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# "To Move People From Apathy": A Multi-Perspective Approach to Ethics Across the Engineering Curriculum

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# "TO MOVE PEOPLE FROM APATHY": A MULTI-PERSPECTIVE APPROACH TO ETHICS ACROSS THE ENGINEERING CURRICULUM

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**Abstract**

Humanist Algernon Black wrote that the unifying goal of ethics is "to move people from apathy, from an acceptance of the evils in life, to face the possibilities of the world…." To this end, faculty in the Picker Engineering Program at Smith College are teaching ethics across the curriculum, employing a range of pedagogical tools that are learner-centered, grounded in real-world contexts, and supportive of critical thinking and reflective action.

Ethics are woven across five required courses in the Smith curriculum: a design-based introductory course, a first year course in mass and energy balances, continuum mechanics, thermodynamics, and the capstone design clinic. The first-year courses motivate a well-rounded engineering education and social responsibility, encourage reflective thought and values articulation, and introduce frameworks for ethical problem solving and case analysis. Core engineering courses build on this experience, employing additional cases that integrate relevant engineering content. In the capstone design course, students apply what they have learned preventively to identify potential pitfalls related to their particular projects. Additionally, advanced ethics topics are explored in two upper-level technical electives, examining key issues of environment and sustainability and considering critically the role of engineering in global development.

The theme of celebrating multiple perspectives unifies this work. Not only are students encouraged to develop the skills of approaching ethical problems from many different viewpoints and engaging in respectful dialogue with peers who hold different positions, but also this difference of perspective is modeled throughout the curriculum as students experience ethics through varying pedagogies, teaching styles, and learning activities.

Assessment of student progress includes evaluating student narratives, case studies, and interactive reflective essays for student ability to reflect deeply, articulate values, frame problems, employ multiple perspectives, think critically and analytically, and generate creative solutions. Results from student focus groups provide additional data that influence our next steps for curricular development.

## I. Introduction and Background

In 2004, Smith College will graduate its inaugural class of twenty engineering majors, the first at an American women's college. Beyond the obvious gender difference, Smith engineers are receiving a technical education in a liberal arts setting, presented in the context of social responsibility. In the words of our vision statement:

> Graduates will be confident and creative women who bridge the traditional boundaries between the sciences and humanities as leaders in both the profession of engineering and in society as a whole. As critical thinkers and socially responsible decision-makers, they will help to engineer a sustainable future for the global community.[1]

Having the unusual experience of designing an engineering curriculum from the ground up after ABET introduced its Criteria 2000[2], we strove to build ethical considerations into the curriculum from the beginning rather than tack them on at a later time. With a small faculty recruited in part because we shared this vision for the program, integrating ethics across the curriculum is possible in ways it might not be at other institutions.

Pedagogically, Smith is oriented toward a learner-centered approach.[3] The teaching of ethics at Smith is directed toward a spirit of lifelong learning and toward the reflective action (praxis) that is an outcome of liberative pedagogies.[4,5] The goal of teaching ethics at Smith College, then, is well captured in humanist Algernon Black's statement of the unifying goal of ethics: "to move people from apathy, from an acceptance of the evils in life, to face the possibilities of the world, to make life sweet for one another instead of bitter."[6]

Because we often define engineering to our students as the application of math and science to serve humanity, we see ethics (and a broader context of a liberal education) as an integral part of an engineering education. Thus, we have taken the approach of teaching ethics across the engineering core. This has several benefits. First, students are able to develop their sense of morality and professional ethics over four years, and mature in their ability to analyze and reflect on ethical problems. Second, students come to understand that ethics is not a one-time inoculation but a practice of thought and exchange of ideas that must be exercised over a lifetime. Third, students see ethical decision-making as part of their core skill set, and as part of the core skill set of their engineering professors. In context, students see how ethical considerations affect the design or problem-solving process, and how preventive ethics might operate in practice.

We find this embedded approach to be valuable as well because other topics related to social responsibility, notably sustainability, are also distributed across our curriculum. Sustainability is a topic that we believe cannot be divorced from the technical content in the classroom, so we teach it in many of our core courses and electives.[7]

Our learning objectives for ethics in the Smith curriculum are for students to be able to see problems from multiple perspectives, to articulate values and discuss ethical problems with colleagues, to frame problems and think analytically about ethical situations, to solve problems creatively (exercise moral imagination) and to anticipate problems and act preventively. We believe it is essential to cultivate an environment of respect for diversity in order for each student to develop an independent approach to ethics.

The faculty of the Picker Engineering Program at Smith College employed this approach in developing both content and pedagogy for teaching ethics across the curriculum. In general, we teach ethics in a learner-centered way, using case studies and real world problems. We present ethics in context with engineering content. We use a variety of tools including discussion, reflective exercises, and narrative writing, all with the central theme of presenting and eliciting from students multiple ways of thinking about ethics.

Development of the ethics component in the curriculum at Smith has been unusual in that all engineering faculty members at Smith are open to teaching ethics, and the department is behind the vision of teaching ethics in an integrated way. At the same time, the pressures of mounting a new engineering program from scratch has made it challenging to coordinate a consistent focus on ethics when so many other issues demand our attention. Thus, a subsection of the faculty have been able to integrate ethics into their courses and through regular discussion and sharing of approaches, develop a sense of curricular content.

Ethics was incorporated into the design-based introduction to engineering from its inception, and enhanced over time. Similarly, the first year course on "Engineering the Environment and Sustainability" (now replaced with "Mass and Energy Balances") incorporated ethics in every iteration. Engineering Thermodynamics and Continuum Mechanics began incorporating ethics in their second iteration, and have each been offered a total of three times. Design Clinic was offered for the first time in the 2003-2004 academic year, incorporating ethics from the beginning.

Coordination and course development have taken a few years, but in our fourth year, the ethics curriculum (like the rest of our curriculum) has now taken a consistent shape. With the graduation of our first set of seniors in spring 2004, we have sought initial feedback from students in tandem with our curricular efforts.

This paper details curricular content and tools we have employed in teaching ethics at Smith. We begin focus groups conducted with junior and senior engineering majors in Fall 2003, which capture their reflections on our early efforts. We then present the curriculum as it exists today, noting where student input has helped develop the program. We will present the current ethics content of each course, moving through the curriculum from introductory courses, through the engineering core and advanced electives, ending with our capstone design clinic. We close with directions for future endeavors identified by faculty and student focus groups.

**II. Focus Groups**

Two focus groups were conducted with junior and senior students in Fall 2003. Students were recruited via email to all seniors and juniors asking for volunteers and offering a free lunch. A total of six students participated, three in each group. Upper level students represent the first two classes that will be graduated from the Smith program, who experienced the program in start-up mode. Having already identified some areas for expanding and improving the ethics curriculum for subsequent classes, the faculty wished to receive student input as we go forward with implementing a more complete ethics curriculum. Two independent (non-engineering faculty) facilitators coordinated and conducted the focus groups, probing five subject areas:

- Motivation for including ethics in the curriculum
- Tools or skills participants feel are essential to include in an ethics education
- Perceptions of preparedness to face ethical issues in career
- Where students feel they received ethical training inside and outside of the classroom.
- The effect of Smith and the engineering program on students' thinking about ethics

Each of these is discussed in turn, followed by a summary of the recommendations and brainstorms of the focus group.

## III. Results

### A. Motivation for an Ethics component in the engineering curriculum

Students seemed to have a clear understanding of some of the reasons for incorporating ethics in the engineering curriculum. In general they raised three different rationales. The first rationale relates to preparation for professional decision-making, an ability to recognize ethical problems when they arise, an ability to practice "defensive" [preventive] ethics, and familiarity with professional standards for ethics. Students who raised this rationale also articulated the importance of being in a practice of ethical problem solving. A second rationale raised by one student is that teaching ethics is "a way for the engineering department to be sure that we receive more of a liberal education than solely a technical education." Two students raised a third rationale, the personal development afforded by an education in ethics.

### B. Essential Elements

Elements that students saw as essential parts of an ethics curriculum included:

- *Standards*: "We certainly need to have at least a general overview of what the standards are for each engineering specialty before we go into them."
- *Responsibilities* ". . . Beyond the standards, just knowing who we are responsible to, including your employer, the public at large, your loyalties, wherever they may be, and being able to weigh the options. . . ."
- *Decision-making*: "The ability to look at a situation and break it down into what kind of a dilemma is this, really, and what the far-reaching effects of your decision might be."
- *Personal moral development*: "I think that the skills you need to make ethical decisions are really strongly based in discovering in forming your own mindset as to where you stand on ethical issues--your personal commitment to ethical standards."
- *Analytical Frameworks and Multiple Perspectives*: "There are definitely tools, ways to analyze problems . . . I'm definitely more aware of them now. I can systematically approach problems . . . a lot better now than I could before . . . and approach ethical situations and weigh the options and, from being able to see all sides of the story and systematic ways of weighing those options, to choose the best course of action."
- *Critical Thinking*: "Thinking critically, objectively. Like, if I'm given a case, I should be able to separate myself from the case, look at it objectively, and look at what kind of consequences will each decision have . . ."

**C. Perceptions of Preparedness**

Students had varying perceptions of their preparedness to face ethical situations in their professional lives. One student cited the varied ways ethics is taught at Smith as having prepared her for her career: "I think we have a pretty good sense from projects that we've done in class and in dealing with other people, and our professors, and listening to lectures, that we have a pretty good sense of what's right and wrong and how we should go about approaching problems like that." One student cited a course text[8] as an important resource for future use. Two students cited the importance of dialogue with colleagues and seeing problems from multiple perspectives (connected with other resources) as evidence of preparedness. "I see ethics as something like, if I have an ethical issue that I'm faced with, I'm not going to decide myself what's right, I'd go over and [say], hey, [Participant 6], can we talk about this? And really try to incorporate as many ideas as possible, so it's something where maybe I won't be able to see every side of the picture based on my education here, I can go and I can talk and I can draw from other people's opinions that have gone through this same thing."

Another student expressed a sense of uncertainty about future difficult decisions. "[E]very situation is different, and sometimes it can be really hard to decide.... Certain situations can arise [where] the line is very hard to draw and there's no direct right or wrong, and you have loyalties to more than one party...." One student suggested that moral upbringing prior to college plays an important role in preparing one for professional decision-making.

Three students expressed a sense that their ethics education lacked skills in developing structural frameworks for approaching ethics problems. "I haven't been trained on how to approach an ethics problem. I've been trained on how to approach a loading problem, and I...don't know if there is a protocol on how to approach the problem, but if there is, I feel like that should have been somehow discussed before we were sent out into this...."

Another student, who took thermodynamics the first time ethics was taught, expressed concern over a lack of interaction among class members. "I can say for sure when I took [thermodynamics], we responded individually to the ethics assignments; we didn't respond to what our group had written, and we definitely didn't read other people's, so we were getting a more narrow focus. By expanding it into a teamwork situation, it definitely made it a better learning experience for me."

**D. Where ethical training occurs**

Experience of ethics varied widely among students in our first two classes. The amount of ethics education each received ranged according to the order in which they took their courses and how many courses they had taken with certain professors who place explicit emphasis on ethics. Some students felt that their exposure to ethics was minimal. Other students found the ethical training across the curriculum to be spotty and not well coordinated. One said, "There's no consistency.... It's sporadic, when we get our ethics boosts." Two students felt that ethics was fairly evenly distributed throughout their education. Some students praised particular courses thermodynamics and continuum mechanics) for integrating ethics with course content.

Students readily recalled ethical training they had received in specific courses (Table 1). The breadth of courses that were recalled is a testament to the distribution of ethics throughout the curriculum, but the fact that not all students recalled the same content or put the pieces together in the same way points to the startup situation in which we have been operating and the need for better coordination and an overarching structure.

**Table 1: Number of Focus Group members naming a specific Engineering Course as Including Ethics**

| **Course** | **Number of Participants** |
|---|---|
| Designing the Future: an introduction to engineering | 5 |
| Engineering Thermodynamics | 4 |
| Continuum Mechanics I | 3 |
| Mass and Energy Balances/Engineering, the Environment and Sustainability* | 3 |
| Design Clinic | 2 |
| Circuit Theory | 1 |
| Advanced Strength of Materials (EGR 372)† | 1 |
| Engineering and Public Policy (EGR 230) † | 1 |

*Mass and Energy Balances substitutes for Engineering, the Environment, and Sustainability as a core requirement as of 2003-2004. Students in focus groups consistently referred to each course in the context of a core offering.
†Elective course

Several students discussed ethical training outside of the engineering curriculum. Participants shared that a large number of engineering majors have taken professional ethics courses offered through the philosophy and religion departments at Smith and the University of Massachusetts. Two students specifically discussed how a liberal education and engineering education complement each other. One said, "I think some of my overall views on things came from other liberal arts classes that I've taken.... Relating my knowledge from my outside classes to using an engineering ethics textbook and standards and systematic ways that they approach engineering ethics problems.... It all ties in, but I definitely got a lot out of learning the engineering approach and being able to analyze specifically engineering-related problems."

Both focus groups had mixed feelings about whether to learn ethics in an integrated way across the curriculum or whether to experience it in a single course. A few students felt the current distributed approach seemed disjointed and that a single, separate course would provide better depth of focus. However, others pointed out that after the course is over, students might stop thinking about ethics altogether. One student commented that one could achieve the desired depth of focus and background by improving the existing distributed curriculum. Four students noted the problem of an already packed curriculum, where adding another course would not be desirable.

**E. Effects of the program**

Students discussed several outcomes related to how the ethics curriculum had changed their thinking on the topic. Four students reflected that the curriculum had raised their awareness and recognition of ethical issues, and given them a sense of the types of situations they might face in a professional setting. "It gave me a way to be more articulate about what my particular thoughts were.... I have a better framework and know more about the types of things to look at."

Two students discussed their personal moral development. One noted that she has a greater appreciation for gray areas. "I definitely came into Smith thinking that there was a clear-cut right and a clear-cut wrong, and the more stuff I've learned about ethics in our classes, the more I realize that …. it's just balancing and trying to get to the best possible decision based on how it's going to impact a whole lot of people or things."

Two students discussed the importance of multiple perspectives and peer dialogue in working through ethical problems. "Working with a team really helps you to realize that [Participant 4] thinks differently than I think, and she approaches it differently, and therefore I know that if I'm faced with a decision it might be really good to see what she thinks about that."

**F. Suggestions from the Focus Group**

In answering the questions posed, the focus group came up with a number of ideas and suggestions for improving the ethics curriculum at Smith. These include:

- *Ethics Elective*. Add an elective in engineering ethics (possibly taught by non-engineering faculty – itself a matter of debate). There were mixed opinions about whether students would take an ethics elective.
- *Seminar series* of lunches with speakers or a reading group, recruiting speakers from area colleges and/or inviting professional engineers to share their experiences.
- *Distribute ethics case studies* across all core courses. "So, . . . my end suggestion would be to incorporate ethics, in one way or the other, in every course that is being taught here--somewhere or other--maybe one case study, so that way it's consistent and it's standard, and you keep building on it."
- *Put more ethics in the first year courses*, where there is less pressure to cover a great deal of technical material.
- *Include More Positive Cases*, to address concerns about ethics being discouraging or frightening.
- *Provide more structural frameworks/Analytical Tools* to support case study work.

**IV. Curriculum Description**

The faculty had already begun working on many of the issues that arose in the focus groups, which served to reinforce much of our own efforts in this area. We have developed a vision for an integrated curriculum, in which structural frameworks for ethical analysis are taught in the first year, and revisited in several core courses and advanced electives. This plan is discussed below, in the typical order in which students might take the courses.

**A. Design-Based Introduction to Engineering.**

The first class most Smith engineers take is a design-based introduction to engineering in which students design educational tools for use in community elementary schools. Alongside this introduction to design, students explore what it means to be an engineer through case studies and personal narrative reflections.[9] The goals are to motivate a well-rounded engineering education and to help students understand the importance of studying ethics (as well as other topics in the humanities and social sciences) as an integrated part of their education. This is achieved through case studies and narrative reflections.

The case studies include

- The Challenger accident, as analyzed by Edward Tufte, highlighting communication failures of engineers and the need to integrate strong written, verbal, and visual communication skills as a core competency in the engineering curriculum.[10]
- The Citicorp building, and the value of honesty, as well as the value of networking in the professional world.[11] This case is integrated with a physical analysis of the structural problems with the building.
- Palchinsky's stand for a liberal education for Soviet engineers, and the consequences of not heeding this advice.[12]

Students additionally read two pieces that illustrate how political and social biases can become embedded in design without our being conscious of it. [13, 14]

Students discuss these case studies and readings over four class sessions and write narratives about their reactions to these topics, and how they affect students' feelings about engineering and their role in the profession.[9]

**B. Mass and Energy Balances**

The course in mass and energy balances provides a calculations-based introduction to engineering that immediately follows the design-based introduction described above. In this course, introduced as a core requirement in the 2003-2004 academic year, students use a portfolio model to learn the mechanics of ethical thought. This portfolio is a major focus of the course, worth 25% of the grade.

Because the course is focused on problem solving as a main theme, it works very nicely to use Harris, Pritchard, and Rabins[8] as a course text. The authors explicitly present the problem-solving framework used in engineering (and other disciplines) as a way to approach ethical problems. It is helpful that the text also uses the Challenger and Citibank tower cases (which student studied in the introductory design course) in its first chapter as a way to motivate the importance of studying ethics.

Students focus on problem framing and analysis, reading and discussing the first several chapters in the text, which cover approaches to solving moral problems. In the first offering of the course, students wrote 1-2 page case analyses on five cases in the text. They worked in teams of four, and after one member wrote her analysis, the others would comment, taking turns so each had at least one chance to write the initial analysis.

In the second iteration of the course, students will build a portfolio for a single case analysis to be worked in a team. Each student will write an initial draft and seek peer comments as well as grader comments, and then revise the draft. Each team will work four separate problems, having primary responsibility for the analysis of one case, but practicing analysis of the other case by reviewing and evaluating peer drafts. More class time will be dedicated to discussing the readings and to peer editing and discussion of drafts than in the first version of the course.

In the second iteration of the course, ethics cases are chosen to align with a community-based project. Students are performing a life-cycle assessment of capacitor production as research for the artist collective subRosa's installation at the Massachusetts Museum of Contemporary Art (Mass MoCA) in North Adams, MA.[15] The museum is housed in a former capacitor factory, which became available when the company filed for bankruptcy, devastating the local economy. One part of the company, bought by venture capitalists and still based in North Adams, moved production to Juarez, Mexico. (Other parts of the company have followed similar trajectories, locating in other developing countries). A series of ethical issues have been chosen for student to analyze related to this project.

An instructional video developed by the National Center for Engineering Ethics is an excellent resource that supports this effort.[16] The video, entitled "Incident at Morales" raises a number of ethical issues related to a process engineer's design of a paint-stripper manufacturing plant sited in Mexico. The technical work in the video is closely related to the material in the mass and energy balances course, so that students can readily understand how ethical issues arise in a professional setting. Because of the similarities in subject matter related to globalization, this piece can serve as a bridge from a well defined "out of the box" case study to the messier real-world problem our students will analyze.

Four ethical cases were developed for the course, related to the project, the video, or both. The first case probes the engineer's responsibility in automation or relocation efforts that have a large local economic and social impact on a town or region. This relates directly to the town of North Adams, where relocation of Sprague Electric's capacitor factory had a devastating economic impact (now being countered by the establishment of Mass MoCA), and where the introduction of the steam drill in the building of the Hoosac Tunnel in the 19$^{th}$ century both saved lives and eliminated jobs. The second case considers the responsibilities of an engineer in making trans-border decisions about environmental and worker safety standards. This is raised by both the video and the community-based project. A third case, taken from the Harris text, examines honesty in presenting an artifact as "made in the USA" when a subcontractor supplies bolts manufactured elsewhere. This case relates directly to the community-based project, in that a small component item such as a capacitor could easily be used in the same way the bolt was in the case. The fourth problem, also adapted from the text, probes issues of property and ownership when engineers change employers, an issue raised in the video and also quite relevant in the competitive market of capacitor manufacturing.

The evaluation rubric emphasizes critical thinking, being able to identify the locus of disagreement in an ethical problem as lying with facts or with values, articulating and employing a number of different ethical frameworks, and being able to see the problem from multiple points of view related to these differences in facts or values. These relate fairly directly to our learning objectives described above.

**C. Engineering Mechanics**

The introductory course in the continuum mechanics sequence includes topics from engineering statics, dynamics and strength of materials. In this course ethical considerations are integrated with the technical content through two case studies.

The first case study examines the 1976 Hyatt Regency Hotel collapse in Kansas City. In preparation for this in-class investigation, students are assigned readings on professionalism that include the ethics codes of the National Society of Professional Engineers (NSPE) and the American Society of Civil Engineers (ASCE). After a presentation introducing the details of the hanger rod assembly that was the cause of the collapse, students apply their technical knowledge to compare the forces in the connections in the original design with the "as built" configuration. Students are often surprised that the mechanics of the failure is so simple. In fact a common student reaction at this point is to wonder how engineers could make such an obvious mistake. This question leads into a study of the ethical issues of the case.

After completing the technical analysis of the failure, students learn about the chronology of events that led up to it. The focus of this chronology is the relationships among the engineers, architects, materials fabricator, and construction contractor involved in the project. At this point students break into groups to discuss the issues of professionalism involved in the failure. These include assigning responsibility for the design flaw, understanding the responsibilities of licensed professional engineers, assessing the communications among the parties, and discussing the discipline actions that were taken. Following the small group discussions, the case study concludes with each group sharing their ideas with the rest of the class. In both the group and class discussions, differences of opinions among students are common and seriously debated. Many cite the NSPE and ASCE codes of ethics to support their arguments. We have found that students have particular interest in the ethical and legal responsibilities that are part of being a professional engineer. They often want to explore this area further or express concerns about taking on such a responsibility for themselves.

In the second case study students investigate both the mechanics and societal effects of the 1985 Michoacan earthquake. The case study begins with a presentation of the facts of the case including Mexican geology, acceleration-time histories and their Fourier spectra from various locations during the earthquake, and pictures of various structural failures. A particular emphasis is made to make students aware of the human dimensions of the tragedy. Following the presentation, students work in groups to explain the damage pattern of the earthquake throughout Mexico. Once the technical analysis is completed, students then research and write a paper on the effect that the tragedy (and the engineer' s role in it) had on Mexican society. Topics arising in these papers include discussions of political unrest, unification of a divided lower class, government re-organization, tourism and other economic effects, exposure of corruption, the response of citizens to the president's actions after the quake, and the tremendous suffering of the victims. For example, one student wrote the following:

> …The losses incurred as a result of the earthquake and below-par building standards provided good timing for an already cynical people to demand changes in their government's structure. Immediately people criticized the standards of past governments and the current government's response to this emergency situation. Many citizens claim that government

workers stood by and watched, or even prevented or inhibited them as volunteer civilians took action to respond to the crisis. Meanwhile, the mostly lower classes that were affected by the earthquake came together as a people do in times of calamity. As a result, the earthquake served as a catalyst for more governmental involvement from what was previously a very aloof group.

**D. Engineering Thermodynamics**
Students analyze four cases related to engineering thermodynamics that are designed to probe several different topics in engineering ethics. All cases are drawn from Harris, Pritchard and Rabins.[8] The first case examines the conflicts of interest in the 1982 case of *American Association of Mechanical Engineers (ASME) vs. Hydrolevel Corporation*, in which ASME standards for boiler safety devices were manipulated in committee in order to competitively exclude another firm. The second case deals with professionalism in expert testimony when a less technologically savvy lawyer poses an incorrectly worded question related to a soda bottle explosion, and the engineer must decide how to answer, choosing either honesty or loyalty to the legal team that hired her. The third case probes responsibilities for designing reliable equipment and honesty in accepting responsibility for failure when it occurs, vs. company loyalty or protection. The fourth case examines group dynamics in a power plant safety case, and whether a less powerful person in the group (female, junior engineer) should dissent and speak up for stricter safety protections, knowing that it will not change the outcome of the company's decision.

The case analyses follow the format introduced in the first iteration of the mass and energy balances course (described above), and are 1-3 pages in length. These are written in teams of four, with students commenting on and adding to the analyses presented previously in their team, and taking turns at who writes the initial analysis. Cases are posted to a Blackboard discussion group so that students can read each other's responses. They are graded with the same rubric described above for the mass and energy balances course.

**E. Engineering, the Environment, and Sustainability**
This elective course combines an introduction to environmental engineering with "big-picture" ethical questions about humankind's relationship with the environment.[17] The course is structured in three units: social balances, physical balances, and economic balances. The social balances unit includes an exercise in personal decision-making, in which students calculate their ecological footprints (land use required to sustain their lifestyle), and a risk analysis assignment, in which students compare bottled vs. tap water in their community, performing a quantitative risk assessment, and addressing risk perception communication issues. The physical balances unit covers water quantity and quality, contaminant and transport modeling, and culminates in a wasteload allocation project. The economic balances unit introduces environmental economics (including market-based approaches), ecosystem valuation, and cost-benefit analysis.

Through class discussion and short essay assignments, students explore their individual impact on the environment (ecological footprint), the meaning of sustainability, and the responsibility of developed nations to developing nations.

The ecological footprint exercise is particularly thought provoking for students, who are often surprised by the enormity of their impact on the environment. Responses vary from guilt and defensiveness, to critical thinking about the instrument used in estimating their footprint, to consideration of positive personal action for reducing environmental impact. In the assignment, students are encouraged to consider how the average footprint varies by country, and how their footprint relates to the U.S. and world average footprints.

This initial exercise sets the stage for a second, more advanced reflection (2-page limit), on the meaning of sustainability and on the responsibility of developed nations to developing nations. Class discussion, which occurs prior to the essays, is typically quite lively. This assignment is graded on quality of argument, critical thinking, documentation and support, and clarity of structure and expression.

Additionally, sustainability is a primary focus of the course. Discussion about the meaning of sustainability probes technical, political, economic, cultural, ideas, and always includes an ethical dimension.

**F. Engineering and Global Development**

This course is focused on the principles of "appropriate technology," taking a critical look at the role of technology in global development efforts.[18] Here the Harris text[8] serves as one of many readings, providing a specifically professional perspective on the conduct of engineers abroad. Students also read and discuss a number of readings about global inequities and money and power and their root causes, and the role of technology in society and particularly in solving or creating global development problems. Case studies of three different economic development models (one entrepreneurial and western-driven, one entrepreneurial but driven from within a developing country with an eye to empowering poor women, and one collective owned and run by poor women) raise questions of ethics alongside questions of political and economic effectiveness.

In a short essay assignment, students confront questions related to the administration of aid from one government to anther and the political, economic and ethical implications of doing so. After learning the principles of appropriate technology, students write a second essay about the role of U.S.-trained engineers in developing countries, and their role a class in the community-based project we undertake.

Appropriate and inappropriate technology case studies are selected to place a strong emphasis on issues of power in collaborative design efforts with communities engaged in economic development efforts.

Students directly confront ethical issues related to power differentials in a community-based design project. In spring 2004, students are working with an urban economic development organization called Nuestras Raices, which runs a local organic bakery with a wood stove that generates a local air pollution problem.  Students are challenged to live out their values in a real-world context and deal with potential and actual consequences of actions they take. For example, readings about foreign aid raise questions about how funders often seek to control projects in ways that undermine community autonomy and self-direction. As students in this course become engaged with having to work to raise funds to support their project, they will have to confront the same issues in a real-world context. Similarly, they will read critiques of appropriate technology as selling “less-than” lower tech solutions to communities with less power and money, and confront choices in their own project related to technology effectiveness and cost.

Ethical analysis is less formal in this advanced elective, but embedded in most of the coursework. We anticipate that drawing on students’ preparation in ethics will enhance their ability to think through the issues in the course.

**G. Engineering Design Clinic**

In our inaugural capstone course, students work in teams of 4 to undertake a real-world design project sponsored by an industry and/or government organization. Required for all senior engineering majors, the year-long Design Clinic provides students the chance to apply their technical skills in a team-based, design setting. Projects for the 2003-2004 academic year include collaborations with the Ford Motor Company, GE Plastics, Metcalf and Eddy, the MITRE Corporation, and the City of Northampton. The project component of the class is supplemented by weekly seminars, often with invited speakers, to present and discuss topics related to design and professional practice. The topics include areas such as engineering economics, quality control, and leadership, and are intended to aid students during the design process and give them a taste of issues they may encounter in their professional careers.

Ethics is incorporated throughout this class in an applied fashion, both formally and informally. Building on their discussions and analysis of ethics in previous classes, students consider the ethical implications of their projects informally throughout the design process. Design decisions that the student teams make are influenced, at least in part, by their recognition of the importance of ethical awareness. The students’ considerations will then be further formalized during a seminar session on ethics and the preparations before and after this session. In this first offering of the course, the session will focus on the ethical implications of weaving design technologies into society, drawing upon ideas from the field of Science and Technology Studies, and will feature a guest lecturer. While the specific details may change slightly in future years, the format will remain similar.

Prior to this seminar, students will be assigned readings (chosen by the guest speaker) that explore the social construction of technology and the benefits of conceptualizing technology not simply as individual artifacts, but as systems that integrate people, design processes, practices, and multiple artifacts. During the first part of the seminar, students will discuss their reactions to the reading, both with reference to their previous ethics analyses and also in the context of their own design projects. Guided by the lecturer, students will also work through a case study together in class that discusses a specific design technology, such as airbags, and its ethical and social ramifications.

During the second part of the seminar, students will pair with another student from a different design team to focus on their specific design projects. Working as partners, the students will brainstorm the ethical and social implications of their two projects and the associated design processes. As a follow-up assignment after class, each student will write a 2-3 page analysis and discussion of her partner's project, thus requiring her to integrate the details of her one-on-one discussion and think critically about another classmate's project.

Following the individual assignments, the students will meet to discuss their projects within their design teams. Each design team will be given a copy of the four different written analyses by their non-teammate classmates. Incorporating their own thoughts and brainstorms with these "external" analyses, teams will be assigned to write a formal assessment of the ethical and social implications of their projects, both during the design process and through implementation. These assessments will become part of the teams' final reports submitted to the sponsoring organization, thus highlighting the importance of ethical considerations within the Smith engineering curriculum.

**V. Discussion and Direction of Future Efforts**

We were pleased that the focus groups' answers related to the rationale for teaching ethics and the key components of an engineering ethics education matched the faculty's sense of our program so closely. We attribute this to our learner-centered pedagogy, where we give significant attention to helping students understand our pedagogical and content choices in the classroom. We support students taking responsibility for their own learning and establishing and pursuing their own educational goals.

The faculty had anticipated and addressed the focus groups' main concern about providing more of a framework for thinking about ethical problems. A major component of the mass and energy balances course is now focused on exactly this issue. In the future, faculty will be encouraged to draw on the material and resources used in that course as a way to provide coherency in the curriculum. As more courses begin to incorporate ethics, our resources of a textbook, case studies, and grading rubrics will be offered to other faculty to promote consistency and reduce workload.

The focus groups definitely seemed to desire more opportunities for ethics education. Due to a current faculty shortage, we believe these are best met through the lunch/speaker series students suggested, and through applied ethics courses offered in other departments. While students expressed some criticism of their peers in other majors, we believe part of their liberal education requires them to respect and be able to communicate effectively with those who may think differently than they do – and some students think differently precisely because they are trained in a different discipline.

The concern about negativity in the ethics curriculum is interesting. We believe that it is best addressed in two ways. First, incorporating more models of engineers making good ethical decisions is valuable because it presents the profession in a more positive light and provides a sense of social support for students who desire to behave in ways consistent with their conscience. Second, presenting cases currently perceived as negative in a new way so that students see ethics problems as opportunities rather than crises, as ways to think creatively to find new solutions that improve the profession and the lives of real people.

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