AC 2011-1205: INTEGRATING ETHICS INTO UNDERGRADUATE ENVIRONMENTAL SCIENCE AND ECONOMICS EDUCATION

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Integrating Ethics into Undergraduate Environmental Science and Economics Education

Abstract

Good critical thinking about environmental issues requires students to identify both factual issues and ethical questions raised by environmental controversies; and separate the two because ethical issues are sometimes difficult to spot in what appears to be "value-neutral" scientific and economic descriptions of environmental problems. This paper explains the goals, methods, and lessons learned of a program, at the Pennsylvania State University, to enhance the critical thinking skills of undergraduate students in environmental sciences and economics as well as environmental engineering by teaching them to spot and evaluate ethical issues that arise in problem identification, evaluation, and solution design.

The three-year program was funded with the expectation that the program's goals and lessons learned would be reviewed at the end of each year with corrections made in the program design based upon lessons learned. The paper explains how lessons learned in the first and second year led to changes in measurement instruments and content taught in the teaching modules. The paper will explain measurement instruments, results of testing, and revisions made in the program and the increased use of the teaching modules. The paper will also describe the creation and use of a faculty teaching module designed to allow other environmental science and economics faculty to use the teaching module at the Pennsylvania State University and other institutions. The paper will describe the increased use of the program across disciplines to test transferability of the teaching module.

Introduction

The goal of the program is premised on the idea that a key critical thinking skill is the ability to spot "ethical" issues as distinguished from "value-neutral" factual claims that often arise in discussion of environmental science, economics, and policy. This goal was viewed to be an important skill to teach undergraduates because many ethical issues are often hidden in environmental science and economics descriptions of environmental problems. The program is designed to teach undergraduate students the ability to spot ethical questions that often go unidentified in scientific and economic descriptions of environmental problems. To develop this ability, the program first teaches students to distinguish between "factual" claims and "ethical" claims about environmental controversies. Then the program demonstrates that what often at first glance appear to be "factual" scientific and economic claims about environmental controversies often hide controversial ethical assumptions. The program seeks to help students particularly spot ethical issues that arise when decisions must be made about environmental impacts in the face of scientific uncertainty and when economic arguments are made against taking action to protect the environment. These ethical issues are highlighted in the program because of the high frequency with which these issues arise in environmental

controversies [1, 3]. This program seeks to, in one class, expose students to these ethical issues in courses that are primarily focused on environmental or sustainability science, economics, policy, or environmental engineering. The course is a Science, Technology and Society (STS) undergraduate course with a variety of majors, 20% of which are engineering students. There is a fair representation of males and females in the class.
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The program is not designed to make students fully competent evaluators of ethical questions for this would require much more than one class. The pedagogical goal of the program is believed to be extraordinarily important in one respect although quite modest in another respect. The pedagogical goal of the program of enabling students to spot differences between ethical and factual issues that arise in environmental controversies is important because many, if not most, undergraduates obtain degrees in environmental science, environmental economics, environmental policy, or environmental engineering without ever being taught to spot ethical issues that arise in scientific and economic descriptions of environmental and sustainability problems. Although in many engineering programs in higher education it is now common to expose students to ethical issues that arise in engineering, many engineering ethics courses do not include spotting ethical issues that arise in scientific and economic descriptions of environmental problems. Therefore, this program is important because if students mistake "factual" claims as "value-neutral" claims then they will not be able to reflect upon the value-laden nature of the claims.

However, the goal of the program in another way is quite modest because it does not presume to teach students to evaluate ethical questions in depth. Developing in-depth skills to evaluate ethical questions raised by environmental controversies is beyond the scope of this program because there is not usually enough time in the courses that this program targets to devote to teaching deep ethical reflection about environmental problems.

The program also seeks to develop a teaching module that will allow transferability to faculty colleagues, who are not trained in ethics, to teach students these ethical spotting skills in and across disciplines, environmental science, environmental economics or ethics courses. The teaching module is designed to allow a faculty colleague to use portions of the module that are suitable for teaching their discipline. The module is flexible and customizable. The program tests the students' ability to spot ethical issues before the module is used in the class and then tests the effectiveness of the teaching of the module at the conclusion of the teaching. The program is funded for three years. Each year we have improved the modules based on the feedback and data from the previous year. The project will be completed in June 2011.

The work funded under this grant seeks to (1) develop modules to enable teachers of environmental courses in undergraduate education to integrate ethical questions into environmental science and policy courses, and engineering ethics, (2) Train faculty to use the modules, and (3) develop an evaluation instrument that allows for iterative assessment of student learning and subsequent improvement of the modules. Two

modules were developed and integrated into selected courses at the Pennsylvania State University.

Human-induced climate change is a problem that raises many profound civilization challenging ethical issues that are often not identified in the public debates about what to do about this growing threat[2, 3]. These ethical issues are often hidden in scientific and economic descriptions of climate change issues. For this reason, the program uses examples from climate change although the ethical issue spotting skills taught in this program are applicable to other environmental and social problems facing society.

The overall goal of this project is to improve critical thinking skills of undergraduate students. Good critical thinking about environmental issues requires students to identify both factual issues and ethical questions raised by environmental controversies. As we have noted the pedagogical goals of the program include enabling students to: (1) spot ethical issues in scientific and economic descriptions of environmental problems, and (2) preliminarily evaluate these ethical issues through the application of basic ethical principles including utilitarian, deontological, and justice concerns. Based on assessment results, the teaching modules have been adjusted this year to improve upon achievement of the pedagogical goals. Critical thinking skills taught in this course are not meant to be exhaustive of good critical thinking skills which include examination of assumptions in arguments, relying on evidence for reasons, identifying biases in reasoning, and giving reasons for conclusions among other critical thinking skills. However, an important critical thinking skill taught in this program is the ability to separate “factual” claims from “ethical” claims. Without the ability to spot ethical assumptions in arguments, controversial ethical positions will go unexamined in public policy formation. This skill is particularly important because interest groups opposing programs to protect the environment very frequently make economic and scientific arguments that contain unidentified ethical assumptions.

In addition to a teaching module, a training session was developed for those instructors who would like to use the module in their courses. The instructors attended a pilot training session after which they provided feedback regarding the potential of making module transferable. The learning module was tested in three additional courses. Feedback in the form of interviews with the instructors and a learning perceptions survey with the students was obtained. This feedback will be used to improve the module for the third year. Feedback from faculty was positive. Because the training was a modeled after the lecture participants periodically stopped the presenter to give just-in-time comments. It was important to have their perspective because the training module was to ultimately be used as a standalone lesson plan. We wanted the faculty to be able to take the lesson plan and adapt it to their courses using it in its entirety or using segments as were applicable to their content.

Design of the Program

The program consists of two modules. Module 1 is the teaching module on the ethics of climate change that is delivered in the classroom using a pre and post test case study

coupled with a lecture on Ethics. Module 2 is a training module that will teach faculty who are interested in adopting module 1 to be used in their course, as a cross disciplinary tool. These modules are described here in detail.

Module 1 – teaching module
At the beginning of the program a teaching module was designed for one undergraduate class that would teach undergraduates to develop critical thinking skills in the context of learning about ethics. The module consisted of a pre and post case study and a lecture on ethics.

The lecture content included:

- The definition of "ethics"
- How to distinguish "ethical" issues from "factual" statements
- Explanations of how ethical issues often arise in environmental science when decisions have to be made in the face of scientific uncertainty.
- Explanation that ethical issues that arise in environmental decision-making in the face of scientific uncertainty often include who should have the burden of proof and what quantity of proof should satisfy the burden of proof.
- Explanation of ethical issues that often arise in environmental economics, particularly in cost-benefit analysis.
- Description of ethical issues that arise in economic analysis of environmental problems include: (a) whether money should be the only measure of value, (b) whether there are distributive justice issues that should be considered when claims are made about maximizing welfare, and (c) the ethics of discounting future benefits in cost benefit analysis.

Assessment was both formative and summative. The instruments created were pre and post tests of student's ability to spot these ethical issues. Students were given a case study containing an ethical issue concerning who should have the burden of proof regarding an environmental policy statement. The pretest was administered in the class session prior to the lecture on ethics. During the next class the students were given the lecture on ethics. The post-test was a section of the final exam at the end of the semester. The pre and post test instruments are in Appendix A.

During year 1 (Fall, 2008-Spring 2009) a pilot was conducted in one Science, Technology and Society course on Climate Change in the Fall semester. The instructor of this course is the Principle Investigator for the grant. He, along with the assessment specialist, developed the initial pre and post test case study, revised the teaching module to be focused on the inclusion of critical thinking skills and recruited students for the study according to the policy of the University Office of Research Protections. The instruments were revised for the launch of the project which was to occur in the next semester.

In the spring semester the teaching module was delivered to two courses. In addition to the course on Climate Change, the teaching module was delivered to a course on Society

and Natural Resources; this was to investigate the transferability of the teaching module outside of the program.

Consequently the program consisting of the use of the teaching module and the assessment tools was tested in three courses during Year 1. These courses included two courses on the science, economics, politics, and ethics of climate change, one course in Society and Natural Resources and one course in The Legal Aspect of Environmental Resource Management.

Based upon lessons learned from the first year we designed a faculty training module so that the teaching module could be used by a larger group of instructors. A training workshop was conducted for faculty who were interested in testing the teaching module in their courses. The assessment specialist conducted interviews with these faculty members to get their feedback on the usability of the training module.

In the second year of the program, the module and assessment tools were used in four courses. These courses included two different sections of a course on climate change science, economics, politics, and ethics, one in rural sociology, and one on natural resource law. The process was repeated for assessment and redesign of the case studies based upon student performance in both the main course, taught by the PI, and the two guest courses tested outside of project course. With each semester the case and training module are modified. The teaching module was tested over the course of 5 semesters. Three courses tested the module. The STS course is the home course for the test because this course is taught by the PI of the project. The two additional courses were in other disciplines

The courses that participated were two general education courses and one upper level course required for a major. The student population was mixed with equal number of men and women. Of the students enrolled in the course on environmental ethics 20% were engineering students. We believe that this module is very appropriate and transferable to anyone who teaches engineering ethics within their course or as a standalone course.

Assessment Strategy

This project required two threads of assessment.
1) Assessment of Learning – (Formative and Summative). Did the pre test determine students' prior knowledge of identifying ethical issues in environmental policy statements and after the lecture did the students' critical thinking skills improve when they did the post test during the final exam? The pre and post test are identical. They used short answer and true/false questions. Assessment of learning was determined by student performance on both tests. The scores on performance for all the semester and courses compared showed that the students who were in the primary STS course scored higher than the students in the other disciplines. We believe that this was due to the fact that the other disciplines participated in the research project and did not give the students points

toward their course grades. We learned that if there are no stakes involved the students are not as serious about the test. (See Appendix B for test scores across courses).

2) Assessment of the intervention - Was the training module effective for use by faculty in other disciplines? This was evaluated by feedback from faculty during training and delivery of the module to their courses. The first time this was delivered to other courses the PI delivered the lecture so that the faculty could observe the practice. Feedback was obtained by interviewing the faculty volunteers.

With each year we improve on both the teaching and training modules. We have revised the pre and post test instruments as well. We have simplified the case and use pointed questions to guide the students. The lecture has been modified as well to target key points in the case (see Appendix B for outline of the lecture).

In addition a student perceptions of learning survey was administered to the STS students at the end of the Fall 2010 semester (Appendix D). The scores were encouraging. On a scale of 1-5, with 5 being Strongly Agree to 1 being Strongly Disagree, when asked if the students could recognize the difference between a factual statement and an ethical statement 60% stated they agreed and 40 % said they strongly agreed. In identifying ethical issues in environmental policy statements 70% of the students agreed with 30% strongly agreeing. Regarding the effectiveness of the lecture on ethics 50% agreed, 30 % strongly agreed, while 20 % were neutral on this item. Students felt that the lecture was easy to understand with 40% of the students strongly agreeing, 30 % agreeing and 30% neutral. 50% of the students strongly agreed that they would recommend this course to a peer.

Lessons Learned and Program Modifications Made

At the end of the first year, we realized we had to simplify the teaching module that would allow the students to more clearly focus on the ethical issues that we believed were of the highest priority. Our first year experience demonstrated that students might identify some ethical issues that were in our case study but miss the high priority ethical issues of concern because the case study was too complicated. We also learned that we needed to simplify some of the questions in the pre- and post- test assessment tools because the first year questions contained complicated factual case studies.

At the end of the second year we recognized that although the second year assessment tool was an improvement over the first year tool, we were still unclear from the results of the assessment tool if we were achieving the depth of understanding that we were looking for because of how the questions were worded in the assessment tool. For this reason, we will design a new assessment tool for the third year which contains more essay questions. We want the students to justify their answers in short answer responses, asking them to explain “Why”. We also plan in the third year to have more faculty teach the training module where the participants of the training will practice teaching the module

In this the second year we continued to learn about how to make improvements in achieving our objectives. This year we developed an improved teaching module to train other faculty (that is other than the PI) on how to use the course module in their respective courses. The course module was originally tested with one volunteer faculty member in the Spring 2009 semester and improved in 2010. This instructor along with two additional faculty participated in a training session in Fall 2009. This practice helped us to reform our module and testing instruments for achieving our goals. Additionally, since the faculty that have been trained by program included a sociologist and an economist, this year's training began the process of sharing of best practices across the university in other disciplines that cover environmental issues.

Conclusion

Undergraduates without formal teaching are not able to easily spot some obvious ethical questions in environmental science, economics and policy description of environmental problems. We have learned that with teaching the ability to identify ethical questions embedded in what appear at first glance to be "value-neutral" languages does improve. With each iteration of the teaching module we have learned that the lecture and assessment instruments needed to be simplified to be more focused on the ethical issues we wanted the students to identify We learned that the case study questions during the first year were too complicated. We needed to make sure the students understood the objectives and that the teaching supported the objectives, that students will identify ethical issues in environmental policy statements.

Some of the courses that have used the teaching module have made ethical issue spotting a requirement of the course and therefore a component of the final grade awarded to the student. In two other courses, performance on the post-lecture test was not part of the grade for the course Our analyses of post lecture improvement in issue spotting skills has led us to realize that students show more demonstrated improvement in issue spotting skills in courses that grade students on these skills. In the final year of this grant, we need to improve performance in courses in which no grade is given for ethical issue spotting. Pedagogically we want the students to learn the spotting skills as they critically evaluate a document, therefore it is important to not only teach ethics but to teach and evaluate critical thinking skills concurrently.

We have also learned that students learn to demonstrate ability to spot ethical questions embedded in environmental controversies with practice that helps students spot these ethical issues. Students initially have some difficulty separating "factual" claims from "prescriptive" claims. This would appear to be both because they have little prior training in ethics coupled with the fact that ethical issues often are hidden in what initially appears to be "value-neutral" descriptions of environmental issues. Although the training received in this course enhances the ability to spot ethical issues, a case can be made from the results of our program that more experience with ethical issue spotting and critical analysis should be a goal of undergraduate education.

We developed a training module for faculty from other disciplines who are interested in using the teaching module in their courses. The training was piloted with three faculty in a formal training session. For formative assessment of the module the instructor modeled the ethics lecture as it is delivered in class. During this process we stopped to get just-in-time feedback from the faculty participants. We discovered that to enhance the ability of students to identify ethical questions they will need to spend a minimum of one class period introducing the students to ethical concepts and teaching the students how to identify obvious ethical questions that frequently arise in environmental science and economics.

In the third year of the grant we plan to develop a scoring rubric for the pre and post tests. We also plan to revise the training module so that faculty who desire to incorporate the lesson will have a detailed lesson plan.

We want to determine whether the students really understand the difference between ethical and factual statements and if they actually understand why certain ethical questions are imbedded in science and economics. To accomplish this we will revise the case study questions to include some essay questions. Students will be asked to explain why certain scientific and economics facts raise ethical questions. We believe that this will strengthen the students' ability for critical thinking.

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Appendix A

STS 201 Ethics: Pre/Post Test

A. Define "ethics."

B. Identify whether the following are ethical or factual statements?

- There are 1000 different species in this forest. Fact_____ Ethical_____
- We should protect biodiversity in this forest. Fact_____ Ethical_____
- If we implement this environmental policy, the state will lose 300 jobs. Fact_____ Ethical_____
- We should not limit climate change causing emissions because it will destroy 2000 jobs. Fact_____ Ethical_____
- Some chlorinated hydrocarbons destroy the ozone layer. Fact_____ Ethical_____
- We should ban chlorinated hydrocarbons. Fact_____ Ethical_____
- If we implement a policy to protect wetlands in this county, it will cost $5 million in lost property value. Fact_____ Ethical_____
- Our national parks are the common heritage of all people and therefore should be protected. Fact_____ Ethical_____
- Because DDT kills birds, it should be banned. Fact_____ Ethical_____
- Because DDT is necessary to kill insects that cause disease, it should not be banned. Fact_____ Ethical_____

C. The State Department of Environmental Protection has discovered some evidence that PCBs cause cancer in small doses but the evidence is not conclusive. A chemical manufacturer proposes to discharge PCBs into a stream that is used as a water supply. What ethical questions arise because of the need of a policy maker to make a decision in the face of scientific uncertainty about the toxicity of the PCBs? You need not evaluate the ethical question but only identify what is the ethical question. Explain why these are ethical questions

D. The United States prepared a Cost-Benefit Analysis (CBA) of proposed climate change legislation that looked at costs and benefits to the United States of reducing its GHG emissions. Most of the costs would fall to the rich countries including the United States but most of the harms would be experienced by poor countries. The United States

calculated the value of the harms that would be avoided if the legislation were enacted by totaling the market values of everything that would be harmed including loss of life, reduction in agricultural production, and flood damages. Based upon the results of CBA, the US decided not to reduce its greenhouse gases because the cost to the United States of reducing its emissions exceed the benefits to the United States of reducing climate change. What ethical questions are raised by the US use of the CBA in this case? You need not evaluate the ethical question but only identify the question. Explain why these are ethical questions.

Appendix B – Test Scores from courses

Year 1
Fall 2008 STS 201 pilot (no data collected)

Spring 2009
Course, Society and Natural Resources
Pre test, n=15 students, average 4.0, total 10.0
Post test, n=10 students, average 5.6, total 10.0

Course, Climate Change, Energy and Biodiversity
Pre test, n=23 students, average 4.7
Post test, n=37 students, average 7.4

Year 2
Fall 2009
Course, Climate Change, Energy and Biodiversity
Pre test, n=16 students, average 4.8, total 10.0
Post test, n=26 students, average 8.6, total 10.0

Spring 2010
Course, Society and Natural Resources
Pre test, n=19 students, average 5.3, total 10.0
Post test, n=16 students, average 5.3, total 10.0

Fall 2010
Course, The Legal Aspect of Environmental Resource Management
Pre test, n=65 students, average 4.7, total 310.2
Post test, n=59 students, average 4.9, total 294.8

Course, Course Climate Change, Energy and Biodiversity
Pretest-n = 14 students, average 4.57, total 10
Posttest, n=31 students, average 7.4, total 10

Appendix C – Teaching Module Outline

What is Meant By Ethics?

Identify the ethical/factual statements?

Identify the ethical/factual statements?

Identify the “ethical” statements?

Where does “ethics” come from?

Because there are different ethical theories, ethical analysis does not necessarily lead to agreement about what to do. Ethical analysis could:

How does ethics differ from science and economics?

At least two different roles for environmental science

Ethical Issues are Sometimes Hidden in Science When Science is Used in Public Policy

Who should have the burden of proof?

Science and Ethics
What Quantity of Poof Should Satisfy the Burden of Proof?
(95% confidence, balance of evidence, reasonable risk?)

Ethics and Economics
Ethics and Cost-Benefit Analysis

Ethical Issues In CBAs
Should the value of benefits protected be limited to market-value measured in dollars?
Discounting future benefits.

Practice questions?
Identify the ethical questions raised below:
• European trawlers may be overfishing off the African coasts resulting in less fish for subsistence fisherman in poor African countries. The Europeans have responded to pleas from the African fisherman by asserting that there is no proof that they are destroying the local fishery although the Europeans concede that fish stocks are down along the African coast and that over fishing may be the cause,

• Because it is practically impossible to test enough mice to determine whether a certain chemical will cause cancer at very low dosages, EPA extrapolates proven cancer rates at

higher doses to determine cancer risk rates at lower doses. Manufacturers of chemicals that are assumed by this methodology to cause cancer at lower doses complain that EPA should not assume that cancer is caused at these lower doses because there is no proof at the lower doses.

Appendix D - Environment Ethics Post Student Perceptions Survey

On a scale of 1-5, Strongly Disagree to Strongly Agree, would you please answer the following questions?

I can recognize the difference between a factual statement and an ethical statement.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

I can identify ethical issues in environmental policy statements.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

The lecture on Ethics, as it was delivered in Dr. Brown's class, helped me to understand who should have the burden of proof in decision-making of environmental policy.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

The lecture on Ethics was easy to understand.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

I would recommend this course to a peer.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5