CEI entail. SSI approaches encourage students to reflectively consider multiple perspectives, from personal to global, when weighing the unequal positive and negative trade-offs that accompany CEI resolution. SSI teaching and learning can promote civic responsibility and scientific literacy necessary for environmental and sociocultural stewardship.

11.2 A Model for SSI-Based Teaching and Learning

Over the last few years, we have developed a model to help translate the theoretical vision along with existing empirical evidence for SSI teaching and learning. The model first emerged through the analysis of nine successful instantiations of SSI-based teaching from around the world including some that focused on environmental issues, healthcare challenges, biotechnology issues, and genetic engineering (Sadler 2011). We presented a revised version of the model as a tool for curriculum designers, teachers, and school administrators interested in using SSI in school settings (Presley et al. 2013) and more recently used the model as the basis for a conceptual framework for aligning EE with science education (Sadler and Murakami 2014). In this chapter, we present the model for SSI-based teaching and learning along with a description of a hybrid classroom and informal EE course showcasing its implementation.

A graphic representation of the model for SSI-based teaching and learning is presented in Fig. 11.1. Interpretation of the model begins with the core aspects, which are situated most centrally: design elements, learning experiences, and teacher attributes. While it is possible to distinguish among the core elements for

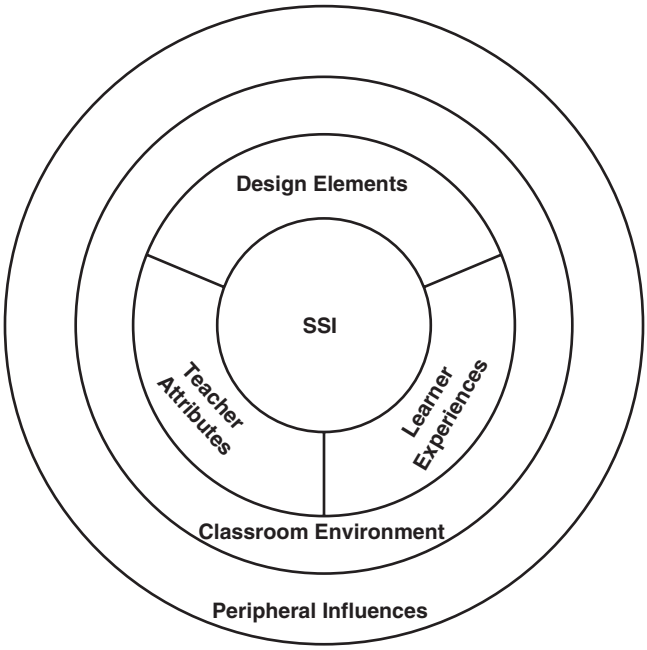

Fig. 11.1 Graphic representation of the model for SSI-based teaching and learning (Presley et al. 2013)

organizational purposes, they are interrelated. Design elements refer to issues and opportunities that should be incorporated in the design, development, and implementation of SSI learning experiences. The model prescribes four specific elements of design that need to be included in SSI-based teaching and learning. First, instruction should be built around a compelling issue; that is, the issue should be the central organizing feature for instructional planning and implementation. Other approaches to environmental education may prioritize other organizing elements for the design of instruction such as standards or content. In the case of SSI-based teaching, instruction may be aligned with standards and address important content, but the decisions around which standards and content to address are informed by the issue to be explored. This prioritization of the issue helps to ensure that the ideas addressed are meaningful and contextualized with respect to the issue being considered.

Second, in the implementation of SSI-based teaching, the issue should be presented early in the experience. Many approaches to science and EE use issues as examples of phenomena or principles, and these examples may be presented at any point during instruction. In order to foreground the focal issue within SSI-based teaching and learning, the issue itself should be presented very early within the teaching sequence.

Third, SSI instruction should provide scaffolding for student engagement in higher-order practices. These higher-order practices can be framed in several ways

including argumentation, decision-making, critical thinking, or socially responsible action. Student engagement and learning with respect to at least some of these (or related) practices is a fundamental goal for SSI-based teaching and learning.

Finally, design of SSI learning experiences should incorporate a culminating experience during which learners can synthesize ideas, compare perspectives, integrate their own commitments, and use the higher-order practices featured in the learning experiences.

Learner experiences comprise the second core aspect of the SSI-based teaching and learning model. The model suggests that learners should have opportunities to engage in six different but interrelated experiences that necessarily overlap with the design elements just discussed. Within the context of SSI instruction, students should have opportunities to:

- Engage in higher-order thinking practices
- Confront scientific ideas and theories related to the issue under consideration
- Collect and/or analyze scientific data related to the issue
- Negotiate social dimensions of the issue
- Confront ethical dimensions of the issue
- Consider nature of science themes associated with the issue

Considering which of these learner experiences are afforded within a particular SSI unit of instruction can help to direct attention to areas of the instruction or curriculum materials that can be expanded and improved.

The final core aspect, teacher attributes, directs attention to teacher knowledge and characteristics. In considering the attributes possessed by teachers, who implement SSI-based instruction successfully, four commonalities consistently emerge. First, successful teachers are knowledgeable about the science content related to the issue. Supporting student exploration of the science involved in SSI requires that teachers have a reasonable degree of expertise surrounding that science.

Second, teachers also need to be aware of social considerations associated with the issue. Given the wide range of social knowledge pertinent to most SSI, it is unreasonable (and unnecessary) to expect that a teacher can have expertise in all relevant areas; however, it is very important that teachers are familiar with at least some of these ideas.

Third, SSI, by definition, are complex problems for which some information is not available. Teachers cannot know everything there is to know about a particular SSI, and they should be honest with their learners about these knowledge limitations.

Finally, given the uncertain status of SSI, and the goal of SSI-based teaching to foster community inquiry and negotiation, teachers need to position themselves as knowledge contributors within their classroom communities as opposed to the sole authority. For some teachers, adopting a role on more equivalent footing with their students can be uncomfortable, but the sharing of power and discourse within the learning environment is essential for successful SSI-based teaching and learning.

The remaining elements of the model, classroom environment and peripheral influences, highlight the point that design and enactment of learning experiences

occur within contexts that significantly shape the trajectories of engagement and learning. Classroom environment is positioned as the first and most temporally relevant source of influence. Dimensions of the classroom environment such as expectations for participation, discourse norms, relationships among members of the classroom community, and resources available will play huge roles in determining how curricular and pedagogical plans are enacted and the kinds of outcomes that will be achieved.

Peripheral influences are positioned immediately beyond the classroom environment. In actuality, this single dimension of the model represents a number of possible spheres of influence that may shape the classroom environment including teachers and students. The classroom environment is shaped by the institutional environment, which, in turn, is necessarily influenced by the community in which the institution is situated. National trends and standards, economic forces, and broader expectations are some of the many peripheral influences that can ultimately affect ways in which SSI-based EE unfolds. However, the point of the model is not to suggest that educators identify all of the possible peripheral influences but rather to develop an appreciation for and sensitivity to the contextual realities of teaching through student engagement in complex and controversial issues.

11.3 A Case of Using the SSI Model for Environmental Education: Contentious Environmental Issues in the Greater Yellowstone Area

In this section, we pivot from the conceptual presentation of the SSI-based teaching and learning model to an applied case profiling an SSI approach for EE. Presented here is an SSI-embedded experiential environmental issues course co-taught by several of the authors that focused on Greater Yellowstone Area (GYA) CEI (e.g., reintroduction of wolves, brucellosis in bison, ranching practices). A notable feature of this course was the extent that the 36 enrolled undergraduate students from diverse majors (e.g., nursing, law enforcement, art, music, education) were immersed for 10 days in authentic experiences with GYA CEI. The students then completed a 3-week online component after returning to their university where they developed a written analysis of a CEI. We present a description of the course and its impacts on student learning; the presentation is organized around the four specific design elements highlighted in the SSI-based teaching and learning model.

Table 11.1 Sequence of interrelated events and the issues addressed

Portion of course	Course activity
Predeparture	Discuss the analogy that the university is to the town (Farmville, VA) as Yellowstone National Park (YNP) is to the GYA
	Interview citizens of Farmville about their feelings about the university and the students. Group discussion on findings (e.g., perspectives, biases) and make connections to the GYA
	Introduce the wolf reintroduction and management issue in the GYA
GYA field experiences	Interact with Jackson Hole residents and Wyoming fish and game biologists about GYA CEI
	Travel through YNP with field stops at key areas including visitors' centers and natural features
	View wildlife in YNP. Interact with wolf ecologists, tour guides, and local residents
	Interact with ranchers possessing progressive and traditional perspectives about GYA CEI. Interact/discuss with Gardiner residents about GYA CEI
	Hike YNP with a naturalist. Interactive presentation with a nature activist/writer
	Students placed into groups based on different perspectives modeled in GYA to prepare arguments for stakeholder council meeting assuming perspectives encountered in GYA and discuss possible resolutions of wolf reintroduction/hunting issues
	Travel through YNP with field stops at nature areas and interactions with Native Americans about GYA CEI
	Students conduct community stakeholder meeting and develop proposed resolutions about wolf issue
	Participate in culminating town hall-style forum on wolf hunting quotas in Montana. Students assume perspectives of GYA stakeholder encountered during experiential field component of course
Post-fieldwork (online)	Analyze public documents and complete a major writing assignment on natural resources management issues

11.3.1 Design Element 1: Build Instruction Around a Compelling Issue

At the forefront of SSI instruction is a compelling and contentious issue. Table 11.1 outlines the sequence of events and the compelling issues addressed during the CEI course. Important to note is that our design of the course was fluidly responsive to the learners' experiences. For instance, the instructors would facilitate the students' learning experiences (e.g., presentations from those impacted by CEI, visits to nature centers) and help them deconstruct those experiences through reflexive pedagogical moves (e.g., modeling questioning practices during presentations and then later helping students understand the intent of the questions and the information they solicited). Furthermore, course experiences were deliberately sequenced so the instructors could scaffold students to autonomously consider multiple perspectives and the scientific, ethical, and sociocultural dimensions related to CEI.

Reflective of the complexities associated with CEI, the course instruction employed an ecological approach by stressing that many environmental issues are interrelated, have broad reaching impacts on humans and nature, and require consideration of many obvious and nuanced perspectives. Several interrelated environmental issues exist in the GYA and were addressed throughout the course. For instance, stakeholders such as ranchers, hunter outfitters, wildlife biologists, nature advocacy groups, and Native Americans possess different perspectives and debate about how to resolve CEI such as elk harvest quotas, bison home ranges and brucellosis, and sustainability of ranching practices. All of these issues are controversial, and the arguments from the stakeholders draw from multiple perspectives including those that are scientific, ecological, sociocultural, ethical, and economic in nature.

At the forefront of the CEI addressed throughout the course was the reintroduction and management of wolves in Yellowstone National Park. According to many GYA residents, wolf reintroduction is the most contentious and polarizing environmental issue in that area. Matthew Wilson (1997) notes that the wolf reintroduction issue is the symbolic representation of the contention between those whose interests are environmental preservation and those whose interests are the economic utility of the Greater Yellowstone Ecosystem. Furthermore, Wilson (1997) points out that unequal access to social power, conflicting beliefs about property use, and discrepant perceptions about nature fuels the controversy surrounding wolf reintroduction. Despite the contention that pervades this issue, scientific evidence has established that wolves are an important member of the GYA ecosystem justifying their restoration to sustainable population levels. This issue is at the heart of the CEI course and remains relevant and controversial (Smith and Bangs 2009).

11.3.2 Design Element 2: Present the Issue Early in the Experience

The contention surrounding wolf reintroduction in Yellowstone National Park was introduced early in the course prior to the students arriving in the GYA. In line with the scaffolding approach advocated within the SSI instructional framework, we utilized local CEI (e.g., impacts of their university's expansion on the local natural and built communities) familiar to the students helping them conceptualize how to engage SSI through argumentation and evaluating multiple perspectives, scientific evidence, ethical considerations, and sociocultural factors. We then introduced students to GYA CEI by focusing on wolf reintroduction and asking them to consider ways in which resolving SSI requires varied approaches. For instance, we asked the students to contemplate how multiple perspectives and environmental ethical considerations might influence how the university expansion is resolved and how that might be similar to underlying issues influencing the wolf reintroduction dispute. Our rational for such an approach is that we recognized that the students' familiarity

with locally relevant CEI could be used as a springboard to facilitate their engagement with the less familiar GYA environment and CEI.

11.3.3 Design Element 3: Provide Scaffolding for Higher-Order Practices

Wilson (1997) writes about the contested nature of the GYA with on the one hand its resonating and prolific natural beauty and on the other the power struggles that accompany land ownership and natural resources management. Specifically, the federal government owns over half of the GYA county land base, and thus all policy decisions such as wolf reintroduction profoundly impact local residents and thus spur controversy around these issues. As Fig. 11.1 illustrates, peripheral factors and the learning environment must be considered when designing SSI instruction. The experiential field component of the SSI instruction profiled here was crucial for immersing students in GYA CEI, so they better understood the nuanced contentious factors associated with wolf reintroduction and management. Throughout the span of the experiential field component, our objective was to scaffold students from a passive role through witnessing the instructors and stakeholders interacting and deliberating relevant SSI themes to becoming active participants who interacted with and took ownership in learning about the stakeholders' backgrounds, cultures, and concerns.

To gain an initial sense of the sociocultural aspects of GYA CEI, the students began in Jackson, Wyoming, where they spent 3 days investigating how various stakeholders perceive CEI including wolf reintroduction. For example, the students spent 1 day talking with residents about their views on wolf reintroduction and how those views were developed. The students also experienced a presentation by area wildlife biologists focusing on the integrated nature of CEI in the GYA such as how various groups perceive wolf management in relation to elk harvests. During early interactions with stakeholders, the authors modeled questioning strategies for the students that reflected many of the subtle aspects needed to investigate socioscientific issues including skepticism, consideration of multiple perspectives, sociocultural factors, ethics, and scientific evidence. The following dialogue provides one example between the instructors and the biologists exemplifying this process:

Instructor Can you talk about the reaction to some of your management practices?

Biologist We have a really diverse public here. We have everything from very traditional 3rd generation Wyoming cowboy hunter type to very environmental green and everything in between…. We have a lot of different views and backgrounds.

Instructor You talked about wolves. In a group I was in today … a lot of newspapers and magazines we found addressed the recent issue of how the

wolf hunting regulations have been redone and the state is now in charge. That was the headline story in two or three of those.

Biologist Wolves were reintroduced to Yellowstone… Until recently they were on endangered lists. They were managed by the federal government. Through lots of politics and court rulings they eventually came off the endangered lists and are under state management for just over 2 years now. So, since they have become under state management and off the endangered species list, we manage them like any other trophy game species: black bears, mountain lions, etc. so people hunt them.

Instructor What do you do with the diversity with the different kinds of groups? You mentioned in the beginning with the different agencies and how they work together in some way… So, can you give me a sense of how these diverse groups, each with vested interests in their own careers, come to consensus to work together? You say it is politics. Can you give me an extended sense of how you negotiate from such diverse points of view?

Biologist There have been times when the agencies have not seen eye to eye and have not gotten along. They went through bad times. I think there is general agreement hopefully at this point from all the different players. We can accomplish more if we do compromise on the things we can compromise on. There are things our agency says, that we cannot compromise. Sorry we just can't work together on this issue. Fundamentally then science is not speaking for itself. You are just polishing it. You try and figure and get a collection and distribute it in a way where you do have an optimal solution, but in a way where everybody gets something. I think there is after years of doing that, there is a tradeoff of like … we are going to compromise on this but remember that the next issue comes up … maybe you guys need to compromise. You have years and years of relationships going on and you have a trust in a way. It comes back down to a lot of people dealing with people. I wasn't really trained to deal with people. Ha ha. It's a lot of dealing with people.

Instructor It seems like when you are dealing within your own agency that some of the discussions go beyond the scientific evidence. You can see we can sustain and manage … to what extent do you sometimes discuss other considerations… such as the ethics of the situation or how it will affect the socioeconomics of the region?

Biologist We actually put a lot of things into the pot when we make a management decision. We try to get as much scientific evidence as we can and that is the base. We have to then make sure we hear all publics concerns. Lots of meetings, etc. The wildlife is held in the public trust. We have public commissions. We have a group of six commissioners, which are just regular citizens that are appointed to the commission board. They are the ones that decide what really they should do. We build the framework and then the public decides.

Instructor To what extent have you had an actual example where you had an ethical consideration override the science evidence? For instance, some groups that have more of a spiritually vested interest in the management that may think it is ethically wrong on how you are managing wildlife populations. Or even a socioeconomic consideration overrode your best judgment from the scientific evidence.

After such interactions, the instructors would engage in reflective discussions with students in formal (whole class meetings) and informal (car rides to field experiences) settings. These discussions were crucial for scaffolding students to consider and engage in discourse about the more complex nuances of GYA CEI.

Over the next 7 days, students transitioned from Jackson to Gardiner, Montana, and Yellowstone National Park (YNP) where they critically examined CEI with a focus on wolf management. Specifically, the students met with two local ranchers with diverse perspectives regarding this issue. The first held progressive ideas on how to protect her animals from wolves through hazing and using range riders to manage herds. The second rancher held more traditional beliefs on protecting his stock, such as trapping and shooting wolves that ventured onto his property. The students also accompanied a wolf ecologist and a naturalist who charter tours into YNP to view wildlife and discuss wolf reintroduction. The students concluded scheduled stakeholder interactions by gaining the perspectives of an environmental activist and author and a member of the Crow Native American tribe. In addition to these formal interactions, students were required to engage with local stakeholders throughout the communities (e.g., at restaurants, at gas stations, and at the hotel) they visited. The explicit modeling from the instructors resulted in students beginning to engage in sophisticated discourse about CEI with one another and stakeholders, suggesting they were considering more complex facets of SSI resolution. Two examples below are questions asked by students to wolf ecologists and naturalists that exemplify how they were conceptualizing CEI from increasingly sophisticated vantage points: “Do you think it might be the negative cultural image of the wolf that it becomes the scapegoat for other perceived natural resources problems?” “How do you think the fact that people hunt elk here affects their views on wolf hunting?” “Do you feel there is a positive relationship between Native Americans in the area and others that live here despite past tensions and how the park is now managed as public land?”

11.3.4 Design Element 4: Culminating Experience

The culminating experience was a town hall-style forum on wolf management in the GYA. Three days prior to the forum, the students were assigned to one of six groups representing a GYA stakeholder and asked to develop solutions and accompanying justifications (see Table 11.2). Important to note, the instructors deliberately assigned groups that held diverse and, at times, polarized views about wolf management to emphasize the contention surrounding this issue and instructed students to

Table 11.2 Town hall forum stakeholder groups' proposed solutions and justifications regarding wolf management

Group	Summary of proposed solution and justification
State wildlife managers	Wolves should be sustainably harvested through controlled hunts. Natural resources and YNP are for the benefit and enjoyment of the people. Social, economic, and ecological considerations must be weighed. Wolves should be present to maintain ecosystem balance and tourism. However, wolf numbers should be limited to mitigate economic losses (e.g., livestock predation) and negative environmental consequences (diminished elk populations)
Traditional ranchers	Wolves should be heavily hunted and state managed, not federally. Ranching is a long-standing family tradition that wolves threaten by predating on cattle which can cost thousands. This threat combined with other economic hardships associated with ranching threatens to end the ranching culture that has been built through many generations
Progressive ranchers	A quota of 20 to 25 per district is feasible but wolves should only be killed when necessary (e.g., extreme livestock predation). The culture of ranching must change. Wolf reintroduction has occurred, and coexistence between ranchers and wolves is possible through new ranching and wolf-deterring methods (e.g., range riders, hazing, electric fences with flaggery, removal of sick or dead livestock and elk)
Ecologists/wildlife viewing tour guides	Wolf harvests outside of park could remain at current levels. However, wolf hunting should be restricted within YNP and a buffer zone around the park that will be determined every 10 years based on park packs' home ranges. Wolves were an important component of the GYA ecosystem when the park opened in 1872 but have only recently recovered from a cruel extirpation by humans. Killing one wolf can break up packs and orphan pups. Wolves can sustainably manage themselves within park boundaries and could be tracked through radio collars. Typically, park packs stay within YNP 98% of the time, and only 1% of cattle deaths outside of the park are confirmed wolf kills. Furthermore, the concern of wolves overkilling elk is unjustified. The primary killers of elk are humans and winterkill, not wolves. Unfortunately, the media portrays wolves negatively, but they are actually very important economically and ecologically
Environmental activists	The killing of wolves should be completely prohibited. Wolf protection buffer zones around the park are irrelevant. Wolves have an intrinsic right to be here just like humans and nature's other creatures. Nature should be left alone to take its course. Wolves, bison, elk, and other species were part of the ecosystem balance long before humans' presence. Humans have eliminated other species such as cutthroat trout, and without wolves, elk and deer populations in the park would be unregulated. This would cause negative environmental impacts such as over grazing and browsing of vegetation

(continued)

Table 11.2 (continued)

Group	Summary of proposed solution and justification
Outfitters and hunters	Montana state annual wolf harvest limits should be increased from 230 to 300 and the limit of five wolves per person eliminated. Wolves can be preserved in YNP but protection buffer zones are unjustified. Hunting elk is a cultural tradition among families that is also important to their economic well-being and livelihood. Wolves negatively impact elk numbers. Hunters bring outside money to the economy, and increasing the wolf limit will benefit ranchers. Furthermore, there is less chance the Fish and Game Department will need to reimburse ranchers for livestock losses, and the money for wolf licenses can go toward wolf preservation in the park. Adjustable buffer zones are unjustified given YNP is 2.2 million acres and buffer zones will constantly expand with wolf dispersal

make a concerted effort to represent the interests of their group rather than those of their own perspectives. Within these groups the students developed a proposal about wolf management including wolf hunting limits and protective buffer zones around YNP. Three students were selected to serve as a federal panel that evaluated the stakeholder group's arguments and given the charge of issuing a detailed ruling on wolf management. Prior to the forum, all of the groups met with instructors to discuss issues associated with using and evaluating different forms of evidence and criteria for decision-making.

The 2-h town hall forum took place at a local restaurant and tavern – an authentic setting where residents of the area typically exchange ideas about local CEI. The forum was student conducted with the instructors assuming a facilitator role. Each stakeholder group prepared a 5-min opening statement presenting their resolution for wolf management and harvest limits to a mock federal panel (in this case, the panel consisted of three students selected by instructors). After the opening statement, the federal panel asked each group clarifying questions. Upon completion of the opening statements and panel questions, each group was provided time to prepare and orate rebuttals to opposing groups. The rebuttals were followed by closing arguments from each group that summarized their proposed resolution and supporting evidence. The federal panel was then sequestered to deliberate and reach a decision with accompanying justifications about how to manage wolves including an annual wolf harvest limit.

The federal panel evaluated arguments and determined a ruling based on five preestablished criteria: (1) pragmatism (best solution for all groups), (2) robustness (resiliency and durability of the arguments), (3) evidence based (scientific, logical, moral, and cultural truths), (4) feasibility, and (5) precedence (e.g., based on historical events and prior policies). The panel's ruling included a wolf-protective buffer zone around YNP with continued research on wolf population distributions and buffer zone adjustments every 10 years. Furthermore, the panel decision established a wolf hunting limit up to 20% of the state population annually, and that wildlife agencies would assist ranchers' predator deterrence efforts and elimination or relocation of confirmed livestock predators.

At the conclusion of the town hall forum, the instructors debriefed the students on the culminating activity and how their course experiences enabled them to contemplate and engage in discourse about wolf management. For instance, the instructors explicitly addressed how the students were considering and discussing multiple perspectives, ethics, scientific evidence, and sociocultural factors when engaging SSI. Furthermore, the instructors stressed the importance of assuming an eco-justice perspective personally, civically, and globally needed to resolve CEI through proenvironmental behaviors.

The final 3 weeks of the course were conducted online after the students returned to their university where they developed a written analysis of a CEI. Students were expected to synthesize the information that was garnered during the field component to create a position paper discussing how to manage their specific resource issue.

11.4 Learner Considerations and Impacts of the Course

Throughout the previous sections, we have attempted to explicate how our design of the course was fluidly responsive to the learners' experiences and conceptions – existing and newly acquired through the CEI course. The course experiences were deliberately sequenced so the instructors could scaffold students to autonomously consider nuanced factors (e.g., scientific, ethical, and sociocultural dimensions) of CEI resolution. During these interactions and subsequent discussions with instructors, the students learned important lessons regarding SSI engagement such as how to conceptualize scientific claims (e.g., accuracy and the nature of those claims) in juxtaposition with ethical and cultural considerations and possible unintended consequences of CEI resolution. As a result of these experiences, the students began to take ownership of their engagement with GYA CEI through actions such as eliciting perspectives from stakeholders through sophisticated questioning and debating with peers and the course instructors about those perspectives. Evident among student discourse was the realization that science is among many valuable ways of knowing that must be judiciously weighed when engaging SSI and that sociocultural, ethical, and economic consequences typically accompany CEI resolution. For instance, scaffolding interactive experiences with a variety of stakeholders, from wildlife biologists and ranchers to Native Americans and activists, who consistently deal with GYA CEI, modeled for students how to draw from scientific evidence as well as indigenous and traditional ecological knowledge, values, and beliefs. We viewed these experiences as crucial in helping many students to move from a position resembling scientism where it is perceived that CEI should only be resolved through scientific truths, engineering, and techno-centered approaches to a more rational and balanced view that weighing additional factors (e.g., cultural, ethical, and historical) must occur when engaging CEI. The following student's sentiments before and after the course exemplify this conceptual shift:

> With advancing scientific research they are gaining more proof about the negative effects that humans have on the environment. You cannot argue with the fact that species are becoming extinct, and glaciers are melting. (Samantha's pre–course views)

> I have learned that scientific evidence is a good base but other things such as morals, culture, and ethics also come to play when making decisions. Scientific evidence can also be bias in the way it is presents and what part of the research is publicized. Many things are complicated, and the scientific reasoning may change, it is not set in stone. I think that science will help with natural resource issues, but I do not think it is the end–all–be–all. (Samantha's post–course views)

Reflective of the course focus, many students drew from their Yellowstone experiences to conceptualize the complexities associated with CEI in their home communities. For instance, one student reflectively linked her Yellowstone experiences with issues her home community is facing by stating:

> I noticed after I went to Yellowstone, I did not consider the different perspectives of issues as much as I had thought. Now I try to always take different perspectives on natural recourse management issues. For example, in my county there is a suggestion to make Powhatan's home a national park. When I heard this after I came back from Yellowstone my initial thought was, what do the nearby locals of that area think vs. the people who are working to get the park in motion? I continued to think of the county locals in various areas and jobs and how they might perceive this issue as well as the impact it might have on the land and wildlife in that area. I think that natural resources management issues can raise social and ethical concerns and conflicts…(Valerie's post–course views)

11.5 Teacher Attributes and Recommendations

The SSI teaching and learning model highlights teacher attributes as a core component of successful SSI instruction. The instructors of the GYA CEI course possessed advanced degrees and extensive professional experiences in wildlife biology, geology, and science education. They also worked extensively in the GYA conducting ecological research and educational outreach. Therefore, they were familiar with many of the scientific and social considerations associated with GYA CEI addressed; however, they also recognized their limitations regarding these knowledge domains and worked with students to create a community of inquiry where knowledge about how to engage CEI such as wolf management was co-constructed through "real-time" experiences and discussions about those experiences. Thus, instead of assuming an authoritarian role, the instructors consistently modified instruction based on knowledge they learned with the students.

Using issues to frame EE is an intuitively appealing approach, and while an issue-oriented approach limits the wide range of possibilities for EE, there are still many critical decisions that must be made by designers and instructors using environmental issues. We have found the SSI framework to provide a powerful model for informing those decisions in ways that ensure alignment between our theoretic commitments, pedagogical priorities, and educational objectives. The model

presented within this chapter specifies the SSI approach with a level of detail that can help to inform design decisions and implementation choices, and the GYA CEI course provides an example of how this model played out in an actual environmental education context. From our perspective, productive advancements to EE can be made by more widespread applications of the model for SSI-based teaching and learning accompanied by rigorous testing of various dimensions of the model. We cannot stress enough how such progressive pedagogical approaches are crucial for effectively implementing SSI and promoting the kind of scientific literacy and sociopolitical action necessary for civil democracy and environmental sustainability.

Questions

Discussion questions that could help instructors and students to engage in meaningful conversation about the ideas presented in this chapter.

1. Consider various local and global environmental issues. In what ways do these exhibit characteristics that would make them socioscientific issues (SSI)?
2. How does an SSI instructional approach foster scientific literacy in a manner that enables people to engage in citizenship and democratic decision-making?
3. In what ways does SSI instruction promote multiple perspectives (e.g. scientific, sociocultural, ethical) regarding contentious environmental issues resolution?
4. How must teachers be prepared so they are able to effectively incorporate SSI instruction in environmental education courses?
5. Consider various local and global contentious environmental issues. How would you implement an SSI approach to promote student engagement with those issues?

References

Ballantyne, R., & Packer, J. M. (1996). Teaching and learning in environmental education: Developing environmental conceptions. *Journal of Environmental Education, 27*(2), 25–32.

Cole, A. G. (2007). Environmental education principles through multidisciplinary frameworks. *The Journal of Environmental Education, 38*(2), 35–44.

Duerden, M. D., & Witt, P. A. (2010). The impact of direct and indirect experiences on the development of environmental knowledge, attitudes, and behavior. *Journal of Environmental Psychology, 30*(4), 379–392.

Gough, N. (2013). Thinking globally in environmental education: A critical history. In R. B. Stevenson, M. Brody, J. Dillon, & A. E. J. Wals (Eds.), *International handbook of research on environmental education* (pp. 33–44). New York: Routledge.

Kurdryavstev, A., Stedman, R. C., & Krasny, M. (2012). Sense of place in environmental education. *Environmental Education Research, 18*(2), 229–250.

Pooley, J. A., & O'Connor, M. (2000). Environmental education and attitudes: Emotions and beliefs are what is needed. *Environment and Behavior, 32*(5), 711–723.

Presley, M. L., Sickel, A. J., Muslu, N., Merle-Johnson, D., Witzig, S. B., Izci, K., & Sadler, T. D. (2013). A framework for socio–scientific issues based education. *Science Educator, 22*(1), 26–32.

Sadler, T. D. (2011). Socio–scientific issues based education: What we know about science education in the context of SSI. In T. D. Sadler (Ed.), *Socio–scientific issues in the classroom: Teaching, learning and research* (pp. 353–367). New York: Springer.

Sadler, T. D., & Murakami, C. D. (2014). Socio–scientific issues based teaching and learning: Hydrofracturing as an illustrative context of a framework for implementation and research. *Brazilian Journal of Research in Science Education, 14*(2), 331–342.

Smith, D. W., & Bangs, E. E. (2009). Reintroduction of wolves to Yellowstone National Park: History, values and ecosystem restoration. In M. W. Hayward & M. J. Somers (Eds.), *Reintroduction of top–order predators* (pp. 92–125). Hoboken: Wiley–Blackwell.

Wilson, M. A. (1997). The wolf in Yellowstone: Science, symbol, or politics? Deconstructing the conflict between environmentalism and wise use. *Society and Natural Resources, 10*(5), 453–468.

Zeidler, D. L. (2014). Socioscientific issues as a curriculum emphasis: Theory, research and practice. In N. G. Lederman & S. K. Abell (Eds.), *Handbook of research on science education, volume II* (pp. 697–726). New York: Routledge.