Integrating Critical Thinking About Values Into an Introductory Geoscience Course

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ABSTRACT

This paper presents an instructional strategy for engaging students with the critical exploration of values in introductory geoscience courses. It is argued that the 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. Allowing students to critically reflect on their values has also been shown to increase student engagement and course performance. I have integrated critical thinking about values into an introductory history of life course through a variety of student-centered activities, including class discussions, homework essays, course blog postings, and exam questions. Topics discussed include anthropogenic global warming, evolution versus creationism, federal funding for science, commercial sale of dinosaur fossils, and cloning of extinct species. Portfolio-based assessments and student evaluations indicate that the values-based strategy promotes student engagement and develops students' ability to recognize and use values in analyzing arguments about socioscientific issues. Values-based inquiry increases both students' motivation to learn science and their academic performance in a science course. Because many aspects of geoscience research have social and ethical implications, the values approach can be readily incorporated into any geoscience course. Fostering critical thinking on values-related issues empowers our students to become informed, reflective citizens. © *2013 National Association of Geoscience Teachers*. [DOI: 10.5408/12-341.1]

Key words: ethics, general education, historical geology, public policy, affective domain

INTRODUCTION

Many colleges and universities require students to take one, two, or several science courses as part of their educational experience. The purpose and goals of these general education science requirements vary by institution and student body (Gaff, 1999; Hart Research Associates, 2009). Typically, some reference is made to the national crisis in scientific literacy, with calls for all students to be exposed to meaningful scientific content at the college level (NCEE, 1983; Pollack, 2001; Gonzales et al., 2004). A second purpose of general education science courses, at least in some fields (geoscience prominently among them), is to recruit potential new majors who may not previously have considered a scientific career (Stage and Kinzie, 2009). Many general education programs also consider science in its wider social context. Even if students will not pursue science as a career, they should understand how scientific discoveries affect public policy (Ehrlich, 2000; Trefil, 2008). Ideally, an introductory science course empowers students to make sound decisions and take actions on issues that matter to them.

In this article, I argue that critically exploring values in introductory geoscience courses offers a particularly effective way to achieve these goals. First, I define what I mean by "values." Next, I provide reasons science should not be viewed as value neutral; rather, values-related discussions should be considered part of a science course's core content. I highlight recent educational research suggesting ways that a focus on critical thinking about values can improve the learning experience of students. I then present a case study (including measures of effectiveness) that describes how values have been incorporated into an introductory history of life course, providing specific examples of topics explored using a variety of student-centered activities in both large and small class sections. Finally, I offer suggestions for how to incorporate critical thinking about values in other types of geoscience courses. By fostering critical thinking on values-related issues in these courses, we can prepare students to become informed, engaged, principled citizens.

BACKGROUND

The Place of Values in a Science Course

For many people, the term "values" is politically loaded, ranging across the ideological spectrum from Christian conservative family values to tree-hugging New Age mysticism. Here, however, I use the most general dictionary definition of what is meant by a "value"—an abstract principle or quality considered worthwhile or desirable (American Heritage Dictionary, 2011). While some values may be universal (or nearly so) among humans, most vary culturally in their prevalence or emphasis. Schwartz (1992, 1994) surveyed tens of thousands of people in dozens of countries around the world and found that cultural values could generally be grouped into 10 domains: universalism, benevolence, tradition, self-direction, stimulation, hedonism, achievement, power, conformity, and security. Some values commonly regarded as typical of Americans are progress, security, openness, individualism, justice, compassion, and ambition.

Many instructors' initial reaction to the idea of including values-based discussions in a science course may be negative. After all, isn't science supposed to be "value

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neutral"? If so, wouldn't it be misleading and confusing to students to talk about values? How could an instructor keep personal values out of play to prevent indoctrination of the students? Instructors may also not want to give up time in their science course for what they view as noncontent, or they may feel unqualified to present values-related issues in their course.

I challenge these views with four counterarguments. First, the notion that any course is value neutral unless values are intentionally and explicitly introduced is false. As Feiss (1998) put it, there "are no value-blind curricula, only value-masked curricula." Instructors express their personal values with myriad decisions that go into designing and delivering a course, from what topics they choose to cover (or not cover), to how class time is organized, to the strategies they employ to assess student learning, to how they interact with students during office hours. Our choices and behaviors as instructors teach values, whether we intend to or not (McKeachie and Svinicki, 2006). Rather than pretend we are "neutral" beings, we should be open with students about what we value and then expect the same from our students (Berkowitz, 1997; King, 2001; Colby et al., 2003; Hersh and Schneider, 2005).

Second, few people today still believe that science is a purely value-neutral enterprise, involving the unbiased collection of factual observations to test hypotheses by following rigorous rules of logic, in which the humanity of the scientist plays no role (Aikenhead, 1985; Stevenson, 1989; Allchin, 1999; Burkhardt, 1999; Stevenson and Byerly, 2000; Bell, 2003). Scientists are not automatons but rather value-laden humans. Our personal beliefs, attitudes, and values influence our theories, and theory influences our perception (Polanyi, 1946, 1958; Gould, 1983). All scientific work is affected to some degree by the values we hold as humans. The fields to which we are drawn, the questions we choose to ask, and how we interpret our results and draw conclusions are all shaped by our values. The criteria we use to evaluate scientific theories go beyond objective measures to include personal values and subjective perceptions (Kuhn, 1962, 1977). If a goal of introductory science courses is for students to understand modern scientific practice, we should not hide behind the myth of pure objectivity but rather help students explore the origins of scientific beliefs and practices (Thelen, 1987). Such a strategy may especially affect nonscience majors, who are accustomed to viewing scientists as "other": as different from them, unconcerned with human welfare, and perhaps not even "human" in the same way as "normal" people (Fleming, 1986; Akerson et al., 2010, 2012). Those who do science tend to hold certain values, like curiosity, openness, persistence, and respect for nature. Why should we hide these values from our students? Isn't it better to share with them the values that motivate us in our work? By demonstrating the "human heartedness" of scientists (Claxton, 1992), students may feel less intimidated and alienated by science and scientists.

Third, the consideration of values is an integral part of professional scientific practice. Put simply, science cannot be done without the ethical behavior of its members. Academic honesty, cooperation, and equitable peer review are all essential components of the scientific enterprise. As practicing scientists, we know this, but we rarely articulate it to our students and certainly do not explain this to undergraduates who are nonmajors. Ethical issues should be considered a core component of science "content" to be taught in introductory science courses (Burkhardt, 1999). Any working geoscientist is qualified to teach about ethical issues within the discipline. For decades, geologists have discussed whether there should be an official code of ethics for geoscience (Stephenson et al., 1997), encouraged geoscientists to become more engaged with values-related public policy issues (Oppenheimer, 2011), and called for deliberate training of students in ethics to prepare them for professional science careers (Tinker, 1977; Vandervoort, 1995; Heath, 2000). An introductory course may be the only exposure that geoscience majors have to ethical decision-making exercises, because specific ethics modules in upper-level courses for majors are still a rarity (Paldy, 1994; Shaner et al., 1996).

Fourth, scientific literacy includes an understanding of the impacts of scientific discoveries on society (AAAS, 1993; NRC, 1996, 2011; Zeidler and Keefer, 2003; Feinstein et al., 2013). Everyone—not just scientists—participates in the decision making about how scientific discoveries will be used. The human consequences of scientific inquiry cannot be sorted out solely by scientific evidence or pure reason. Indeed, various studies have shown the greater influence of values than of facts in decision making about scientific issues in society (Bell, 2003; Bell and Lederman, 2003; Aikenhead, 2006; Kahan, 2010). Consciously or not, our value preferences help us evaluate socioscientific problems, and to make informed decisions, we should be aware of what those preferences are.

Pedagogical Advantages of Incorporating Values

The preceding arguments demonstrate that values are a valid and legitimate component of science. That does not necessarily mean that it is worthwhile to incorporate critical thinking about values into a science course. Are there pedagogical advantages to including values-related issues in introductory courses? How does such a strategy align with what we know about how students learn?

One area receiving increasing research attention involves the importance of engaging students' affective domain (Kirk et al., 2007; Gilbert et al., 2009; McConnell et al., 2009; Perkins et al., 2010; Vislova et al., 2010; Wirth et al., 2010; van der Hoeven Kraft et al., 2011; McConnell and van der Hoeven Kraft, 2011). The affective domain encompasses one's emotions, feelings, attitudes, values, and motivations. Strategies to engage students by demonstrating the larger relevance and significance of the work they do in a course have been shown to improve student motivation, confidence, and self-efficacy (van der Hoeven Kraft et al., 2011; McConnell and van der Hoeven Kraft, 2011). The discussion of values, and in particular providing space for students to critically explore their values and value preferences, is one such strategy.

These strategies appear to have particularly beneficial effects for those populations of students who are most vulnerable in an introductory science course. Stereotype threat is a phenomenon in which members of a group subject to a negative stereotype are at risk of unconsciously internalizing that stereotype (Steele and Aronson, 1995). For example, students who are female or African American perform more poorly on standardized math tests than male or white students when attention is called to their gender or race. However, when the "threat" that the test will reveal the expected stereotype (that females and African Americans are not as good at math) is downplayed in the testing environment, all students perform similarly. Several studies have shown that asking students to complete short written exercises in which they explore their personal values has a strong positive effect on their course performance; these effects are seen particularly for female students (Miyake et al., 2010) and underrepresented minority students (Cohen et al., 2006, 2009). It is suggested that such exercises are an effective way to subvert stereotype threat and permit students to perform to the best of their abilities (Steele, 1988; Cohen et al., 2006, 2009; Sherman and Cohen, 2006; Cohen and Garcia, 2008; Miyake et al., 2010). In a similar vein, a remarkably successful undergraduate science, technology, engineering, and mathematics (STEM) program that serves as a national model for increasing diversity in STEM fields has as a key component time and space set aside for students to talk openly with one another about their values and beliefs (Hrabowski, 2012).

Another pedagogical advantage of the values approach relates to how it meshes with contemporary goals for general education. The learning goals for introductory general education courses have fundamentally changed over the past decade or two. As we increasingly shift to an information society, it becomes less important to merely impart basic factual knowledge to our students (Read, 2013). Rather, students need training in how to critically evaluate the new knowledge with which they are constantly being bombarded and to make sound decisions based on that knowledge (AACU, 2002; Alberts, 2009; Read, 2013). Focusing on the process, rather than solely on the content of science, improves students' self-confidence in understanding, interpreting, and using scientific ideas. Including discussion of values-related issues in introductory science courses may inspire students to want to learn more about the science behind controversial topics, as well as provide practice in critical thinking and analysis (Paldy, 1994; Soja and Huerta, 2001; Iwaoka and Crosetti, 2008). Indeed, Webster (2008), following the seminal arguments of John Dewey, has argued that the modes of critical inquiry inherent to scientific thought make science courses particularly well suited to the careful exploration of ethical issues. In the critical evaluation of values, students analyze arguments, trying to perceive the value preferences that underlie and motivate a position and how they can best defend their value choices. Students must appraise and justify viewpoints, not just express unsupported opinions. Developing these higher-order thinking skills is a key learning outcome of many contemporary general education programs.

The development of a scientifically literate, informed citizenry—emphasizing ethical and social issues and sound decision making —is frequently cited as another purpose of general education or introductory science courses (Kolst, 2001; Massey and Myers, 2006; Egger, 2007; Yacobucci, 2009; Nair, 2011). By explicitly connecting course content to its social implications, students gain exposure to controversies that may affect their daily lives. These socioscientific issues typically involve myriad value conflicts. Lutz and Srogi (2010), for example, argued that to develop students' "skills of citizenship," material should be set within a values context; they presented a values framework for discussing environmental issues in a geoscience course based on the work of biologist Stephen Kellert (1996). Showing the clear relevance of course material to their lives motivates students to learn more about the science behind the issues and gives them the background and tools needed to become actively involved in the problems in which they feel personally invested.

VALUES IN A HISTORY OF LIFE COURSE

Instructional Setting

Bowling Green State University (BGSU), part of the University System of Ohio, is a relatively large, public institution in northwest Ohio with a total undergraduate enrollment of about 14,800 students and graduate enrollment of about 2,900 students. The 6-y baccalaureate degree graduation rate is 60.5% (2004–2010 cohort). The freshman class entering in fall 2011 had an overall high-school grade point average of 3.31 and average composite ACT score of 22.34 (~65th percentile nationally). This freshman class was 58% female, 74.6% white, 15.8% African American, 4% Latino, and 1.1% Asian American. BGSU's basic Carnegie Foundation classification is "research university—high research activity (RU/H)" (BGSU, 2012).

The geology course Life Through Time is a general education lab science course that provides an introduction to the origin, evolution, and extinction of major fossil groups in relation to a changing Earth through time. The 4-credit-hour course includes two 75-min lecture periods and one 2-h lab period per week. Large section enrollment ranges from 90 to 135 students; a smaller all-freshmen lecture section with 22 to 35 students has also been offered. Lab sections are capped at 22 students each.

Life Through Time is taken primarily by nonscience majors seeking to fulfill a science requirement; however, several other populations of students enroll in the course. Adolescent/young adult science education majors specializing in Earth Science are required to take the course, and it is a recommended science option for middle childhood education majors. Education majors typically account for 10%–18% of the course's enrollment. The course is also required for geology majors who are paleobiology concentrators and for paleontology minors, and it is one of several options for the required introductory course for other geology majors; these geology majors and minors usually account for no more than two to five students enrolled per semester.

I have taught Life Through Time more than 20 times since creating the course in fall 1999; during this time, I have worked to incorporate more active learning approaches and innovative pedagogies into the course. In 2003, I began teaching the course as part of BGSU's BGeXperience (BGX) program. The mission of the BGX program was to prepare students to become effective, engaged, principled citizens by focusing on the critical exploration of values. The program included several components, including a 2-d orientation for freshmen, during which they worked in small groups with a faculty member and an undergraduate peer facilitator. This faculty member and peer facilitator were then the instructional staff for a small section (capped at 35 students) of a general education course in the fall semester that focused on the exploration of how values shape academic and public discourse within that course's subject area. The BGX program used a standardized approach to values exploration,

TABLE 1: Values-related topics in a history of life course.

Anthropogenic global warming
Evolution and creationism
Government funding of scientific research (NASA Mars mission)
Commercial sale of dinosaur fossils
Controversial ideas in geology (continental drift, the Alvarez hypothesis)
The idea of "rewilding" North America
Attempts to clone a woolly mammoth

including definitions of "value," "value conflict," and "value preference" developed by BGSU philosophy faculty. Each course's instructors then developed materials and activities that applied these concepts to their specific subject matter. I taught a BGX section of Life Through Time from 2003 to 2010, when the BGX program was terminated due to lack of funding to support such a large number of small sections. I also acted as a peer trainer for other science faculty new to the BGX program. I found it relatively straightforward to incorporate many of the materials and activities I developed for the BGX section of Life Through Time into the large lecture sections of Life Through Time that I taught in the spring semesters and have continued to teach since the end of the BGX program in 2010. In particular, I have divided the large lecture class into groups of three to six students to work on values-related problems during class time. I circulate around the room, engaging each group in discussion, and then call for volunteers to present their conclusions to the rest of the class.

Materials and Strategy for Implementation

Students in Life Through Time have engaged in values-related issues through a variety of means, including in-class open discussions in lecture and lab, in-class pairs or small-group worksheets, homework essays, online course blog postings and reactions to other students' postings, and exam questions. Generally, students preferred discussions and small-group activities, in which they could both express their ideas and hear those of other students, to solitary activities, in which feedback was less immediate.

Many topics typically covered in a history of life course lend themselves well to discussions about values (Table 1). For example, after discussing the carbon cycle and the use of stable carbon isotopes to reconstruct ancient atmospheric carbon dioxide levels, we devote a class to discussing current concerns about anthropogenic global warming. Students read the Intergovernmental Panel on Climate Change (IPCC) science summary for policymakers (IPCC, 2007) before class and then during class are given a short article describing how personal values are a stronger influence on people's beliefs on global warming than are scientific data (Kahan, 2010). They are then asked to think about where they hear about information related to climate change, what views they personally hold on the subject, and what personal value preferences they hold that lead them to those views. After discussing their views with other students, they work in pairs or groups of four to see whether they can reach a consensus view, using the science communications strategies recommended by Kahan (2010). Groups submit a short written report of their discussion and final consensus at the end of class. (See Appendix A.1 for a sample class worksheet for this assignment.)

Another topic that stimulates a great deal of class discussion is the issue of government funding of scientific research. We spend about a week in class discussing the origin of Earth and life and major events in life's history during the Archean and Proterozoic eons. Then we turn our attention to Mars. Why are we sending rovers to Mars? What are they looking for? Why do National Aeronautics and Space Administration (NASA) scientists think there may have been life on Mars early in its history? Are these missions worth the cost? How much do they cost, relative to other aspects of the federal budget? To help facilitate discussion, I provide a little background information on the Mars missions and show students current budget figures for NASA, the other major federal science agencies (National Institutes of Health, National Science Foundation, Environmental Protection Agency, U.S. Geological Survey, etc.), and other major components of the federal budget (e.g., Departments of Defense, Homeland Security, and Education). Students then engage in discussion of several values-laden questions. Is it ethical to fund an expensive research project, like Mars exploration, that may appear (at least at first) to have little direct relevance to our earthly problems? What values might underlie a scientist's desire to look for life on Mars? Why set this as a research goal? If we were to find replicable life (either living strains or fossilized genetic material that could be "revived") on Mars, what should we do with it? Should we bring it back to Earth? Is greatly increased knowledge of basic life processes worth the risks of "monkeying" with alien life? Students are not allowed to merely express an opinion here but must support and defend their viewpoint with justified reasons.

The course explores other values topics where geoscience and society intersect, such as the commercial sale of dinosaur fossils—is it ethical to buy and sell scientifically valuable fossils? (See Appendix A.2 and A.3 for relevant assignments.) We also, however, examine issues in which questions of values are embedded within the scientific discipline, such as the reactions of geologists to Alfred Wegener's proposal of continental drift or Luis and Walter Alvarez's hypothesis that an asteroid impact caused the end-Cretaceous mass extinction. (See Appendix A.4 for examples of blog prompts that address this topic.) Why was the geological community initially so hostile to these ideas? In what ways did these new ideas challenge long-held values within the disciplines of geology and paleontology? These discussions reveal a different side of the scientific enterprise from the ones most students ever consider, helping to humanize scientists and make their professional work more relatable to students.

Evidence of Effectiveness

Three measures have been used to evaluate the effectiveness of the values approach: a portfolio, an essay question, and an anonymous student evaluation.

Portfolio Measure

In the all-freshmen BGX sections of Life Through Time, a portfolio approach was used to assess whether students were meeting the learning outcomes of (1) being able to identify relevant values and value conflicts and (2) make an argument based on their value preferences. Copies of student work were retained throughout the semester, and students' ability to identify and use values was tracked. In addition to feedback on each assignment, students received a copy of all their values-related work with a final evaluative summary from the instructor at the end of the semester and were asked to review their progress.

Early in the semester, most students struggled with the concept of what a value was, often describing nonvalues instead, e.g., "a few values the university must uphold is…having students interact with one another." They also were reluctant to take a firm position, choosing instead to merely present two sides and say that it is hard to know which to choose. As the course went on, students became more proficient at identifying and describing values and connecting them to their viewpoints.

For example, about halfway through the semester, one blog assignment asked students to describe what the term "evolution" means to them and to discuss their comfort level with the idea of human evolution. They were then asked to identify values they hold that lead them to their view of evolution. Many students were able to articulate their views and values fairly well:

Student 1

> *"[W]hat values do I associate with my view of evolution? However contradictory this may sound, skepticism is actually one of the main ones. I'm skeptical not in believing evolution exists/occurs, but because that value strongly ties in with agnosticism—such knowledge or belief in a deity/deities is unknowable as far as I'm concerned. This clearly emphasizes why I can so easily believe in evolution. Another value would be a high respect to intellect, in opposition to simply believing in whatever one's heart is supposedly beating for. Proof exists for evolution, regardless of what sort of nonsensical Bible-literalist material it contradicts. Piggybacking off of that, intrepidness and courage play a big role here too—having the nerve to say a sentence like the last, knowing it could very well (and most likely did) offend certain people. Even though I didn't necessarily mean it to be an insult, I wrote it that way because it accurately portrayed my belief, and I was honestly hoping that it would firmly convey my simple perspective on evolution."*

Student 2

> *"Values that I associate with evolution would be openess, you have to be willing to hear everything out when it comes to it. But I would have to say the biggest value would be respect, there are going to be so many different opinions and people's beliefs that come into play when discussing evolution so, therefore, all of these matters are going to have to be respected and therefore, hear what the other side has to say, doesn't mean you have to agree with it but be respectful."*

Student 3

> *"The value I associate with my view of evolution is truth, and the Bible is the truth. We didn't come from apes. God created us individually with our own special characteristics. I believe this because it is what I was taught all my life. It is wrong to think otherwise and go against the Bible. This is important to me because I want something to look forward to after death, to go to Heaven. So if human evolution is right, and the Bible is wrong, what do we have to look forward to after death? With evolution, one idea, being right, that means almost everything the Bible says is wrong, and that can't be right."*

(All student responses are transcribed verbatim, with typographic and grammatical errors uncorrected.)

Essay-Question Measure

To evaluate progress through the semester, at the end of the term a common essay-style question was posed on the final exam in each of the seven semesters of the all-freshmen BGX sections. The question presented information about ongoing efforts to recover biological material from frozen woolly mammoth specimens to produce a living clone. It then asked students to provide a written analysis of this research effort, including a discussion of the values that might motivate scientists pursuing such work, what other values might be in conflict with such a research program, and where the student stands on the issue (based on personal value preferences). Students were required to explain the reasoning behind their viewpoint, rather than merely stating an opinion, and consider the potential consequences of holding a particular preference. (See Appendix A.5 for exact wording of the question and several examples of student work.) Each element of the required response was evaluated on a three- or four-point scale, and final scores were given out of 25 points. The scoring was set such that a percentage in the 80s or 90s would be equivalent to an A- or B-quality response, a percentage in the 70s to a C-quality response, and so on. Results were tallied each semester.

Over the seven semesters, 170 freshmen completed a response to this question, with 22.4% of responses falling in the A range, 38.8% in the B range, 18.8% in the C range, 18.2% in the D range, and 1.8% in the F range. Overall, by the end of the semester, 80% of students could provide a C-quality or better response to this question (with 61.2% providing a B-quality or better response). Clearly, these first-semester freshmen, while not yet universally proficient, improved their ability to identify and discuss relevant values and employ them to make an argument for or against a position.

Anonymous Student Evaluation Measure

The third way in which the effectiveness of the values approach was evaluated was via anonymous student evaluations at the end of each semester. These evaluations included targeted questions asking for feedback on values-related activities, including in-class activities in the large lecture sections of Life Through Time. This feedback was useful for assessing student reactions to the use of values-related materials in a science course and whether they felt this approach enhanced their engagement with the course. Most responses were positive in both the small and the large sections of the course. Students discussed various aspects of the course and how they affected their learning experience. Some students commented on their overall impression of the course:

"This course is a great intro into the world of Geology. You have the have the right taste for a science like this. It really is something to behold, and the class did a great job conveying not only the facts and theories of the class, but also the values and standards that the Geologic and Paleontologic community holds."

"I feel that the course was very interesting, especially because of the values aspect that was integrated into the class. This course taught me a lot about concepts that I either didn't know much about or had misconceptions about."

"This course does a really good job at challenging students to think critically and forces the students to expand their way of thinking."

Others focused on specific activities they were asked to do:

"I really enjoyed doing the blog assignments because they could be from my point of view. I felt like I could voice my opinion in a more relaxed way which was refreshing."

"I enjoyed the blogs, and I would recommend that there be a few more blog assignments. I think that expressing an opinion about the topics we studied in class helped the material to become more relevant and meaningful."

"The in-class assignments gave us a chance to work with other people in the class and share ideas. It was also intellectually stimulating because, like the homework assignments, they allowed us to think outside the box."

"The in-class discussions really helped me in understanding other ways of viewing a topic, it was interesting to see what other people had to say and trying to convince them to think my way was fun. It made learning the material a lot easier because I could actually interact and voice my opinion."

There were some negative comments expressed in the course evaluations. I had anticipated that a primary complaint would be that students might feel that they were being indoctrinated to a particular set of values or would argue that values had no place in a science course. However, these concerns did not materialize. Rather, the negative feedback revolved around the typical issues that come up when a course involves active learning and group activities. For example, several students complained about their dislike of group work when not every student participates adequately:

"[D]iscussing the activity with another group often didn't work very well, as many of the groups we paired up with didn't put any effort into the discussion, and often would leave my group to do all of the work."

"[T]hey [in-class activities] were difficult to do in this room b/c of its set-up. Basically only two people jotted down the answers while the rest of us just sat there agreeing. In-class activities just don't work in such large lecture rooms."

Some students viewed anything other than lecture as a meaningless distraction from what they were paying their tuition dollars for—presentation of material by the professor:

"The in class discussions were ineffective. I don't care what other people think who are on educated. The only opinion I care about when I am paying this much for college is that of the teacher and her colleagues."

"In class activities didn't help me much at all. I like the lecture, however I don't think the rest of my classmates would agree."

Finally, a few students expressed their view that discussing ideas with classmates was a waste of time because they were unimpressed with their fellow students' arguments:

"I didn't mind the blog assignments. They were a good way to express my opinion. The comments from others were pointless though, everyone says the same thing and [is] not critical at all."

"I personally prefer learning by lecture, because discussions in large classes tend to be bogged down by bland, uninteresting arguments presented by people that tend to have little debate skills or have little idea of what they are talking about. The small groups were a good idea, but I feel that it didn't quite achieve the desired effect due to the lack of willingness of the participants to 'give their all.'"

"I HATE IN CLASS ACTIVITIES. THEY ARE AWFUL AND I CAN'T STAND STUPID PEOPLE WHO DON'T BELIEVE IN GLOBAL WARMING."

Despite these more negative reactions, however, most student evaluations indicated that the values approach is well received and promotes student engagement with the course and critical thinking about issues within the course's intellectual domain.

SUGGESTIONS FOR IMPLEMENTATION IN OTHER GEOSCIENCE COURSES

Many of the topics discussed in the Life Through Time course are amenable for use in other geoscience courses. Government funding of scientific research and controversial ideas within geoscience, such as continental drift, would be appropriate for an introductory physical geology course. Anthropogenic global warming would fit well in an environmental geology course. An exploration of evolution versus creationism would be beneficial for a course targeted toward preservice teachers. Numerous other values-related topics would also work well for courses like these. A physical geology course might devote time to discussions of coastal and river management practices, mining policies, and strategies for dealing with volcanic and earthquake hazards, while an environmental geology course could focus on decision making related to land use planning, groundwater contamination, water resource rights, and conventional versus alternative energy sources. Any geoscience course could discuss more general issues of scientific practice, such as who "owns" scientific knowledge, whether research practices or results should always be shared (and with whom), and with whom the responsibility for evaluating the social consequences of scientific research lies.

Instructors are encouraged to keep an eye out for current news articles, op-ed pieces, and blog postings on geologically related topics. Instructors can then build a class discussion or assignment around these materials, highlighting values, value conflicts, and value preferences that are embedded in these immediately relevant issues. In small classes, numerous discussions, writing assignments, and group projects are possible. However, even in large sections, including a few days of small-group discussion on values-related issues can prove beneficial to students.

Incorporating values into a course is not without its challenges. It is imperative to spell out clearly what is meant by a "value"—an abstract principle or quality considered worthwhile or desirable, such as curiosity, knowledge, honesty, or cooperation. Students routinely struggle with this concept. They might consider anything they like to be a "value" (e.g., I like my dog, and I "value" my dog; therefore, "my dog" is a value, "pets" is a value, or "pet ownership" is a value, none of which is a correct use of the term). Encourage students to dig deeper to find the value behind what they are trying to argue (e.g., perhaps the dog represents loyalty, love, comfort, safety, or tradition). Students may also conflate opinions with values, such that anything that is an opinion is a value and therefore cannot be questioned without giving offense. Here it helps to reemphasize the definition of a value and to highlight the importance of value conflicts in many debates; that is, it is reasonable for two people to disagree on a question because they value different things or give preference to one value over another in that particular context, not because one person "has values" and one does not. The critical evaluation of arguments based on value preferences is an important skill to emphasize.

Any class activity that involves controversial topics may provoke tension or fear in students, undermining their ability to learn. Instructors must set ground rules for all class discussions to mandate respectful discourse, ensuring that students feel safe in expressing their viewpoints. It should also be made clear (and repeated frequently) that students' grades will not be based on what viewpoint they hold but rather on how well they can argue and support that viewpoint. Students should thus be aware that they are expected to support their arguments and that merely expressing an opinion is insufficient. Emphasizing that students will be gaining experience in constructing arguments and practicing critical thinking—skills they need in courses for their majors—helps overcome initial student resistance.

Finally, it is critical to provide feedback to students, rather than merely collecting or tabulating their responses or viewpoints. Students benefit from having the opportunity to reflect on and deconstruct their work (Thelen, 1987; McConnell and Steer, 2006; McConnell, 2009). Expressing viewpoints merely to complete a worksheet or making arguments without ever receiving constructive feedback on their quality frustrates students and undermines the purpose of implementing these strategies.

CONCLUSIONS

A convincing case can be made that a values focus enhances student learning in an introductory geoscience course. However, numerous further studies of student experiences and outcomes could be proposed. For example, because of the structure of the BGX program, it was not possible to set up control groups for geology courses, that is, courses on the same topic, of the same size, and with similar student characteristics but without a values emphasis. Such a comparison could reveal how much of students' shifts in attitudes and abilities are due specifically to the values focus, as opposed to other aspects of the BGX program, such as learning within an all-freshmen cohort. (A controlled study comparing BGX versus traditional Introduction to Psychology courses was performed; Gillespie, 2005, 2011).

A second avenue for further study is the role of gender, race, and ethnicity in student gains. As noted in the Instructional Setting section, BGSU's student population includes about 20% underrepresented minority students and 58% female students. So far, the impact of a values-linked course on these special populations has not been assessed. These students represent groups that are less likely to become science majors. Does a values focus more strongly affect views on science and scientists for women and underrepresented minority students than for majority male students? Would such students be more likely to see themselves as scientists than students in a more traditional classroom?

Third, it would be helpful to more carefully track and correlate student performance on values-related tasks with students' grasp of geoscience concepts. Can student performance be quantified, for instance, via a "values reasoning inventory" that could then be compared to students' scores on the Geoscience Concept Inventory (Libarkin and Anderson, 2005)? Gillespie (2005, 2011) developed a Critical Thinking About Values Assessment instrument to evaluate student performance in introductory psychology courses. A similar instrument could be used in geoscience courses.

Finally, I would argue that integrating the critical exploration of values into geoscience courses can be a transforming and empowering experience for students. Rather than treating nature as something separate and removed from those that study it, this approach allows students to develop and explore their values-laden relationship with the natural world (Witz, 1996). Where do they fit within nature? How do they personally approach the study of the natural world? What values have shaped their views on issues like evolution, extinction, and environmental change? A values focus may also transform the way students view science, scientists, and their own role in society. Discussing the values inherent in scientific practice reveals the human side of science, which may encourage more students to consider a geoscience career. In a values-infused course, students engage in real-world problems not by merely expressing their opinions but rather by critically evaluating the values they hold that affect their viewpoints. A focus on values, then, is an effective way of getting to the heart of scientific literacy—empowering every student to make informed, reflective decisions about the socioscientific issues we all face.

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APPENDIX A. Sample Class Activities.

1. CLASS DISCUSSION ON GLOBAL WARMING (SUITABLE FOR CLASSES UP TO 135 STUDENTS)

Step 1

(1) Partner with someone sitting near you. Record both your names above.
(2) Tear off and read the attached article "Fixing the communications failure" by Dan Kahan.
(3) Discuss the following questions with each other.
(4) Record below both your responses to these questions.

Q1. Where do you stand on the global warming controversy? Do you think global warming is happening? Do you think human activities, like burning fossil fuels, are causing it? Why or why not?

Q2. Kahan argues that those who are skeptical about global warming tend to be people with "individualistic values, who prize personal initiative, and those with hierarchical values, who respect authority," while those more likely to be concerned about global warming would be people who have "more egalitarian and communitarian values" (p. 296). *Given your own value preferences and view on global warming,* would you agree or disagree with Kahan's assessment? Why?

Q3. Generally speaking, do you trust scientists? Did you believe what you read in the IPCC report? When a scientist is presented as an expert on television, do his or her personal attributes—male vs. female, old vs. young, "besuited and grey-haired" vs. "denim-shirted and bearded," as Kahan puts it—affect how you view the information the scientist conveys? Explain.

Step 2

Now join up with another pair of students. Record your two new group members' names here:

____________________ ____________________

Compare your responses to the questions on the first page. Identify one question on which some of you disagree, at least in part. If you all totally agree, come up with some related issue (such as what we should do about global warming, whether gas-guzzling SUVs should be banned, etc.) on which you might disagree.

Q4. Write out a short description of the nature and source of the disagreement. What key ideas are in contention?

Q5. Consider the communication strategies that Kahan suggests in the last section of the article. Now, using those strategies, can one side convince the other so that you reach a consensus view within your quartet about the issue you disagreed on? If so, what is the consensus view, and how exactly were group members convinced? If not, can you identify the central, core issue that forms the stumbling block? What is it?

(Each pair should record this response on their own worksheet, although it should essentially be the same for both pairs.)

Step 3

Q6. Think for a moment about your own reactions to today's conversations. Come up with one idea, experience, comment, reaction, or argument you heard about today that surprised you, and explain why it did.

(Each original pair of students should record each of their surprising ideas below—it's doubtful you had exactly the same idea.)

2. CLASS DISCUSSION ON THE COMMERCIAL TRADE IN DINOSAUR FOSSILS

Step 1

(1) Partner with someone sitting near you. Record both your names above.
(2) Discuss the following questions with each other.
(3) Record below both your responses to these questions.

Q1. Consider the "Paper sparks fossil fury" news article, which comes from the prestigious science journal *Nature* (Dalton, 2009). How do you react to this story? To which side are you sympathetic? Why?

Q2. Now consider the different stakeholders in this dispute:

1. The dealer who sold the fossil (Hollis Butts)
2. The neuroscientist who bought it (Vilayanur Ramachandran)
3. The commercial collector who wrote the published article about it (Clifford Miles)
4. The professional paleontologists who protested its publication (Mark Norell, Philip Currie, and Bolortsetseg Minjin)

What do you think is motivating each of the different stakeholders? Are value conflicts significant in this debate? Or does the dispute stem from other sources? Explain your reasoning.

Step 2

Now join up with another pair of students. Record your two new group members' names here:

Q3. Your quartet works for an American science journal that publishes peer-reviewed scientific research. You have been asked to prepare a short policy statement on whether or not the journal will publish research articles about fossils that may have been collected illegally.

In your statement, consider the following issues:

- Is the collecting of vertebrate fossils (like a dinosaur) for nonscientific purposes unethical? Is the for-profit buying and selling of vertebrate fossils that have already been collected unethical? Does it matter where the fossils came from, e.g., privately owned vs. public/government land or certain countries?
- Who do you consider "qualified" to collect fossils? To study and publish on them?
- Do you think publishing of illegally acquired or stolen fossils will encourage more thefts? Do you think that the scientific findings from such fossils are valuable enough to offset these negative consequences of publication?
- Does it matter whether the scientific research is funded with federal grant money (i.e., taxpayers' dollars) or by private donors?

Step 3

Q4. Reflect back on your discussions. What one idea, comment, or argument did you most disagree with?

(Each original pair of students should record each of their responses.)

3. HOMEWORK ESSAY ON PROTECTING VERTEBRATE FOSSILS

The Paleontological Resources Preservation Act

The past 15 years have seen ongoing controversy in paleontological circles about how fossils on public lands should be protected from illegal collecting. Several previous attempts at passing federal legislation have failed, as academic paleontologists, commercial fossil dealers, and amateur fossil hunters argue with one another over what limitations should be placed on each group's activities. Fueling the flames was the Federal Bureau of Investigation seizure and eventual auctioning in 1997 of the fabulous *Tyrannosaurus rex* specimen "Sue" (see the Field Museum of Natural History's Sue Web site at http://www.fmnh.org/sue/dispute.html).

Over the past 2 years, the U.S. House and Senate have been considering the proposed Paleontological Resources Preservation Act (PRPA, Senate bill S.263). In July 2005, the Senate passed S.263; the equivalent bill in the House is still in committee. To learn more about the bill—and the controversy behind it—see the following links:

- The American Geological Institute's Government Affairs Program: Background and summary of bill, with a link to the congressional Web site for S.263, where you can read the proposed legislation for yourself. http://www.agiweb.org/gap/legis109/fossils.html
- The Society for Vertebrate Paleontology (academic science): Statement in support of the PRPA. http://www.vertpaleo.org/policy/policy_statement_Preservation.html
- The Black Hills Institute of Geological Research (commercial fossil collectors—the ones who excavated and then lost Sue): Statement against bills like the PRPA. http://www.bhigr.com/pages/ffacts/ff_main.htm (click the "Law and Policy" link for more information and statements against a similar bill proposed in 2001)

Once you have a sense of the dispute, it's time to get to work. You are a congressional science fellow with the Geological Society of America; this means you have been appointed to work in a congressperson's office for 1 year to assist and advise the congressperson on science issues. Your congressperson has asked you to prepare a two-page position statement on the PRPA.

Things to include in your statement:

1. Establish the factual basis of the dispute: What would the PRPA do? Why do people disagree about whether the act is a good idea? Who are the stakeholders in the debate? What are their positions? What reasons do they give for their positions?
2. Consider the ethical dimensions of the issue: Do you think that the collecting of vertebrate fossils for nonscientific purposes is unethical? Or is it unethical to prohibit "ordinary" people from owning and selling vertebrate fossils?
3. Acknowledge the role of values in the dispute: What values do you think are motivating each of the different stakeholders? Are value conflicts significant in this debate? Or does the dispute stem from other sources?
4. Provide a values context in which your congressperson can argue either for or against the bill in Congress: First, based on your response to Part 2, should the congressperson argue for or against the bill? What values should the congressperson then bring up on the House floor? How should your boss use these values to make the case to the other congresspeople for or against the bill?

Be sure to limit your position statement to two pages—you know how short congresspersons' attention spans are.

4. PROMPTS FOR BLOG POSTINGS

(1) Imagine it's 1920 and you're a young geologist. Do you think you would have sided with most geologists against Alfred Wegener and his continental drift idea? Or would you have gone out on a limb and supported him? Why or why not? What values do you hold that would lead you to that position?

(2) No scientific topic is as controversial in the United States as evolution, even though it's considered the foundational concept in biology, paleontology, and the medical sciences. In this blog posting, you'll reflect on your personal view of evolution.

First, what does the word "evolution" mean to you?

What images does it invoke? What processes do you associate with the term?

Second, how comfortable are you personally with the idea of evolution in general, and of human evolution in particular? Can you trace the origin of your viewpoint (e.g., your parents, teachers, or friends)?

Third, what values do you associate with your view of evolution? That is, why do you think what you think? What is important to you that leads you to the view you hold?Later, visit the blogs of your group mates and post comments on their evolution blogs. In particular, focus on the values the writer identified. Are they actually values as we defined the concept? Do you agree that these values are relevant to the writer's view on evolution?

(3) In 2001, *Forbes* magazine (a leading business and investment periodical) ran an entire article devoted to how to effectively invest in fossils as rare collectables that will increase in monetary value (similar to the ways people invest in art objects). If you had the money to purchase a dinosaur or other rare fossil, as a collectable or investment, would you do so? Why or why not? How do your personal values affect your position?

(4) How do you react to the "rewilding" argument—that we should repopulate North America with modern elephants, cheetahs, and other large mammals that are related to animals that became extinct here more than 10,000 years ago? Is this an ethical thing to do? What values do you hold that underlie your decision to support or reject the rewilding argument?

5. EXAM QUESTION ON MAMMOTH CLONING

Woolly mammoths are the icons of the Ice Age and only became extinct about 10,000 years ago. Mammoths are sometimes found frozen in permafrost, with soft tissue and hair preserved, and scientists in several countries are actively trying to recover DNA and/or sperm in order to create a mammoth clone or a modern elephant–mammoth hybrid.

Given the slim chance of finding viable mammoth cells in the Siberian permafrost, why would one pursue such work? Consider the following claim by Dr. Kazufumi Goto, leader of a joint Japanese–Russian research team:

"If successful, we may be able to revive other extinct species using the same process.... We don't know until we try it."

Write a one- to two-paragraph analysis of this issue, including consideration of the following questions:

- What values underlie Dr. Goto's reasons for pursuing this research? How can you tell?
- What other values might conflict with Dr. Goto's?
- Based on your own value preferences, do you accept or reject Dr. Goto's argument?

Be sure that you define and describe the values you mention and consider the potential consequences of holding one preference or another. Explain the reasoning behind your viewpoint; don't just state your preference.

Sample Student Responses

(All student responses are transcribed verbatim from their final exams.)

Student 1

"Some values that may underlie Dr. Goto's reasons for pursuing this research is the desire for more knowledge and understanding. He wants to know what the extinct species is like and if it is possible to clone it. Also it seems that he values is dedication/determination. Even though his chances of completing this experiment is slim to none he still pursues it.

"Some values that may conflict with Dr. Goto is stability. People may think it morally wrong to try and bring back an organism that has, for whatever reason/purpose, died out.

"I would reject his argument because I value stability. Sure it would be nice to know how an organism was in the past, but I don't think you need to waste time and effort to learn something you may already know through uniformitarianism. Also, it died for a reason, it may not have been able to survive, so what would make it able to now?"

Student 2

"When I heard about the woolly mammoth tissue that was to be formed into a modern mammoth, I was interested. To bring an animal back from extinction. Even though the chances are slim, if it is somehow done it will mark one of the greatest scientific experiments of all time. It would open doors for other creations and allow scientists to learn a lot about woolly mammoths. Dr. Goto's values have to be knowledge and curiosity. If him and his team are successful, the knowledge that will come from their recreation will be monumental, and very important for researchers. He also has the value of curiosity. He is trying to do this, although it may be unsuccessful. But if he doesn't try, he'll never know if it is possible.

"There are many people who oppose this attempt at recreating a species. Many of these people would claim that an animal becoming extinct is part of nature, and recreating it is messing with natural selection. The values these people have are respect and life. They have respect as a value because these people believe the history of earth should be respected and not trifled with. And they value life because if the species is resurrected than it would be the doing of man, and not of God or evolution.

"Personally, I believe this research should be done. I agree with Dr. Goto and his quest to bring back woolly mammoths. I, too, value curiosity and experimentation. Just the concept of creating something that has been long extinct is fascinating and worth developing in my opinion."

Student 3

"Based on Dr. Goto's statement, one can conclude that he obviously values knowledge and discovery. He believes that if humans can find a way to understand something that it is in their best interest to do so. You can tell this by his statement "We don't know until we try it."

"Some values that conflict with Dr. Goto's would be values such as the mentality that states "everything happens for a reason" or values of leaving things be. Some may argue that these creatures are extinct for a reason and maybe if someone were to play God and try to bring them back there could be terrible consequences and suffering that might result.

"I personally believe, based on my experiences watching too many science fiction movies, that bringing back an extinct

creature, although exciting, is in humanity's worst interest. I believe everything happens for a reason and I have faith that God made the creatures that are extinct for reasons beyond my knowledge. I guess you could say I value faith.

"If we are not going to recreate this creature we could be missing out on data and discoveries on how it lived, but I am willing to sacrifice that information for the chance to keep people out of harm."