Sustainability: Why the Language and Ethics of Sustainability Matter in the Geoscience Classroom

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ABSTRACT

Because challenges to sustainability arise at the intersection of human and biophysical systems they are inescapably embedded in social contexts and involve multiple stakeholders with diverse and often conflicting needs and value systems. Addressing complex and solution-resistant problems such as climate change, biodiversity loss, and environmental degradation thus demands not only a scientific understanding of Earth systems, but consideration of the underlying human values, institutions, and norms that drive unsustainable ways of living. The search for solutions amidst a multiplicity of players and an array of potential outcomes inevitably leads to ethical quandaries. The purpose of this commentary is to synthesize perspectives from the geosciences and philosophy to provide a rationale for including the ethical dimensions of sustainability in geoscience education and to clarify the nature and ethics of sustainability. Drawing on an approach developed in the book *Living Well Now and in the Future: Why Sustainability Matters* (Curren and Metzger, 2017), we outline a way to conceptualize sustainability that bridges scientific and ethical perspectives and present four fundamental principles of sustainability ethics derived from our analysis and from core commitments of common morality. We supply a compilation of relevant teaching approaches and materials to help geoscience educators connect the enumerated concepts and principles to classroom practice and we conclude with a call for further cross-disciplinary conversations among geoscientists, philosophers, and social scientists who share a commitment to including sustainability concepts and ethics in their teaching. © *2017 National Association of Geoscience Teachers*. [DOI: 10.5408/16-201.1]

Key words: sustainability, ethics, wicked problems, geoscience teaching

INTRODUCTION

As geoscience educators at all levels of instruction move toward integrating the topic of sustainability into their courses, they will naturally begin from their understanding of Earth systems. They are likely to feel themselves least equipped to teach the aspects of sustainability farthest removed from science—the ethical, social, and political aspects of sustainability. Geoscientists may be reluctant to bring consideration of values and norms into their science instruction or feel ill equipped to guide students in ethical inquiry. Yet, we know from many conversations with geoscientists that they would welcome guidance on how to integrate an ethical understanding of sustainability into their teaching.

Many agree that sustainability is profoundly important, but what does the term actually mean? How can the geosciences better inform policy-making around sustainability challenges such as climate change, management of limited natural resources, and deforestation, when making decisions about these issues inevitably involves values as well as facts? What responsibilities do geoscientists have as individuals and professionals to help identify and address barriers to sustainability? These questions lie beyond the confines of any one discipline and underscore the need to provide our students with a holistic understanding of sustainability that interweaves its scientific, socioeconomic, and ethical dimensions.

In the spirit of interdisciplinary collaboration, this commentary blends perspectives from the geosciences and philosophy to provide a rationale for addressing the ethical dimensions of sustainability in the geoscience classroom and to clarify the nature, forms, and ethics of sustainability. Drawing on an approach developed elsewhere (Curren and Metzger, 2017), we present a way to conceptualize sustainability that synthesizes ecological and ethical perspectives and we provide suggested approaches, examples, and resources to support geoscientists in their efforts to engage students in reasoning and problem-solving around the scientific and ethical aspects of sustainability.

GEOSCIENCE, ETHICS, AND SUSTAINABILITY

As experts in observing, describing, interpreting, and modeling Earth's biophysical systems and how they change through time, geoscientists are uniquely prepared to address the scientific aspects of sustainability (e.g., Bralower et al., 2008; Reid, et al., 2010). However, as reflected in increasingly more urgent calls for better integration of the sciences and social sciences in addressing global challenges, the underlying drivers of unsustainable ways of living are found in human traits, institutions, and cultural practices (e.g., Raupach, 2012; Hackmann et al., 2014; Weaver et al., 2014; Miller, 2015; Grundmann, 2016; Curren and Metzger, 2017). Teaching the science-relevant aspects of sustainability in isolation from consideration of human values and social dynamics leaves students with a fragmented understanding of the systemic underpinnings of (un)sustainability and

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obscures the complexity of the obstacles we collectively face in seeking a more sustainable existence.

The first step in problem-solving is to understand the nature of the problem being confronted. Rittel and Webber (1973) described two fundamentally different types of problems, *tame* and *wicked. Tame problems* may be technically complex and extremely difficult to solve, but can be largely managed from the top down by experts with little input from stakeholders. In contrast, *wicked problems* pertain to the functioning and evolution of interconnected and complexly interacting socio-ecological systems. The problems of sustainability are often said to be wicked and they defy solution because they are multicausal, intertwined with other problems, and value-laden. Such problems can rarely be addressed by any single discipline, organization, or sector, making collaboration essential to managing them (e.g., Rittel and Webber, 1973; Batie; 2008; Curren and Metzger; 2017). Wicked problems challenge traditional problem-solving skills, tools of analysis, management strategies, and organizational structures.

In the words of Dr. Herb Childress, Dean of Research and Assessment at Boston Architectural College, "The world is more wicked than our disciplines" (Childress, 2013). Attempts to address the challenges of unsustainability solely from the perspective and expertise of science ignore the fundamental nature of the dilemmas involved and may impede the production and communication of policy-relevant scientific knowledge (e.g., Batie, 2008; Miller, 2015). It is the entanglement of facts with personal, professional, and societal values that makes the problems of sustainability so resistant to solution. This has important implications for the science–society interface and underscores the importance of an education that provides students with the knowledge, skills, tools, and experiences needed to recognize ethical dilemmas, identify relevant stakeholders and analyze their perspectives, construct and evaluate potential solutions, and engage in collaborative problem-solving with others who may have diverging knowledge, needs, perspectives, and values (e.g., Frisk and Larson, 2011; Wiek et al., 2011; Lake et al., 2016).

Situating geoscience in the context of societal issues and discourse is the goal of the National Science Foundation–supported InTeGrate project (http://serc.carleton.edu/integrate/index.html), which fosters interdisciplinary collaboration in the interest of a more holistic understanding of sustainability (Gosselin et al., 2013, 2015). A guiding principle of this project is that geoscientists have a professional responsibility to participate in addressing problems of sustainability, with the knowledge that solutions to these problems require more than scientific understanding. Sustainability ethics is a vital component of sustainability education and an aspect of *geoethics,* which is concerned with the ethical obligations that come with the unique knowledge and skills that allow geoscientists to investigate, manage, and modify the Earth system (Mogk et al., 2014; Wyss and Peppoloni, 2014; Bobrowsky et al., 2016; Peppoloni and Di Capua, 2016; Curren and Metzger, 2017).

Geoscience educators in K–12 settings should also be aware that the Next Generation Science Standards (NGSS Lead States, 2013) not only emphasize skills that help students to comprehend, analyze, and directly apply sustainability principles, they also feature content central to education in sustainability, including a greater emphasis on climate change, an Earth systems science approach, and explicit attention to interactions among human and natural systems through inclusion of "Earth and Human Activity" as a core concept. Feinstein and Kirchgasler (2015) have criticized these standards for neglecting the ethical and social dimensions of potential solutions to sustainability problems and recommend systematic collaboration between educators in science and social studies to "provide realistic and powerful preparation for future sustainability challenges" (Feinstein and Kirchgasler, 2015, p. 121). While acknowledging significant structural barriers to the integration of pedagogy and concepts across disciplinary boundaries, they suggest that project-based learning may supply an avenue for collaboration if the science and social studies teachers instruct the same group of students.

The complexity of the dilemmas involved, which transcend the knowledge, methods, and tools of science, makes understanding and teaching about sustainability and its ethical implications a daunting task for the geoscience educator. Adding to the challenge is a lack of clarity about the fundamental nature of sustainability. This is where a philosophical analysis can help by clarifying the nature, forms, and normative aspects of sustainability.

THE NATURE AND ETHICS OF SUSTAINABILITY

A survey of the language of sustainability would quickly reveal a welter of terms and concepts, reflecting the orientations and concerns of different fields of study, professions, economic sectors, and approaches (Thiele, 2013; Caradonna, 2014; Portney, 2015). Familiarity with the breadth of ideas and developments in the field of sustainability may stimulate ideas for how to bring the ethical aspects of sustainability content into geoscience education, but it can be challenging and time-consuming for an individual instructor to synthesize ideas from disparate fields in a coherent fashion. Worse still for clarity about the ethical aspects of sustainability, the most widely known concept of sustainability—sustainable development—is value-loaded in a way that is actually an obstacle to ethical inquiry. Rather than survey the existing terminological terrain, we offer a small number of well-defined concepts and explain their advantages for geoscience educators.

Sustainability is often approached as a comprehensive ideal of social justice. In this common usage, it is an umbrella term under which many ideals have sought shelter. These include ideals of democracy, global environmental justice and health, and fair distributions of resources and opportunities. The obvious *political* logic of this is that any kind of reform that is essential to the long-term survival and quality of life on Earth should command instant respect. From an *analytical* perspective, however, this "big tent" understanding of sustainability is an obstacle to disciplined inquiry concerning the ethical dimensions of sustainability and the relationships between different forms of sustainability. As such, it is also an obstacle to sound education in sustainability, which, we believe, should engage students in *inquiry* concerning the ethical aspects of sustainability.

Such limitations are evident in the familiar Brundtland definition of *sustainable development* as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs"

(World Commission on Environment and Development, 1987, p. 12). The governments that advanced the idea of sustainable development agreed that development and environmental protection are mutually reinforcing, but that agreement was based on a false assumption. It overlooked the fact that environmental damage generally increases as economic activity increases (Speth and Haas, 2006, p. 56–61; Dietz et al., 2012; Jorgenson and Dietz, 2015; Stern, 2015). The terms we use in scientific and ethical inquiry should not be predicated on false assumptions, and the set of terms we use should enable us to clearly frame the hypotheses we need to investigate. This requires some precision, and the ideals of social justice presupposed by common ideas about sustainability are seldom precise or entirely suitable.

One illustration of this is the reference to meeting needs in the Brundtland definition of sustainable development. This definition would be satisfied in a world in which everyone alive at some point in time enjoys immense opulence while damaging the Earth in ways that leave future generations just barely able to meet their basic needs. Is this a scenario in which the population enjoying immense opulence is living sustainably? We think it would be obvious to most people that it is not, because the opulent society would be living in a way that degrades the Earth's capacity to provide opportunity to live well in the future. So we reject the Brundtland definition on two grounds: (1) it is predicated on at least one false assumption, and (2) its attempt to formulate the ethical heart of sustainability in terms of meeting needs is flawed.

We should emphasize that in offering this critique, we do not at all mean to imply that justice, democracy, and meeting basic human needs are unimportant. Intergenerational justice is an intrinsic aspect of the idea of sustainability, but it must be properly formulated. Other forms of justice are undoubtedly important. Some have moral importance independently of sustainability, and some have strategic importance in the domestic and global pursuit of sustainability. Sustainability requires global cooperation, and an important focus for sustainability research and teaching is inquiry concerning fair terms of cooperation. What terms of cooperation should we accept as fair in the interest of protecting the basis for a desirable quality of life into the distant future? What terms of cooperation would be fair with respect to ocean governance, or climate governance, or the protection and sharing of freshwater? These are unresolved questions, and they are ethical questions as much as they are questions of policy. Acknowledging this reality provides a clearer basis for sustainability teaching and practice than importing extraneous ideals of justice into the very idea of sustainability.

From the point of view of geoscience education, the fact that the Brundtland definition is fundamentally concerned with development is a further notable obstacle to bridging the science and ethics of sustainability. Definitions that are concerned with the environmental and ecological conditions of life are much more helpful in linking an understanding of planetary systems with ethical inquiry in the geoscience classroom.

The American Geosciences Institute (AGI) sees sustainability as pertaining to resource issues, environmental stability, and matters of health and safety (AGI, 2012). Our own definitions (Curren and Metzger, 2017) similarly distinguish *throughput* or environmental sustainability from *ecological* sustainability:

> *"The totality of practices of some human collectivity is sustainable with respect to* throughput *or is* environmentally sustainable *if and only if the material throughput on which it relies is compatible with the projected provisioning capacity of natural systems."* (p. 9)

> *"The totality of practices of some human collectivity is* ecologically sustainable *if and only if it is compatible with the long-term stability of the natural systems on which the practices rely."* (p. 8)

The former is specifically concerned with living in such a way as to not consume more than our environment can provide over the long term, and the latter pertains more broadly to not destabilizing or degrading the ecosystems that do much more than provide needed resources. In the language of ecosystem services, we rely on not only provisioning services (e.g., the reproductive activities of fish populations that allow us to catch and eat fish), but also supporting services (e.g., nutrient cycling, soil formation, and clearing of wastes), and regulating services (e.g., climate and flood regulation). By a *practice*, we mean a structured, norm-governed form of activity making up part of a culture. The structures and norms of practices shape human activities and give them a kind of *momentum* or forward *trajectory*. By a *totality of practices* and its *compatibility* with the long-term stability of natural systems, we mean all of the activities of a human collectivity during some time period, considered both with respect to their dependence and impact on natural systems and with respect to the momentum or trajectory of the activities entailed by their structure and norms as practices. The environmental impacts of different practices and individuals within a culture and population vary enormously, of course.

These definitions reflect the idea that the language of sustainability is, at its core, a way of referring to the long-term dependence of human and nonhuman well-being on the natural world, in the face of evidence that human activities are damaging the capacity of, and diminishing the accumulated beneficial products of, the natural systems on which humans and other species fundamentally rely. What unsustainability implies is that humanity is collectively living in such a way as to diminish opportunities to live well in the future and we regard *the preservation of opportunities to live well* as the overarching normative focus of concern for sustainability. Expressed in these terms, the opportunities for members of nonhuman species to live well have ethical significance, just as the opportunities of human beings have ethical significance, but our approach has been to show that a compelling ethical case for aggressively pursuing sustainability can be made solely on the basis of future opportunities for human beings to live well. Factoring in the conditions of nonhuman life on Earth only strengthens the moral imperative for systematic efforts to live sustainability.

Turning to the ethics of sustainability, our approach is to show that some important principles of sustainability ethics are implied by core commitments of *common morality* to respect others as rationally self-determining persons and to take care not to harm others. We refer to these commitments as belonging to common morality for two reasons. The first reason is that the endorsement of these commitments by diverse theories of morality and cultural traditions is so strong, widespread, and essential to social cooperation that it is reasonable to regard them as common norms (Gert, 2007). The second reason is that the common law tradition of England, the U.S., and Canada has understood a basic ethic of mutual respect and taking care not to harm others as not only common, or widely shared, but as so self-evident that it need not be codified in order to serve as a basis for legal liability (White, 1980). These grounds for accepting the existence of core commitments of common morality are surprising to *moral relativists*, who assert that ethical beliefs vary widely across cultures and who assume on this basis that all ethical beliefs are equally justified (Midgley, 1991; Wong, 2001; Rachels and Rachels, 2007; Shafer-Landau, 2004, 2010). Yet, relativism of this kind is rarely defended by philosophers. Indeed, it is common for elementary ethics textbooks to begin by examining and setting aside such views as impediments to serious ethical inquiry (Shafer-Landau, 2004, 2010; LaFollette, 2007; Rachels and Rachels, 2007). First, it is not clear that there are persistent cultural differences of belief about the kinds of core ethical commitments we have in mind. There are observable differences of beliefs about specific practices (such as eating pork, for instance), but such observable differences might reflect different circumstances or beliefs about relevant facts (e.g., what is safe or what is sacred), rather than basic commitments to respect what is morally valuable. Further, even if there are some persistent cultural differences of fundamental moral belief, it would not follow that the beliefs of different cultures are equally true and their practices are equally justifiable. There might still be some basic moral truths we can know. *Moral realism* is the view that there are objective moral truths knowable to human beings, and many contemporary philosophers who are moral realists are also *moral naturalists*, who argue that there are knowable truths about what is naturally good and bad for human beings (Foot, 2001; Curren, 2013). Moral naturalists make evidence-based claims about what enables and impairs healthy functioning or flourishing, such as that lead poisoning is bad for children and having parents and teachers who consider childrens' points of view and help them succeed is good for them. The theory of human well-being we defend is a form of moral naturalism about what is good for human beings, and it relies on several decades of research on basic psychological needs and what is and is not essential to people being happy (e.g., Curren and Metzger, 2017).

The following principles of sustainability ethics can be derived from our definitions of sustainability and core commitments of common morality to respect and take care not to harm others:

1. Take care to ensure that the human attributes, practices, institutions, systems, and policies within your control, authority, or influence are conducive to ecological and throughput sustainability.
2. Seek fair terms of cooperation conducive to sustainability. Actors whose actions affect each other have an obligation to cooperate in negotiating fair terms of cooperation in living in a manner that is collectively sustainable.
3. Do not obstruct transparency and cooperation with regard to sustainability.
4. Do not subject individuals or collectivities to detrimental reliance. Do not cause anyone to be in a position of fundamental reliance on hazardous or vulnerable systems or resources—systems or resources that cannot be relied on without exposure to unreasonable risk to their fundamental interests.

Climate change denial that undermines cooperation to stabilize Earth's climate violates all of these principles. Failures to educate for sustainability, reform practices and institutions, and lead others in pursuit of a sustainable human presence on Earth violate the first two principles. Exploitation of market position to perpetuate and expand reliance on vulnerable systems and resources (such as automobiles and petroleum) violates the first and fourth principles, as does humanity's collective contributions to a growing ecological footprint that will expose future generations to immense risk. Many specific examples of such violations could be developed into case studies for teaching.

A historical example that provides an interesting cautionary tale is the Dust Bowl of the 1930s (Egan, 2006). Named in 1820 the Great American Desert, the high plains grasslands later rebranded the Great Plains were designated by surveyors as too dry for farming. Nevertheless, with encouragement from the railroads and prairie state senators, the Enlarged Homestead Act of 1909 promoted dryland farming by distributing parcels of undeveloped federal lands. Homesteaders were induced through a variety of incentives and more than a little deception to relocate, plow up the grasslands, and farm a region that could not be sustainably farmed. The disaster that ensued can be attributed largely to violations of Principles 1, 3, and 4.

Contemporary cases in which there are tradeoffs and outcomes that are still playing out can provide different kinds of exercises in ethical analysis and simulated ethical decision-making. Hydrofracking presents tradeoffs between short-term energy production and long-term threats to groundwater that are obscured by industry resistance to revealing the chemical composition of fracking fluid—in a context in which a more equitable or just distribution of opportunities between rural areas and urban centers might alleviate the pressure on rural communities to choose today's jobs over health and sustainability. Individuals' consent to accept environmental hazards as the price of jobs is ethically meaningless—and would not absolve civic and business leaders of responsibilities associated with Principle 1—if those who must make the choice are denied equal occupational opportunity and the equal protection of environmental and occupational safeguards. Such cases illustrate the relevance of philosophical theories of justice to matters of sustainability and the application of basic ethical concepts, such as consent (see Curren and Metzger, 2017, Chapters 3 and 4). Justice with respect to occupational opportunity and environmental protection is similarly relevant to such cases as the mismanagement of water resources and infrastructure in Flint, Michigan, and in other municipalities and regions. If the profitability of bottled water and other commercialized forms of water delivery is playing a role in the politics of neglect of vastly more energy-efficient delivery of water through pipes, sustainability ethics would have much more to say than the obvious point that allowing municipal water to be tainted by dangerous concentrations of lead is a violation of

Principle 1.[3] The larger question of sustainability ethics and justice is how to structure present opportunities to be compatible with a long-term preservation of opportunity to live well. Creating better near-term opportunities for good work and health for rural Pennsylvanians and residents of Flint might be essential.

For a more detailed analysis of sustainability and sustainability ethics we refer readers to our book (Curren and Metzger, 2017). In the following section, we provide an overview of teaching strategies and resources for translating the concepts, definitions, and sustainability ethics principles enumerated above to classroom practice.

STRATEGIES FOR INCLUDING ETHICS IN TEACHING ABOUT SUSTAINABILITY

Philosophers typically teach practical ethics through model analyses, which students can be taught to critique, emulate, and improve upon. Instructors model and lead students in activities such as identifying and evaluating key arguments and assumptions, examining the adequacy of analyses, and using examples to test the principles on which the analyses rely. This is easiest to do using collections of case studies (e.g., Pierce, 2005; Association for Practical and Professional Ethics, 2016) and anthologies of readings that present multiple analyses of standard topics, such as debates over the morality of capital punishment, euthanasia, and animal rights (e.g., LaFollette, 2007). While such collections and anthologies exist in environmental ethics (e.g., Crocker and Linden, 1998; Light and Rolston, 2002; Derr and McNamara, 2003; Brown and Schmidt, 2010; Gardner, et al., 2010; Schmidtz and Willott, 2012; Boylan, 2014), sustainability ethics is at present largely represented by collections of exploratory essays (Moore and Nelson, 2010; Raffaelle et al., 2010; cf. Norton, 2015) that do not present the kinds of rigorous model analyses common in fields such as biomedical ethics, which possess more highly developed frameworks for ethical analysis.

Ethical inquiry has not been a traditional component of geoscience education, but this is changing in part through the efforts of the International Association for Promoting Geoethics (IAPG; 2017), a "multidisciplinary, scientific platform for widening the discussion and creating awareness about problems of Ethics applied to the Geosciences." IAPG's definition of geoethics makes explicit that an ethical practice of geoscience incorporates consideration of the social and cultural aspects of human interactions with the Earth system:

> *"Geoethics consists of the research and reflection on those values upon which to base appropriate behaviours and practices where human activities intersect the Geosphere. Geoethics deals with the ethical, social, and cultural implications of Earth Sciences research and practice, providing a point of intersection for Geosciences, Sociology, and Philosophy. Geoethics represents an opportunity for Geoscientists to become more conscious of their social role and responsibilities in conducting their activities."* (IAPG, 2017)

Although pedagogies and frameworks for ethical analysis around sustainability are still being invented, there are strategies that geoscience educators can use to engage students in ethical reasoning. For example, the definitions and principles we enumerate in the previous section can be applied and tested against case scenarios in group discussions, simulations, and student research projects, and examined in the context of more systematic ways of thinking about ethics and justice that are presented in ethics textbooks and scholarly works (Foot, 2001; Shafer-Landau, 2004, 2010; LaFollette, 2007; Rachels and Rachels, 2007; Curren and Metzger, 2017).

The Teaching GeoEthics Across the Geosciences Curriculum Web site (Mogk and Bruckner, 2017) is an excellent starting place for geoscience educators seeking practical advice for how to incorporate ethics into their instruction. This set of Web pages provides an extensive collection of resources for teaching about four facets of geoethics that relate to students' personal and professional lives and pertain to their responsibilities as scientists, citizens, and planetary stewards: geoethics and self; geoethics and the geoscience profession; geoethics and society; and geoethics and Earth. Links are provided to papers and books about teaching ethics in geoscience and other disciplines, codes of ethics from professional societies, and classroom exercises and assessments.

Case analysis is a common method for teaching ethics across the disciplines and, as noted by Sprain and Timpson (2012), case studies are particularly well-suited for teaching about sustainability because they provide opportunities for students to grapple with complexity, develop the capacity to cope with the uncertainty inherent in the wicked problems of sustainability, and work collaboratively with others to develop solutions (Sprain and Timpson, 2012). Case studies, student research, or news stories about sustainability-related events and issues can be used to help students develop awareness of ethical dilemmas and hone their critical thinking and problem-solving skills. The Teaching GeoEthics across the Geoscience Curriculum Web site includes a collection of case studies submitted by geoscience educators, and we have developed a trio of illustrative case studies (the Gulf of Mexico oil spill, Australia's National Water Management System, and changing patterns of food production in the Mekong Region of Southeast Asia). These interrelated case studies progress in scale from the local and regional to the national and international, are all concerned in some way with climate change, and highlight connections among water, food, and energy systems at the *water–food–energy nexus* (Curren and Metzger, 2017).

A common approach to teaching ethics is to provide a framework or template for ethical decision-making that can be used by students working in small collaborative groups to evaluate potential solutions to an ethical dilemma. Although it is important to recognize that any model for making ethical decisions unavoidably represents an oversimplification of actual reflective reasoning about ethics (Tavanti, 2007), such frameworks provide a helpful way to structure student thinking; the "Seven Step Guide to Ethical Decision-Making" framework developed by Michael Davis (1997) is a widely used example (Fig. 1). The tests included in Step 5 of

[3] It is a violation of Principle 1 because it damages and limits the usefulness of a critical resource or form of throughput and it necessitates the squandering of energy and massive amounts of plastic waste entailed by delivering water in bottles.

1. *State the problem* (e.g., "There's something about this decision that makes me uncomfortable" or "Do I have a conflict of interest?"). *This step is designed to develop an awareness of the ethical aspects of a problem.*
2. *Check facts* (many problems disappear upon closer examination of situation, while other change radically).
3. *Identify relevant factors* - e.g., persons involved (the *stakeholders)*, laws, professional code, other practical consideration.
4. *Develop list of options*.
5. *Test options,* using such tests as the following:
   a. *Harm test* - does this option do less harm than alternatives?
   b. *Publicity test* - would I want my choice of this option published in the newspaper?
   c. *Defensibility test* - could I defend choice of option before Congressional committee or committee of peers?
   d. *Reversibility test* - would l still think choice of this option good if I were adversely affected by it?
   e. *Colleague test* - what do my colleagues say when I describe my problem and suggest this option as my solution?
   f. *Professional test* - what might my profession's governing body or ethics committee say about this option?
   g. *Organization test* - what does the company's ethics officer or legal counsel say about this?
6. *Make a choice* based on steps 1-5.
7. Review steps 1-6. *If the situation involves implementing a selected course of action, reflect on the results and use them to inform additional action(s).*

What could you do to make it less likely that you would have to make such a decision again? Are there precautions you could take as an individual (announce your policy regarding the problem; change jobs, etc.)? Are there ways to change the organization (e.g., suggest policy change at the next departmental meeting)?

FIGURE 1: A seven-step guide to ethical decision-making. Modified from Davis (1997).

the Davis framework could be modified to include consideration of the ethical principles we have outlined above, or other principles of ethics and justice. Gert (2007) provides a good introduction to principle-based ethical decision-making, and the journal *Teaching Ethics* is an excellent source of guidance on teaching ethics across the curriculum.[4]

Classroom activities that use a decision-making framework to guide student reasoning about the ethical aspects of sustainability issues can be found in the Teaching GeoEthics Across the Geoscience Curriculum case studies collection (http://serc.carleton.edu/geoethics/case_studies.html). For example, Shaun Taylor describes a type of collaborative problem-solving exercise (Geoethics Forums; http://serc.carleton.edu/geoethics/activities/84325.html) in which students "research a particular dilemma, identify stakeholders, and then consider possible solutions and tradeoffs working towards the most acceptable path" using a decision-making template (Taylor, 2014). In Taylor's "The Grey Side of Green" activity (http://serc.carleton.edu/geoethics/activities/83374.html), students consider the pros and cons of developing green technologies that utilize rare earth elements. Students weigh the economic and environmental benefits of developing renewable energy technologies against the environmental and health costs of extracting the required natural resources, costs that are often borne by people in other countries who do not share the benefits. This exercise includes a downloadable template for student analysis of ethical considerations and connections to the Next Generation Science Standards (Taylor, 2014).

Yacobucci (2013) describes several strategies, including class discussions, student portfolios, and blog assignments, for incorporating thinking about values into introductory geoscience courses. Acknowledging that some geoscience educators may be uncomfortable with encouraging students to reflect on values, Yacobucci argues that "consideration of values (i.e., abstract expressions of desirable qualities such as cooperation, security, curiosity, and honesty) is an integral part of scientific practice and therefore appropriate for a science course" (Yacobucci, 2013, p. 351) and cites evidence that engaging students in criterial reflection on their values enhances both engagement and academic performance.

As emphasized by Mogk (2014), the inclusion of ethical reasoning in sustainability-focused geoscience instruction not only supplies students with a more holistic view of sustainability, but also supports good pedagogy by promoting systems thinking, reflection, and active learning that connects geoscience content knowledge to societal needs and planetary stewardship. In a broader sense, connecting the geoscientific aspects of sustainability to its human dimensions also aligns with national calls for more integrative STEM education that better prepares students for life and work in "a world of unscripted problems" (Schneider, 2015) by linking the content of the STEM fields to interdisciplinary investigation of complex and urgent societal problems. Reform initiatives such as the previously mentioned InTeGrate project (http://serc.carleton.edu/

[4] Volumes 2–13 of *Teaching Ethics* are among the resources available at the website of the Utah Valley University Center for the Study of Ethics; https://www.uvu.edu/ethics/seac/.

integrate/index.html), Project Kaleidoscope (PKAL; Elrod, 2010), and Science Education for New Civic Engagements and Responsibilities (SENCER; 2017) focus on active learning and the application of science concepts in real-world settings using a variety of ''pedagogies of engagement'' such as the collaborative, solutions-oriented learning experiences described above (Ferrett, 2013).

CONCLUSION

In this commentary, we have explained how the complex and value-laden nature of the problems of sustainability render them ''wicked'' in the parlance of Rittel and Webber (1973) and suggest that engaging students in ethical reasoning around these problems not only furnishes them with a more holistic understanding of sustainability, but also provides opportunities to hone their critical thinking and collaborative problem-solving skills. We have presented some basic aspects of our cross-disciplinary conceptualization of sustainability and sustainability ethics as a basis for integrating the ethical aspects of sustainability into geoscience education. We have surveyed relevant instructional approaches and resources and noted some relationships between our approach and wider efforts to promote instruction in geoethics and sustainability in the geoscience curriculum. We hope this will be useful to geoscience educators and provide a stimulus for further cross-disciplinary conversations among educators who share a commitment to the development of instructional approaches and curricula for engaging students in integrative explorations of sustainability and sustainability ethics.

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