Combining Ethics and Design: Monsanto and Genetically-Modified Organisms

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> One most unfortunate product is the type of engineer who does not realize that in order to apply the fruits of science for the benefit of mankind, he must not only grasp the principles of science, but must also know the needs and aspirations, the possibilities and the frailties, of those whom he would serve. (Vannevar Bush, quoted in Zachary, 1997, p. 70)

This paper will describe a case study we developed at the University of Virginia for teaching the social and ethical dimensions of technology to engineering students. The case study concerns Monsanto's efforts to be a cutting-edge life-sciences company in agriculture, developing genetically-modified seeds. In order to understand the case study, one has to understand the program out of which it emerged.

A Graduate Option in Engineering, Ethics and Policy

At the University of Virginia, we have created a graduate option in Engineering and Ethics that links the Darden Business School, the Division of Technology, Culture and Communications and the Department of Systems Engineering. This engineering graduate option attempts to overcome the negative side effects of specialization and compartmentalization by building an intimate link between technical and ethical training. With support from the National Science Foundation[1], we created a research and educational experience that focuses on producing engineering graduate students who will be able to understand the social and ethical dimensions of complex, heterogeneous technological systems. As part of their training, the students in this option produce case studies that emphasize ethical issues in the design process. Students then undertake a thesis that combines ethical and technical aspects of engineering by focusing on the case study.

Our goal is to turn out ethical professionals who are able to engage in moral imagination. According to Patricia Werhane, one of the key faculty in the option, moral imagination involves recognizing the role, scheme or mental model that one is adopting, disengaging from it and evaluating alternative perspectives and courses of action (Werhane, 1999).

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The global economy has made understanding the needs and beliefs of people very different from our own an essential skill for engineering students. “Companies as agents and drivers of global change, must be engaged in efforts to develop solutions to critical social and environmental issues” (Logan, Roy, & Regelbrugge, 1997, p. 115). Adding the word ‘engineers’ to ‘companies’ in this quotation serves as a statement of our goal. In the long term, socially beneficial and environmentally sustainable designs will be essential components in a company’s global competitiveness, and it is engineers that will create these designs.

We are dedicated to transforming engineers into ethical practitioners who will reflect on the consequences of their designs and discoveries. Most educators understand the need to provide engineering students with ethical training lest these students find themselves ill-equipped and unprepared to handle difficult ethical problems in the workplace; however, few engineering schools feature even a single course on ethics (Stephan, 1999).

The Case Study Approach

Case studies are being used increasingly to teach engineering design (Kagiwada, 1994) as well as ethics (Harris, Davis, Pritchard, & Rabins, 1996). Case studies provide an opportunity for a kind of vicarious mentoring, in which the student is taken through a compressed version of a real dilemma, debates alternatives, makes a choice, and is shown expert solutions. Case studies can also be adapted for use in multiple classes, allowing engineering ethics to be emphasized even in curricula that do not have room for a special class on that topic.

Realistic case studies, similar to the ones created by graduate students in our option, can range from the simple, short cases based on minor ethical dilemmas faced by engineers on a daily basis, or ones that are based on complex, international, long range strategy decision that affect millions of lives, and generations of people. Encountering a carefully crafted story, and playing a role in that story gives students an experience they may remember well after graduation. If instructors manage to engage the students to this level, much will have been done to enhance their moral reasoning and moral imagination when addressing ethical dilemmas as practicing engineers.

Our current group of case studies include:

- The Dow Corning breast implant controversy, focusing on the dissonance between scientfic evidence and public perception.
- The design of an environmentally intelligent furniture fabric, intended as a model for global sustainable development.
- How the world’s fourth largest utility can literally extend ‘power to the people’ in an equitable and profitable fashion in rural South Africa.
- How Unilever, a global company, is working to implement a ‘triple bottom line’ in which social and environmental benefits will be as important as economic ones.

These and other cases are included in Gorman, Mehalik and Werhane (2000) and are also available from the Darden Business School’s case library (www.darden.edu/case/collection/index.htm).

Monsanto’s Vision for Global Sustainability

The rest of the paper will describe one of our current case studies in progress on Monsanto. In 1995, Robert Shapiro became the CEO of Monsanto. Shapiro’s vision for Monsanto was that the company would do well by doing good. As he said in an interview: “…new technology is the only alternative to one of two disasters: not feeding people (and) letting the Malthusian process work its magic on the population, or ecological disaster.” He saw the solution as new technologies, specifically, “biotechnology and information technology. I’m treating them as though they’re separate, but biotechnology is really a subset of information technology because it is about DNA-encoded information. Using information is one of the ways to increase productivity without abusing nature. A closed system like the Earth’s can’t withstand a systematic increase of material things, but it can support exponential increases of information and knowledge. If economic development means using more stuff, then those who argue that growth an environmental sustainability are incompatible are right. And if we grow by using more stuff, I'm afraid we'd better start looking for a new planet. But sustainability and development might be compatible if you could create value and satisfy people's needs by increasing the information component of what's produced and diminishing the amount of stuff" (Margretta 1997). He also noted that "The market is going to want sustainable systems and if Monsanto provides them, we will do well for ourselves and our shareholders" (Kilman & Burton, 1999, A10).

A case study of Monsanto would therefore confront students with ethical issues on the cutting edge of biotechnology, information technology and environmental sustainability. It would also help them gain the talents and the skills to exceed in the newly evolving global economy. A company that does not have the wisdom to understand cultural differences is at a disadvantage in a global marketplace—as Monsanto discovered when it tried to enter the European marketplace.

Overview of the Monsanto Case Study

John Francis Queeny founded the Missouri-based Monsanto Corporation in 1901 when he brought the technology of manufacturing saccharin from Germany to the United States. In addition to developing that product, Monsanto became the largest producer of Aspirin in the US. By the 1920's the company had spread into manufacturing sulfuric acid and other basic industrial chemicals. In 1923, Monsanto began its first overseas ventures. Since transportation to China was difficult and sugar was heavy, the lighter artificial sweetener saccharin became such a huge export success that by 1976, one third of all Monsanto earnings were coming from this overseas investment.

Monsanto started to venture into agriculture in the mid-1950s with the production of fertilizers. It wasn't until the era of Roundup and Lasso herbicides, first introduced in 1969, that the company's agricultural division thrived. Monsanto introduced Roundup herbicide to the world markets in 1974 and it soon became the company's most bankable manufactured good. At the time of its introduction, it was not known by exactly what mechanism Roundup functioned; all that was known was that it was arguably the best product on the market. Aside for being a very potent herbicide, it was also known to break down quickly in the soil and not leach into the water supply. These benefits made it an extremely popular consumer product. All in all, agriculture was very profitable, and Roundup's success meant Monsanto could afford research into new technologies.

Throughout most of Monsanto's history they considered themselves a chemical company. Most of the individuals who sat on the Board were educated in chemistry or related fields. The corporate story was one of a chemical company that branched out into many different fields. However, this corporate identity was threatened by externalities to their system. During the 1970s the price of oil was steadily rising. The Board of Directors was concerned that Monsanto could be forced out of business unless they changed their business core from Chemical to something else. Due to the long-term future of the agriculture business evidenced by Round-up's success, issues like growing global population, and better distribution technology, Monsanto felt that the agriculture business was the most viable option for its long term success. The chemical business was going to work as a source of funding while these efforts took off.

A widely-circulated internal story typified Monsanto's fear of staying immobile too long. Monsanto looked to the history of the Railroad industry as an example of what can happen if one refuses to change with the time. For Monsanto, the railroad industry was faced with a decision when the automobile and airplane industries began to flourish. It was a definition decision. Was the railroad industry, in the railroading business or in the transportation business? By sticking with the status quo, the railroad industry changed from being near the core of the American Society to fringe existence.

Throughout most of the 1960s and 1970s a researcher working for Monsanto, Earnest Jaworski, had been working, in his spare time, on the notion that the genes of plants could be altered to change the plants characteristics. Jaworski took part in international conferences on the subject and performed work on his own as well. He became convinced that with continued work, man could alter the genetic makeup of plants.

Jaworski made a presentation to the board of directors on his research. He stated that he believed that it was possible to create "new life." In spite of the nearly universal opinion that his task was impossible, Jaworksi argued that the future of agriculture lay in genetic engineering.

To follow his dream, Jaworski assembled a team of scientists from different backgrounds. He started recruiting his team during late 1980 and early 1981. Each team member had a research specialty. The first member to join the team was Robert Fraley. Fraley and Jaworski met in the Boston Airport. Jaworski told Fraley his goal of genetically modifying plants and Monsanto's financial commitment to this research project. Fraley was not immediately sold, but eventually decided to join. "This corporation's decision to make a big bet financially on biotechnology was revolutionary," said Fraley.[2]

The next member to join the team was Stephen Rogers. Rogers graduated from Johns Hopkins University with a doctorate in biology. Jaworski sent Rogers a letter explaining the research project that was beginning at Monsanto. Rogers threw the letter in the garbage, but after some prompting from his wife, he called Jaworski back and was soon part of the team.

The final member of the team, Robert Horsch, was looking for a research career. He was doing post doc research at the University of Saskatchewan. Researchers suggested contacting Jaworski because he had connection to University and supported its programs.

Jaworski's group was first temporarily housed in the new biotechnology laboratories on the fourth floor of "U" Building at Creve Coeur campus in 1981. In the same year his group started with 36 members. Later, they increased to more than 100 people housed in a $150 million modern life-science research center in Chesterfield, Missouri.

Horsch developed his tissue culture techniques. Rogers developed genes that "mark" cells carrying the new DNA. Fraley worked on a means to carry the new gene into the DNA of a plant cell. In 1982, Jaworski's group was able to genetically modify plant cells, petunia and tobacco, for the first time in scientific history. At the Miami Winter Symposium in January of 1983, Horsch announced this success.

In 1985, Monsanto developed tomatoes that were tolerant to Roundup. Their next project was to make plants insect resistant. They did so with the introduction of Bacillus thuringiensis (B.t.) to plant cells. It was then time to focus on the commercial application aspect. Fraley, followed later by 10 of his scientists and Horsch, transferred to the Ag division to build a skill-base and support the applied side of commercializing the crops.

In June 2, 1987, the US Department of Agricultural permitted Monsanto to plant genetically modified tomatoes, the first time these types of plants were to be grown outdoors. This success was followed by the development of soybeans and potatoes resistant to Roundup—such crops were termed Roundup Ready and were a success with U.S. farmers and in a variety of international markets, at least until recently (2000; Cook, 1999; Swallow, 1999)(Stecklow & Moffett, 1999).

In order to recover its large R&D investment in these products, Monsanto used patents and licenses (Kilman, 2000), but also evolved other strategies. One method was to require farmers who purchased their modified seeds to sign a contract that stated that the farmers will not reuse seeds from the plants or trade or sell those seeds to anyone else. The contract also granted Monsanto the right to inspect their property for up to three years afterwards, with or without the farmer's presence, to verify that the contract has not been broken. Farmers purchasing Round-Up Ready herbicide resistant seeds must also promise to use only Round-Up herbicide on their plants (http://www.uaw.org/breaktime/family_values/soybean.html). This was seen by many as an infringement

[2] Unless otherwise noted, quotations and information in this article are from interviews with current or former personnel at Monsanto. We are particularly grateful to Ernest Jaworski, James Trice, Leonard Guarraia and Gary Barton. None of these individuals are responsible for any errors in this document, and the opinions expressed here are ours, not theirs.

on the rights of farmers. Other companies such as Agrevo have opted not to use contracts. In the past, farmers have traded their best seeds with each other, but the new contract would forbid this practice.

Monsanto anticipated difficulties in enforcing their contracts in developing countries where seed trading had always been the common practice. Hence sales to these countries were somewhat limited. The Delta and Pine Land Company developed a potential technical solution to this legal problem. This solution was to add a gene to the seeds that would render them sterile after the first generation, a process for which Delta and Pine Land Company and the USDA had received a joint patent.

The case method involves putting the students into dilemmas faced by companies or individuals. One of the dilemmas we plan to use with students is the issue of whether Monsanto should go forward with what critics have labeled the 'terminator gene.' Monsanto pursued the acquisition of Delta and Pine, then decided against it (Kilman, 1999), even though the USDA is eager to have this technology pursued. Students confronting this set of choices need not follow the company's path—they are encouraged to come up with alternatives.

As Monsantos' genetically-engineered technology spread globally, it attracted more criticism—particularly in Europe, where bio-engineered crops were labeled Frankenfoods" (1999). This criticism has sparked a backlash that has spread to the U.S. and threatens the survival of Monsanto (Barboza, 1999; Stecklow, 1999), which recently merged with Pharmacia. Again, these developments offer students an opportunity to debate the strengths and weaknesses of this new technology, and also the company's strategy for introducing them. Does biotechnology represent the future of global agriculture? If so, Monsanto's failure can be blamed on the company, not the technology (Kilman & Burton, 1999). Are there inherent problems with the technology? Is this an area engineers and scientists should not explore—or explore only after evolving new ethical codes (Markoff, 2000).

We are currently conducting more research into these issues, trying to give the students enough background to understand the choices faced by the company as it tried to come up with new technologies that Shapiro and others believed would both feed the world's population and make agriculture more environmentally sustainable. Graduate students spearhead the research, under joint supervision by faculty from engineering and business, and write cases for use in the undergraduate classroom.

Piloting the cases in engineering classes

Cases are piloted by the graduate students who wrote them. In a recent pilot of the Monsanto case in course on scientific and technological thinking for first-year honors students, one student wrote:

> The ethical dilemma of genetic engineering is important to understand. Manipulating the genetic makeup of crops to apply specific traits such as being resistant to herbicides or having the terminator gene has both its benefits and disadvantages, depending on the perspective. Monsanto is a business so it wants to protect their competitive advantages, which in this case were the genetically engineered seeds. By implanting the terminator gene, the company forces buyers to annually purchase their seeds. By buying the new seeds the company provides the farmers, which a better seed for producing crops. However this is where issues arise. When the farmer does not have the resources to purchase the new seeds, why should the company prevent them from using next generation seeds?

Here the student clearly sees the dilemma from the perspective of the company and one of its major customers, which is a key step in moral imagination. Another student raises the issues of the labeling of genetically modified organisms on a personal level.

> I had no idea before I read this article and after today's discussion that genetically altered plants were being sold in the stores and that most likely, I've already eaten some of them. It's pretty scary because they aren't labeled and I really had no idea.

This student has personalized the issue, which can also be a step towards seeing the perspective of multiple stakeholders. If an engineering student is taken aback by having unwittingly eaten genetically-modified food, how will the average consumer feel? We asked students in this first-year engineering class whether they would want GMO seeds labeled. About a third said yes, sparking a vigorous debate.

Case studies that are on the cutting edge of the current social and political issues serve not only to help the student gain skill in how to deal with obtuse situations, but also educate them in them. Class discussion can be lively and heartfelt as students are not only role playing but also dealing with the issues on a personal level. This is why we require the students to keep journals in which they reflect on the cases. These journals serve the dual purpose of letting us see what the student thought about the case and reading their suggestions for improvement. Journals also give the students a space for reflecting on issues discussed in class.

In a course that uses multiple cases through out the semester is that the students begin to create their own heuristics for solving these issues. Students often remark about how case studies "get easier" through out the year. In reality, the student learns how to "do" case studies. By the end of the semester they have new eyes with which to look at problems. They can see multiple perspective and realize that any good solution will take into account the point of view of all stakeholders. No longer do they feel that one can judge the success of a project by the only the bottom line or only on the production outcome. They realize that engineering is more than just numbers, that it is rich in human concerns and ethics.

Additional cases available to us help do more than instruct students on moral imagination. These cases highlight ways for the student to avoid compartmentalizing their actions. For example, our environmental fabric case asks the students to vote on design alternatives from the standpoint of one of the global team members, and also from their own perspective as students (Gorman et al., 2000). The students themselves introduced another dichotomy, between what they would do as people and as engineers. The irony is striking, and sparks a vigorous debate.

The Monsanto case forces students to consider the implications of continuing increases in global population, at least for the next several decades, and the concomitant reduction in arable land. Are genetically-modified seeds the answer? . When the Monsanto case is completed, we intend to ask students to vote on a variety of GMO options both as Monsanto engineers and as themselves. Will they see their personal ethics as different from their professional ones?

As part of teaching the case, we will expose students to the critics of GMOs. Students need to exercise moral imagination and see the problem both from Monsanto's perspective and from the perspective of critics. Garrett Hardin and others argue in favor of global population control (Hardin, 1993). Nobel Laureate Amartya Sen and others maintain that increasing educational opportunities and empowerment for women will stabilize global population (Sen, September 22, 1994). Monsanto's Robert Shapiro wants to introduce a new chapter in the green revolution by turning to biotechnology, so that if population continues to grow, there will be enough food. Engineering students need to understand global problems like increasing populations and consider whether technological solutions represent appropriate responses and, if so, what technologies should be considered.

The Monsanto case also raises the issue of the control of nature to its highest level, because GMOs involve the conscious control of the process of evolution itself. In any kind of highly complex system, there will be unexpected events (Perrow, 1984)—like rapid adaptation of pests to genetic modifications. Ultimately, genetic engineering and organic farming may need each other. If there are organic alternatives, then the world is not totally dependent on a technology that may have unanticipated consequences. Pests, for example, will still have organic plants to feed on, slowing their adaptation to GMOs. For the organic farmer, GMOs provide an alternative to feeding the global population. The two approaches may even be integrated, at some future date.

Case studies give students real world examples of engineers that tried to benefit the world and their own careers while making their companies more profitable. Not all these attempts succeed, and there are often trade-offs. The traditional, short term bottom line is rarely a winner in these cases; companies like Monsanto and Unilever see long-term benefits in novel approaches to global food shortages. In the long-term, if there are too many people and not enough food, the companies that produce the food could be in a position to make huge profits, but at a hideous social cost. We believe that the real world case study format is the strongest most effective method for helping students learn the importance of imagining better futures, and for practical lessons on how to reach noble goals.

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