Using Detailed, Multimedia Cases To Teach Engineering Ethics

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ABET has decided to switch to outcome-based assessment of engineering programs rather than lists of required courses (See the last page of this paper for resources on outcome-based assessment). Thus, programs will be evaluated according to their contribution to the skills ABET has decided must be demonstrated. While a progressive move in some ways, it raises serious questions for the teaching of ethics. What kind of outcome-based measure can be used to assess whether we are producing ethical engineers from our undergraduate programs, programs which must demonstrate an ". . . emphasis on effective communication and professional and ethical responsibility, awareness of the global societal context of engineering, and knowledge of contemporary issues . . ." (Luegenbiehl, 1996)?

Adapting Mortimer Adler's Paiadeaia Proposal (Adler, 1982) to ethics, we would argue that we seek outcomes in three areas:

> 1) Knowledge: Every student ought to know something about ethical theory. For example, Harris, Pritchard & Rabins teach students to distinguish between a utilitarian approach and one based on respect for persons (RP) (Harris, Pritchard, & Rabins, 1995). The assessment of knowledge is straightforward. A standard test or quiz will tell us whether students can list facts about each of several ethical theories and whether they know the codes of their professions.
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> 2) Skills: Students will also need to know how to apply ethical theory and professional codes to practical problems--they will have to be able to engage in moral reasoning. Clever essay problems on tests might be able to assess aspects of this reasoning, but the best method is to use cases--an approach adopted in textbooks like Harris et al's and Martin & Schinzinger (Martin & Schinzinger, 1989).
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> 3) Wisdom: In the end, we hope we can turn students into virtuous practitioners. Gioia, in his discussion of the Ford Pinto case, makes the distinction between ethical decisions, which accord with accepted professional standards and codes of ethics and moral decisions, which stem from a higher conviction about what is 'right' (Gioia, 1992). Note that this higher conviction can only emerge after students have mastered ethical decision-making. The key final step here is to grasp the spirit of the codes and be able to apply them to new situations for which they were not specifically designed. Moral imagination is a crucial part of this process.

Moral imagination is more than just a skill--it requires students to be able to switch frames, to really understand how a problem might appear from another point of view. In his provocative novel *Ishmael* , Daniel Quinn (1992) tries to create such a frame shift, arguing that the Taker

myth that permeates our culture should be replaced by one based on Leaver values; the former sees Nature as something to be controlled, dominated and manipulated, whereas the latter sees Nature as something to be left alone, whenever possible. In terms of moral theory, Quinn believes in creating virtuous people by altering the myth most of us live by--once we have internalized a new myth, we will know how to share resources, not just with other human beings but also with other species. What Quinn is outlining is a process of moral imagination: recognizing that one's cultural world view is a myth, trying out another view, and seeing how problems look from that perspective.
But one should not hold the new view dogmatically. Moral imagination is a tool for combating dogma, for recognizing that there are different ethical perspectives that can be applied to a problem. The hope is that by exercising moral imagination, practitioners will become reflective, considering alternative views and arriving at decisions that are better than one could develop from only one frame of reference.

The best way to teach and assess moral imagination is again through the use of cases, but this effort will require extended cases, based on real ethical dilemmas, that involve multiple decision points. At the University of Virginia, we have created a Web site, http://cti.itc.virginia.edu/~meg3c/id/ethics/ethics_frame.html, which contains a series of such case-studies. This Web Site was awarded first prize in a competition sponsored by MIT's Ethics Center for Engineering and Science. The site features primarily cases that have been researched and written by students, with faculty support from the School of Engineering and Applied Science and the Darden School of Graduate Business Administration.

The cases generally focus on ethical considerations in the early stages of the invention and design process, rather than as aftermath of a completed design. Because of the growing use of cases in engineering courses, and because it is difficult to separate out design issues from those in ethics and in the environment, we are developing cases that encourage students to think imaginatively about design in light of the increasing concern for the environment and other issues that will be challenging to them in their work as engineers. We hope to produce engineers who will be better able to make ethical decisions about creating and marketing new technologies (Mehalik & Stocker, 1996).

The first set of cases we are developing illustrate organizations which make sound engineering design decisions based on the best knowledge available, that think carefully about safety, the public good, and the environment, yet find themselves in trouble (Dow Corning (A) and (B)). What they lack is moral imagination: the ability to disengage themselves from their engineering/scientific point of view, to be aware of the ways in which other people frame and structure their experiences, and to understand and evaluate their activities through perspectives that are different from, even alien to, their own (Mehalik & Stocker, 1996).

A second set of cases are being built around the challenge of trying to meet a rule-based Kantian imperative which argues that risk should be virtually eliminated. Engineering students are typically trained in a more utilitarian perspective that engages in a cost/benefit analysis of design-environmental costs, risks, and outcomes (DesignTex (A) and (B) and Rohner Textil cases). These cases will encourage students to exercise moral imagination by trying to meet challenges such as: Can one design a product that is environmentally sustainable and viable in the market place? Can one take into account and/or avoid social and political risks that are inherent in any product design (Mehalik & Stocker, 1996) ?

The goal of the project is to develop and disseminate cases and supporting materials that teach students to exercise good judgment and moral imagination, that help them learn that design always entails an ethical perspective, and that demonstrate that environmental design is both challenging and viable. These materials have been or will be tested in the classroom and should have appeal in a variety of disciplines including engineering, technology, environmental studies, and ethics (Mehalik & Stocker, 1996). They will be published in the Darden Graduate School of Business Case Bibliography and eventually in a book.

This presentation will highlight two of the cases, both of which have been used in fourth-year courses involving ethics required of all engineering students at the University of Virginia (Technology, Culture and Communication 401/402), and a course on technological thinking given to first-year honors students in engineering. This course includes the kind of culminating design experience called for in the new ABET criteria, and also has a strong ethics and communications component. These cases attempt to teach students moral imagination and ethical reasoning.

I. Towards a Sustainable Tomorrow: The Design of an Environmentally Intelligent Fabric

The new ABET criteria explicitly include environmental sustainability among the important considerations that students should consider when they invent and design(Lugenbiehl, 1996). This case shows students how sustainability can be used to shape the design process. All of our cases have more than one decision point, the first decision is labeled A, and then succeeding letters of the alphabet are used for later decisions the students must make based on the outcome of earlier ones.

Summaries:

DesignTex (A): Susan Lyons, a vice president at DesignTex, a firm that develops high-end custom fabric collections, wants to create an environmentally-responsible fabric that would provide a model for sustainable design. Ms. Lyons consulted with William McDonough, Dean of the School of Architecture at the University of Virginia and a noted designer of environmentally sustainable buildings. McDonough argues that designers and inventors need to think about cost, performance, and aesthetics, but adds two additional constraints: Will the design process and eventual product be ecologically intelligent? Will they meet the criteria of social justice?. McDonough's stated ideal is that "No environmental risk is acceptable." Engineers tend to talk about "acceptable" and "unacceptable" risk so that McDonough's statement challenges a traditional paradigm and seems outrageous as a criterion for a practical design. Students have to engage in moral imagination if they are going to comprehend McDonough’s point of view.

In this case, Susan Lyons took up his challenge to see whether or not DesignTex could design a fabric that would meet McDonough's ideal. The case follows the development of a new furniture fabric and asks students to decide whether McDonough's principles go too far--whether it is really necessary or feasible to redesign the chemical protocols by which all fabrics are manufactured in order to produce a completely compostable product that emerges from an absolutely clean manufacturing process.

DesignTex (B): The successful creation of a fabric that met McDonough's specifications is described. The B case asks students who should be asked to pay the additional cost of implementing McDonough's protocol.

Evaluation of the DesignTex Cases in actual engineering classes:

We believe the DesignTex cases offer valuable additions to engineering curricula. They offer students concrete examples of the importance of ethics in engineering. Students enjoy the chance to learn such lessons through "hands-on" experience. These cases encourage engineering students to consider ethics as a component of design, rather than as an afterthought. They force the students to steep themselves in that quagmire called ethics, an area not often emphasized in engineering classes, but a very real consideration of practicing engineers. The cases successfully required the students to consider ethical, practical, and economic components of a product in making decisions about its design and production. Rather than bore these students with moral platitudes and pre-packaged lectures, the DesignTex Cases required the students to actively consider the factors at play in integrating ethics into the engineering profession and the business world. They not only introduce the students to a real-world concept, but foster a greater empathy for the role of managers as decision makers (roles which most engineers move into as their careers progress). Students appeared to enjoy this change and acknowledged the need for such considerations now and in the future. When discussing the cases, students revealed a growing awareness of the tension between modern business/engineering design and the extent to which one infuses ethical considerations into these areas (Russell & Stocker, 1996).

Example of Survey Results:

About fifty fourth-year students from two sections of a fourth-year engineering course with an ethics component responded to the surveys on the DesignTex cases. (Students filled out the surveys on different days, and the number of students attending each day varied slightly. Also, blank answers and "Not Applicable" were not included in the calculations.) Figure 1 summarizes the results.

The results below reveal students' tendency to compartmentalize ethics away from other topics. For example, they recognized the environmental nature of the case issues (as shown below), but did not recognize these issues as ethical ones, revealed in the lower score on whether the case "Raised important ethical issues". Overall, however, the students found the DesignTex case and the class structure around it interesting and relevant to their engineering education. While this is an encouraging observation for the future of engineering, it needs continual reemphasis through cases similar to DesignTex (Russell & Stocker, 1996).

Questions	**Mean**	**Standard Deviation**
How many hours did you spend reading, studying, and researching for the case?	1.38	.56
How difficult was the case study (1=Very Difficult . . . 5=Easy)?	3.51	.78

In the following, students rated their level of agreement in a scale from (1 Strongly Agree) . . . (5 Strongly Disagree).		
This case . . .		
a. Raised important ethical issues.	3.12	1.02
b. Raised important engineering issues.	2.73	1.00
c. Raised important engineering design issues.	2.35	1.07
d. Raised important environmental issues.	1.94	.97
e. Contained interesting subject matter.	2.73	1.06
f. Provoked interesting class discussions.	2.25	1.02
In the following, students responded on the following scale: 1 (Very Helpful) . . . 5 (Completely Unhelpful))		
How valuable did you find . . .		
a. The World Wide Web for accessing the case?	1.53	.74
b. The World Wide Web for the presentation and organization of the case?	1.92	.89
c. The case exhibits?	2.74	1.00
d. Relevant class lectures?	2.41	1.00
e. Relevant class readings?	2.92	1.05
f. Class discussion of the case?	2.18	.99

Figure 1: Quantitative evaluation DesignTex, fall term 1995.

II. Science or Superstition? The Dow Corning Breast Implant Case

Engineering students frequently assume that it is sufficient to present good data in order to make a point, that the data will speak for itself. The Dow Corning case illustrates what happens when a company takes this stance.

Summaries:

Dow Corning Corporation (A): There are several cases already written on the breast implant litigation situation. However none of the case writers have been allowed access to Dow Corning's records or key personnel. We have been offered this access. In particular, we explore the set of original design decisions that led to the creation, manufacture, and marketing of implants, and what was entailed in their subsequent redesign and alleged improvement. We asked the students to decide whether to put this "new, improved" implant on the market.

Dow Corning Corporation (B) (in progress): This is a follow- up to the (A) case, with emphasis on Dow Corning's reaction to increased regulation and changing federal and scientific community standards for testing of medical products, such as implants, as well as the first lawsuits against Dow Corning's implants.

Usually, at the end of the class session, we bring the students up to date on the status of the litigation. If the independent epidemiological data continues to be consistent with a multitude of present findings, it will turn out, just as Dow Corning has claimed, that the causal relationship between breast implants and disease is, at worst, a very weak correlation. "The best evidence now is a relative risk of 1.0, indicating no contribution of implants to the disease" (Angell, 1996, p.197). Yet despite what appears from a scientific and engineering point of view to be "good scientific evidence," and despite the fact that Dow Corning scientists and managers believed they acted virtuously according to professional scientific and engineering standards, this company has been sued for over 4 billion dollars in a class action suit involving 440,000 women, and it is currently in Chapter 11 bankruptcy. These cases should be good illustrations of the importance of design decisions for the development and future of a product. They also raise questions about moral imagination, because they exemplify what can happen legally as well as morally when one has a product such as a breast implant and one does not take into account the perspective of women who received the implant.

Evaluation of the Dow Corning Cases in actual engineering classes:

When piloted in two freshman-level classes, the students reacted to Case A with a "no-brainer type" decision to market the implant, as originally anticipated by the authors. However, in some senior-level classes, there was difficulty overcoming the piecemeal knowledge the students had of the breast implant litigation, since it has been so well publicized. Because the students already know the outcome (bankruptcy for Dow Corning), they will often request further testing, relying on science to save the day. Typically, the students resist having to make a judgment call, since it forces them to share in the responsibility for the product and the amount of testing done to ensure its readiness for market.

Still, overall, both the first and fourth-year students recognized the inherent difficulty in deciding when a product has been tested enough to go to market. This case especially highlights the need for moral imagination, since the Dow Corning scientists, and thus the students using this case, must break out of their engineering mold and look at it from the perspectives of the managers, corporate lawyers, marketing personnel, and the women receiving the implants.
Case B continues this facilitation of moral imagination in the students. It presents the second phase of the history of Dow Corning's breast implant, from the time the new-and-improved version went to market to the first legal decisions against it. This case shows what happens when the scientists at Dow Corning failed to use their moral imaginations. As far as they were concerned, their science demonstrated the safety of the implants, but they failed to see the situation from the view of a woman with implants who has started hearing frightening news about them causing disease, although she feels fine at the time. In the end, students acknowledged the difficulties of relying solely on science in defending a product, since society overall, and especially the courts, treat evidence differently the scientific community.

Example of Survey Results:

About 40 fourth-year students from a fourth-year engineering course with an ethics component filled out the survey about Case A, and about 35 for Case B. (Students filled out the surveys on different days, and the number of students attending each day varied slightly. Also, blank

answers and "Not Applicable" were not included in the calculations.) Figure 2 summarizes the results for Case A, and Figure 3 for Case B.

In contrast to DesignTex, students appeared to find both engineering and ethical issues in the Dow Corning Cases at about the same rate, which indicates good balance between the ethics and the science of the cases. Overall, the students found both cases and the class structures around them interesting and relevant to their engineering education.

Questions	**Mean**	**Standard Deviation**
How many hours did you spend reading, studying, and researching for the case?	1.22	0.79
How difficult was the case study (1=Very Difficult . . . 5=Easy)?	3.05	.55
In the following, students rated their level of agreement in a scale from (1 Strongly Agree) . . . (5 Strongly Disagree).		
This case . . .		
a. Raised important ethical issues.	2.15	.85
b. Raised important engineering issues.	2.37	.86
c. Raised important engineering design issues.	2.22	.85
d. Raised important environmental issues.	3.26	1.13
e. Contained interesting subject matter.	2.20	.91
f. Provoked interesting class discussions.	2.46	.92
In the following, students responded on the following scale: 1 (Very Helpful) . . . 5 (Completely Unhelpful))		
How valuable did you find . . .		
a. The World Wide Web for accessing the case?	1.78	.93
b. The World Wide Web for the presentation and organization of the case?	2.08	.84
c. The case exhibits?	2.64	.82
d. Relevant class lectures?	2.46	.82
e. Relevant class readings?	2.63	.67
f. Class discussion of the case?	2.51	.82

Figure 2: Quantitative evaluation of the Dow Corning Case A, spring term 1997.

Questions	**Mean**	**Standard Deviation**
How many hours did you spend reading, studying, and researching for the case?	1.41	1.62

How difficult was the case study (1=Very Difficult . . . 5=Easy)?	3.26	.86
In the following, students rated their level of agreement in a scale from (1 Strongly Agree) . . . (5 Strongly Disagree).		
This case . . .		
a. Raised important ethical issues.	2.31	1.06
b. Raised important engineering issues.	2.29	.90
c. Raised important engineering design issues.	2.19	.89
d. Raised important environmental issues.	3.38	.87
e. Contained interesting subject matter.	2.19	.92
f. Provoked interesting class discussions.	2.61	1.13
In the following, students responded on the following scale: 1 (Very Helpful) . . . 5 (Completely Unhelpful))		
How valuable did you find . . .		
a. The World Wide Web for accessing the case?	1.79	.74
b. The World Wide Web for the presentation and organization of the case?	2.12	.69
c. The case exhibits?	2.61	.80
d. Relevant class lectures?	2.47	.99
e. Relevant class readings?	2.55	.95
f. Class discussion of the case?	2.50	1.03

Figure 3: Quantitative evaluation of the Dow Corning Case B, spring term 1997.

As the reader sees above, the pattern of results from Case A and Case B are very similar. Thus, we know that the cases work well together, and that they successfully balance the science with the ethics component, allowing the student to delve into both areas simultaneously.

Conclusion

We hope this paper demonstrates that cases can be a powerful method for introducing students to moral imagination and ethical reasoning in a way that shows a clear link to the design process. These cases lead to at least two outcomes:

1) Students learn to exercise moral imagination by:

a) adopting the point of view of a participant, like a small textile manufacturer in the DesignTex cases or a Dow Corning implant chemist, guessing what decision the person will make and defending it;

b) making and defending their own decisions about the case, which might be different from the participant's.

2) Students also learn to engage in moral reasoning as they make and defend their decisions. For example, can they identify how Utilitarian and RP perspectives might lead to different decisions in the DesignTex case? Or, in the Dow Corning case, can the students support their decision whether to market the implant, by examining the different segments of society interested in the implant, and the degree of risk acceptable in different cases? We use role-playing to facilitate this kind of imagination and reasoning.

We are now at the stage where we are trying to design ways of measuring these outcomes. Our current evaluation surveys address student satisfaction, but not student ability to engage in moral imagination and reasoning. We have students write journals and essays, and need to be able to extract information from these that will help us do a better job of assessing whether they are engaging in moral imagination and reasoning. The best demonstration of learning from these cases would be to see if the students gained enough wisdom to apply what they had learned to their own design projects. For example, as part of the fourth-year course, students have to propose an undergraduate thesis topic and carry it to completion. We are trying to give them the DesignTex and Rohner Textil cases before their project proposals, to see if it influences their choice of topic and approach, and the Dow Corning cases later, to see if it influences how they think about the impact of their project on society.

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Please note that the opinions expressed in this paper are solely those of the authors

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List of Outcome Assessment Resources:

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