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Values and Justice Education in College Science Courses

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Introduction

As an undergraduate geology and philosophy major and then as a doctoral student in geology, I felt a profound joy in "pure" science. Although several of my outstanding faculty in both college and graduate school studied environmental geology, I felt that for myself, bringing human social concerns into the harmonious realms of theory would both diminish the joy of science and further complicate an already complex field of study.

Then in 1992 I started teaching at a Jesuit university, and, surrounded for the first time by a community of scholars and teachers who were deeply concerned with justice, I began to reflect on the profound material differences between my culture's people and those around the world. I also realized how highly privileged an academic life I had led, and began to recognize a resultant responsibility: from those to whom much is given, much is expected.

This paper is based on my efforts to integrate justice and values concerns into my college earth-science courses, focusing on the classroom. I will share some approaches that have worked for my students and me, and described some challenges I've encountered along the way. My perspective as a geologist, of course, is that of a natural scientist, not a medical or social scientist whose field of study by definition focuses directly on human beings.

Incorporating values discussion into science courses: con and pro

Before I describe some of my teaching experiments, however, I would like to acknowledge several authentic reasons for which many thoughtful natural scientists may be reluctant to explicitly incorporate questions of values into science courses. I have discussed these earlier1, and will only summarize briefly here.

- The desire for "scientific objectivity" is derived from a profound respect for the natural world. One form this respect can take is the desire to remove oneself completely from biases that could affect a scientist's ability to interpret honestly her observations (data) of the physical world. Introduction of values discussions into science teaching can be perceived as potentially introducing biases into scientific interpretation.
- Some scientists who reflect deeply on their personal values feel that their professional work is not the appropriate place for such reflection. They believe that values and ethics are matters of individual concern that should not be brought into the public sphere through science teaching.

- Dealing with issues of values inevitably raises the question, "Whose values?" Many scientists are justifiably concerned that raising such issues may lead to someone else's values being superposed on scientists' work, potentially restricting its range and/or funding support.
- A highly expert scientist may humbly decide that he is not as highly qualified to analyze values and ethics issues, or to effectively raise these with college students.

Nonetheless, it is my own belief that discussions of values should be brought into many science courses. How are we, and our students, to move closer toward respectful observation of, and interaction with, the natural world without an effort to recognize and consider our own value frameworks and potential biases, as well as those of others? This is where the professional and the personal inevitably merge. Funding of scientific research is always limited and always contingent on the values that others--Congress, the public that elects its representatives, private foundations, corporations--place on its methods and potential results. Should these limiting values not be open for discussion? And expertise in science does not carry with it the burden of presumed expertise in other areas; I have found that my students do not expect me to be an "expert" in raising values issues, but respond positively to my raising these topics as a human being like them. Finally, I think it's reasonable to assume that a lack of discussion about values in their entire science education could lead future scientists to conclude that a science career does not carry with it a responsibility to consider personal and social values in the context of that career: a dangerous conclusion for both the scientist and society.

Ways of incorporating values discussions

How, then, can we incorporate consideration of values into classroom sessions of a college science course without sacrificing its essential focus on scientific processes and information? Following is a description of how I have restructured one course toward this goal. Many of the approaches used in this course could be easily adapted to other natural-science courses. I'll first sketch the course's overall design, then describe in more detail some case studies I've used for specific sections.

Programmatic context. The course, "Introduction to Geosystems," is a required foundational course for majors in Seattle University's interdisciplinary Ecological Studies Program, which is designed in a sequence of studies from Earth (physical sciences), to Life (biological sciences), to the Human (social sciences), to Spirit (humanities). (More information about the Ecological Studies Program is available at http://www.seattleu.edu/artsci/.) In its role as the program's introductory course, Geosystems introduces to students as they first enter the program the concept of sustainability and the importance of justice. Although the 100-level course is designed for freshmen, much of its population is often upper-division transfer students. Neither of these groups typically have taken previous college-level science courses.

Course organization. The science topics in Geosystems are divided into the four elements named in many cultural traditions: Air, Water, Earth, and Fire (energy). For each of these elements, we follow this sequence:

1. Initial presentation of a current or recent case study that involves both the element and one or two questions of values or justice.

   Usually this presentation is in the form of a story, told by me (or, ideally, someone personally involved with the situation); students could also watch part of a video or

read a short essay. It is, unfortunately, easy to find an article in that week's New York Times or Washington Post, or local newspaper, reporting an environmental problem that raises values questions. Using a story as students' first encounter with the element communicates that knowledge is valued in a context, and one that is invested with meaning. Additionally, because of the power of story to attract humans' attention, students tend to mentally fit each piece of information in its relationship to the story--a form of pedagogy that I believe supports retention as well as interest.

2. Students learn basic scientific principles and processes related to the situation.

   For instance, in a case study related to air, students would learn about global air-circulation patterns, high- and low-pressure systems, and various causes of weather; in one related primarily to earth, they would learn about plate tectonics and mineral formation processes. I usually combine short lectures with small-group activities for this section, under the assumption that students have done the assigned background reading.

3. We discuss our local natural history with regard to this element.

   This is important for two reasons. First, when students understand the significant effects that local natural processes have on their own lives, I believe they are better able to understand the significance of these processes for others in other places, and to enter into considerations of values from an empathetic rather than a distanced stance. Second, academic learning, scientific and otherwise, is too often experienced by students as an abstract activity removed from "real life." Students may learn about the physical world in traditional science education, but they have not often been encouraged to care for the part of the world where they actually live. When they've learned to develop at their college a sense of place that is deepened by their scientific learning, they can carry this way of being to the place where they grow their roots after college.

4. We then return to our initial case study with an increased depth of scientific understanding.

   There are a wide variety of ways for students to engage with the case study in a way that requires them to learn scientific principles en route to a thoughtful consideration of values questions. Two examples are discussed in detail below, followed by a brief list of suggestions for other activities.

5. Students record 24-hour observations of their personal use of the element.

   It can be too easy for privileged students to consider injustice as something that happens to "those unfortunate people, out there" (for whom they may care deeply) rather than something to which they themselves may be contributing. Having them monitor their own use of water, earth (materials), and energy can help them see not only the contrasts but also the interconnections between their lifestyles and those of people in other parts of the world.

6. We end with a discussion of potential solutions or reasons for hope regarding human use of the element.

Almost any in-depth study of the environment, particularly using current case studies, can be depressing. It often seems that when an environmental situation makes the news, it is because of deterioration and damage. A common response is either despair or anger, and I believe that while both of these can generate action to improve a situation, for many they are not sustaining motivations over the long term. It is important to me to offer my students a sense of hope and empowerment, and so with every element, we end with a discussion of an effort that has succeeded.

Example: Afghanistan (element: water)

After the tragedies of September 11, I decided that my contribution to healing would be to educate my students about natural systems in Afghanistan. No matter what their political perspectives, they could better understand the events surrounding September 11 through knowledge of the constraints of natural systems on how Afghanis live and what interactions with Westerners might occur there. For each section of the course (air, water, earth, energy), after our initial grounding in scientific principles, we studied the natural history of that element in Afghanistan before moving to focus on our local natural history. As a visual focus for our deepening understanding, we maintained a large map with additional transparent overlays for information and interpretations from each new section of our study. In addition to reminding students of their prior learning, this technique helps students understand the interconnectedness of Earth systems.

For the water section, our central question was about the drought in Afghanistan. I divided this broad topic into several parts--background, current situation, scientific explanations, and outlook---that each included sets of questions. (Appendix A) Students were divided into teams, which then chose question sets to research. Our class had randomly been assigned a classroom with at-desk computers, so students could conduct Web research in class, but in another setting it would be easy to assign library and Internet research time outside of class. Students were encouraged to share with other teams any particularly valuable Web sites that they came across. Partway through the research process, work was stopped and each research team reported on its interim findings for discussion. The advantage of these progress reports is that students can begin to see the character and value of the scientific process in addition to its outcome. A lack of full knowledge is shown as necessary and appropriate when it's en route to understanding, not as a deficit to be embarrassed about. Additionally, students can learn both to contribute to others' work and to accept contributions from others: valuable lessons in both empowerment and humility.

After we studied causes and effects of the Afghanistan drought, students monitored their personal water use for 24 hours. Getting accurate estimates required some investigation: for instance, by measuring how much water their own shower consumed, or by obtaining the manufacturer's analysis of water used by a dishwasher or clothes washer. Many students who ate in the university's cafeteria had to recognize their hidden water use, since their food was cooked by someone else. Students brought in their individual water-use estimates, then on that basis (acknowledging assumptions we had made) we calculated our class's water use for a year. Finally, I told them the annual water consumption of a typical Afghani -- and the class audibly gasped. Without their 24-hour observations, the figure could have been just a number; in context, it gave a glimpse of a way of living, and a sharp contrast between overdeveloped and less-developed cultures.

Example: Convent, Louisiana (element: air)

Another format that has worked well with my students is a role play in which students are randomly assigned various roles associated with a case related to environmental justice: for instance, a scientist working for an environmental group, a scientist working for an industrial company, a politician trying to get reelected, a single parent, a company manager, an unemployed worker, and so on. Two students draw roles as facilitators. Students then hold a "town meeting" in which they must decide, for instance, whether to invite a particular industry to locate in their town, and what conditions might be placed on the company's operations.

I used this format for several years (while the actual case was still unresolved) in an examination of the prominent environmental-justice case of the Shintech Corporation, which in 1996 announced its intention to build a PVC plant near the primarily African-American town of Convent, Louisiana. PVC production has been associated with the release of toxic compounds, including dioxin, and the plant was predicted to release approximately 600,000 pounds of air pollutants per year. Shintech's plans also included 165 new permanent jobs in this area of high unemployment. As local and national groups developed opposition to the proposed siting, this situation gained national prominence as a potential initial test case for the Environmental Protection Agency's Office of Environmental Justice.

In their role plays, students developed scientific arguments supporting and countering the proposed toxicity of the plant's airborne emissions, beginning to learn how to critically examine scientific research. They debated short-term versus long-term values frameworks; for instance, could the advantages of permanent employment for 165 families outweigh the disadvantages of potential toxicity? Students also considered various questions regarding their own group decision-making that themselves raise issues of justice: who should participate in the decision? How should various voices be heard and weighed? What about minority opinions? How should the process be facilitated? How should the final decision be taken? During the years in which I used this role play, students regularly reported on final course evaluations that it had been one of the most meaningful parts of the class. **Other approaches**

Local case studies, including campus-based ones, are important in helping students understand in an immediate way their roles as community citizens. Additionally, local field trips offer holistic learning that cannot be equaled by other methods. As whole persons, students learn from sound, sights, smells, and the three-dimensional "feel" of a place. Furthermore, they come to understand that case studies involve a whole place. When I take students to a part of Seattle that is the focus of environmental-justice concerns from toxic wastes, they are surprised to realize that it is not the ugly, stench-filled place they imagine from articles and photographs, but a "normal"-looking neighborhood. This experience diminishes the perceived otherness of people victimized by environmental damage.

Another useful approach is a scientific debate format. The students are informed that a government budget committee is considering whether to allocate funding to remediation of a specific environmental situation or instead to some other worthy purpose. (It can be too easy for students in simulations to gallantly "make the right choice" to allocate ever-increased funding to environmental problems, if real-world alternatives are not introduced in a finite-sum setting.) Teams of students are assigned specific stances on the situation (for instance, that global warming is or is not a serious, human-caused problem) and must research and present scientific information that supports their stance, and deal with questions from the other side. At the end of this process I usually ask students to write a synthesizing essay defining their own position and its basis considering what they've learned.

Although this paper focuses on classroom techniques, potentially even more powerful approaches are service-learning and internships in which students contribute scientifically to an actual problem in their own community. Seattle University's chemistry and engineering departments have successfully incorporated such experiences for their students.

A critical part of each of these approaches is debriefing the process afterwards, including both its scientific and its values dimensions. During this reflection, we consider questions such as the following:

- How do we make choices and interpretations among apparently conflicting scientific information?
    - What does an average represent?
    - How significant is a particular change over time?
    - What are appropriate time spans over which to measure change?
    - What are reasonable comparison groups?
    - How strong a connection should be drawn between an effect and a proposed cause?
- What are appropriate and responsible ways to gain scientific information? Is there information that should not be obtained?
- With whom should scientific information be shared? Are there any parties from whom it should be withheld?
- On what bases do some people or roles hold greater credibility for us?
- What difference does, and should, form of scientific communication make? For instance, do we find ourselves giving more credibility to a smoothly-run PowerPoint presentation than a stumbling verbal one?
- How firm should our scientific knowledge be before making a decision or taking an action?
- How should we weigh short-term versus long-term human needs? The needs of nature?

Some challenges

One of the challenges of using current case studies as the context for science learning is that I rarely have the depth of personal knowledge of the situation that I would have previously considered essential for good teaching. There is never "enough" preparation time -- that is, enough so that I am the clear authority in our class. For instance, I don't know what is causing the drought in Afghanistan. In actual experience, however, this potential drawback has been more than countered by several benefits:

- The relevance of scientific understanding is immediately clear to students when we focus on a situation currently in the news.
- The power relationship between me and my students shifts toward greater symmetry: we are collaborators in a communal learning process, and it is apparent to the students that I am learning from them as they learn from me.
- As a "master learner," I can model for them both intellectual and emotional aspects of the learning process: when they share with me their initial results, they see what questions and ideas for further research come to me Ã± not as well-practiced leading questions to take them somewhere I've already been, but arising out of my own excitement and curiosity. They can see how I find the gaps in my understanding and seek to fill them, and what some reasonable next questions are from a particular insight.

At the beginning of the course, I share my concerns with my students, and explain to them why I've gone ahead to use this approach with them anyway: because I believe the resulting educational and social values outweigh the disadvantages. Some other particular challenges I've encountered in trying to raise values questions in science teaching, along with some considerations that I believe compensate for them, include the following:

- Because the course becomes interdisciplinary, I'm regularly teaching outside my content area of expertise. As stated above, this can mean that students are empowered toward their own expertise. Additionally, students may see that their instructor expresses other forms of expertise, in learning and investigation.
- This interdisciplinarity means that the students' learning is broad but potentially shallow. Depth of learning, however, is increased by the students' active application of scientific knowledge to real-world situations.
- In discussing values and justice, class time and therefore coverage is lost from "straight" science. In any college course, the instructor must restrict coverage because of limited time, prioritizing on some basis. Incorporating values questions is easier in science courses for non-majors because their learning in the course is generally not the basis for succeeding courses leading to a science career. For science majors, though, at least one course should be offered, or even required, that asks them to consider how values integrate with their chosen career fields.
- Because values discussions are so compelling, it can be difficult to re-focus students' attention on the scientific components of their learning. This problem is helped by setting clear priorities for the students' learning at the beginning of the course and for assignments and assessments.
- Usually justice is construed as a human-oriented concept, and therefore can be implicitly anthropocentric. In the Ecological Studies Program, students take a required course in Environmental Philosophy, which focuses on non-anthropocentric as well as anthropocentric frameworks. In other courses, students can be introduced to ecocentric concepts of justice as well as human-centered ones.

Finally, the despair factor. Investigating a variety of case studies characterized by injustice or environmental violation can open students' eyes to a more complex and fractured world than they may be familiar with. It can be challenging to help them (and ourselves) find a way to hold this complicated world with both honesty and hope. Some of the most powerful conversations in my courses have come when I've asked the students themselves to describe their sources of hope. And the knowledge that their learning can help promote a more just world can be a source of strength and energy for all of us.

References

Tucker, T. (2001). Just science: reflections on teaching science at Jesuit universities. *Conversations on Jesuit Higher Education, 19*, 42-47.

Appendix A

Afghanistan case study ~~ Water

Research clusters

I. The typical situation in Afghanistan

Cluster 1:

Global circulation patterns and seasonal variations
Typical annual rainfall and when it occurs

Cluster 2:

What happens to rain when it falls on Afghanistan?
-Surface water/groundwater
-Regional variations and why

Cluster 3:

Where do most Afghanis get their water?
What is water used for?
How have human activities affected water availability in Afghanistan?
Have these uses been sustainable in the years before the drought?

II. This yearâ€™s situation

Cluster 4:

Given your atmospheric pressure maps for January and July [developed by students during the preceding lab], what changes would you expect to be occurring in Afghanistan this time of year?
Have this yearâ€™s weather patterns for Sept â€" Oct been what you predicted?
How are Afghanis responding this year to the continued drought?

III. Scientific explanation for drought

Cluster 5:

How long has the current drought lasted?
What atmospheric processes (large-scale or local-scale) have changed to produce the severe drought of the last few years?

Cluster 6:

Have human activities played a role? If so, what effects have these had? If you find that human activities have not played a role in Afghanistan, under what circumstances could human activities produce a drought?

IV. Outlook

All groups:

What future do you see for the Afghan peopleâ€™s water situation? If you worked for the UN in resource development and sustainability, what would be your recommendations to the people?