Collaborative Teaching of a Course on Technology, Society, and the Natural Environment

Douglas Tougaw and Dean M. Schroeder

Department of Electrical and Computer Engineering, Valparaiso University / College of Business Administration, Valparaiso University

1. Introduction

For most of the twentieth century, engineering educators in the United States focused largely on developing the technical expertise of their students. Little attention was paid to non-technical design constraints, nor to complexities that arise at the boundary between two disciplines. This strategy was enormously successful for many years, but changing technological and global competitive realities make such a limited approach no longer appropriate. With the emerging need for multidisciplinary teams, non-technical design constraints, and the ethical implications of engineering projects, it has become evident that engineers must understand and consider the larger context of their work and have the knowledge and attitudes necessary to foresee the potential impact of their work on society and the natural environment.[1] Achieving this important goal begins with the way we educate our students. The question is how can we go about doing this?

The authors of this paper found useful insights into this question from an unlikely source – a graduate program in business. We share some of the lessons we learned that can help others when identifying ways to give our engineering students some of the non-technical skills and perspective they will need to succeed in an increasingly complex world.

2. The Valpo MBA Program

The Master's of Business Administration (MBA) program at Valparaiso University is uniquely positioned to offer us some interesting insights for engineering education. Before this three-year-old degree program was designed, extensive discussions were held with and input sought from both industry leaders and other academic units within the university. The MBA program development team operated with a mandate to make the program a "university" program by forging synergistic linkages to other units on campus – particularly engineering and law. Since the program director had an undergraduate degree in engineering and industry experience managing production facilities, and several of the key program donors were business leaders with strong engineering backgrounds, technology issues and engineering linkages were considered when designing the program. The result was a recasting of a traditional MBA program to emphasize three core principles:[2]

- Values-based leadership
- Environmental stewardship
- Managing with technology

As a result of these emphases, the Valpo MBA program has been very successful at attracting engineering graduates to the program, with as many as half of the students in many classes having an engineering or technical background.

The MBA curriculum is broken into three sections. Up to 14 credits of foundation courses are required for students without a business background, followed by 26 credits of core courses taken by every students in the program, and finally 12 credits of electives chosen to complement the particular student's interests and career needs. The following three courses provide an introduction to values-based leadership, environmental stewardship, and managing with technology:

- MBA 601 (2 credits) Business, Technology, and the Natural Environment
- MBA 602 (1 credit) Managing Technology and the Natural Environment I
- MBA 603 (1 credit) Managing Technology and the Natural Environment II

These courses form the "core of the core," giving students the knowledge and attitudes they need to succeed in future core courses and enhancement electives.

Students in MBA 601 are introduced to topics related to business as a contemporary social institution. Emphasis is placed on the role of business in modern society, ethical frameworks for business decision making, the perils and promises of new technology, sustainable business and the natural environment, issues of social and economic justice, and values based leadership. It is in this course that students come to see that "business ethics" is not an oxymoron, and that there are many reasons to consider issues of corporate social responsibility and sustainability when making a technical decision. The choice of technologies to pursue is examined as a long-term values-based decision, rather than a solely short-term economic one.

MBA 602 and 603 are a pair of courses that together expand on the lessons learned in MBA 601. Whereas MBA 601 opens the students' eyes and adjusts their attitudes, MBA 602 gives them a firm intellectual framework in the areas of technology and the natural environment. MBA 603 then follows up this more general and academic discussion with concrete examples, requiring working students to write a technology plan and an environmental management plan for their company, or full-time students to draft such plans for a selected local company.

Since the MBA program is run on seven-week terms, most students will see all three of these courses within their first six months as part of the program. They are first introduced to new ideas and new ways of thinking about these issues (MBA 601), then they are given the theoretical tools to understand these issues (MBA 602), and finally they are asked to apply those tools in order to create specific and useful plans for a real-world company (MBA 603).

The multidisciplinary nature of these courses is one of the main reasons why they are beneficial to the students, but it also makes them extraordinarily challenging for one person to teach. During the 2004-2005 academic year, they are being taught by the two authors of this paper. Dr. Tougaw is an electrical engineering professor with research expertise in the area of nanotechnology and is chair of the Electrical and Computer Engineering Department, while Dr. Schroeder is an expert in the area of strategic management and managing change, and is also the Director of the MBA Program. Dr. Tougaw taught MBA 602 in the fall semester with help and guidance from Dr. Schroeder, who then taught MBA 603 in the spring semester with help and guidance from Dr. Tougaw. In this paper, we will focus on the content, structure, and assessment of the second of these courses, which was taught in the fall semester of 2004. We will also share a few lessons that engineering programs can barrow from the overall program.

3. MBA 602: Managing Technology and the Natural Environment

The goal in teaching MBA 602 was to provide students with a theoretical framework for understanding the appropriate way to make complex decisions involving people, technology, society, and the natural environment. Specifically, the following learning objectives were used for this course:

After successfully completing this course, students should be able to:

1. Explain the reasons for long-wave patterns in technology development and dissemination and how they impact economic patterns.
2. Describe the different phases of the S-curve and explain the forces that cause them.
3. Explain how attributes of innovation affect their rate of adoption.
4. Describe the major technology adoption strategies and the characteristics of those who employ each.
5. Explain the difference between destructive and reinforcing innovations.
6. Explain the reasons why individuals and groups may act to prevent change.
7. Describe the three main strategies for overcoming resistance to change.
8. Summarize the historical development of domestic and global environmental regulation.
9. Explain the three pillars of sustainability: economic impact, environmental impact, and social impact.
10. Give examples of the three major reasons to establish a proactive environmental policy: Risk Management, Competitive Advantage, and Corporate Social Responsibility.

As can be seen from these learning objectives, students in this class were exposed to a variety of issues related to the use of technology in a corporate setting.

By helping students to understand the social and economic forces that lead to technology discontinuities, the goal of the course was to help them to make better decisions that will benefit their company, its stakeholders, and society as a whole. In particular, reading assignments and discussions supporting the first three objectives addressed issues of long-term technological change,[3] the life cycle of a particular technological innovation,[4] and the adoption or rejection of new technologies by consumers. [5]

From the perspective of a customer, it is important to understand when a new technology should be adopted. Class readings and discussions focused on developing a decision-making framework that would help students to understand the correct timing of such decisions.[6]

At every opportunity, an emphasis was placed on studying these issues in the light of values-based and ethical decision-making. For example, when the class studied destructive innovations and resistance to change,[7-9] an historical perspective was presented, showing how every new technology displaces people whose livelihood was tied to the obsolete technology. From saboteurs and Luddites in the nineteenth century to steelworkers in the twentieth century, students were asked to consider the impact of their "technical" decisions on real people with real families to care for.

Ethical and political issues also dominated during the discussion of environmental regulation,[10] but a larger context to these decisions was presented by discussing the three pillars of sustainability, which requires a balanced consideration of the environmental, economic, and social demands on each technical project.[11-12] Furthermore, the class discussed a number of benefits to the development of a comprehensive and proactive environmental management system, which helped to demonstrate to the students that treating the natural environment with respect would also provide financial benefits to their companies.

Finally, the class studied the purely ethical aspects of engineering projects and whether there are any subjects that simply should not be studied and developed.[13] By interspersing readings and discussions on topics of technology management, sustainability, and ethics, the class was able to see how these three critically important topics are integrally tied together in the values-based decision-making process of a modern manager.

4. Outcomes and Assessment of MBA 602

The course evaluations for MBA 602 demonstrated that students found the efforts in the course to be highly successful. Students were asked to respond to each of 27 questions on a five-point Likert scale, and then weighted averages were calculated for each question. Thus, student responses could range from a one (being very negative) to a five (being very positive). Among these 27 questions, students were asked to perform a self-assessment of their achievement of each of the course learning objectives. The results of these questions are summarized below:

1. Can you explain the reasons for long-wave patterns in technology development and dissemination and how they impact economic patterns?
Response: 4.43 / 5.0

2. Can you describe the different phases of the S-curve and explain the forces that cause them?
Response: 4.78 / 5.0

3. Can you explain how attributes of innovation affect their rate of adoption?
Response: 4.48 / 5.0

4. Can you describe the major technology adoption strategies and the characteristics of those who employ each?
Response: 4.63 / 5.0

5. Can you explain the difference between destructive and reinforcing innovations?
Response: 4.67 / 5.0

6. Can you explain the reasons why individuals and groups may act to prevent change?
Response: 4.67 / 5.0

7. Can you describe the three main strategies for overcoming resistance to change?
Response: 4.64 / 5.0

8. Can you summarize the historical development of domestic and global environmental regulation?
Response: 4.30 / 5.0

9. Can you explain the three pillars of sustainability: economic impact, environmental impact, and social impact?
Response: 4.81 / 5.0

10. Can you give examples of the three major reasons to establish a proactive environmental policy: Risk Management, Competitive Advantage, and Corporate Social Responsibility?
Response: 4.78 / 5.0

The overall average student self-assessment on the learning objectives for this course was 4.61/5.0, which exceeded the average score achieved by the same instructor in his electrical engineering courses. This result demonstrates that students at least perceived that they had developed the skills and attitudes necessary to accomplish the learning objectives of the course.

In addition to these ten questions, more general questions were asked about the course structure, content, and administration. Two of these questions yielded particularly interesting results:

11. Did you benefit from having this course taught by an instructor whose primary expertise is in a technical field?
Response: 4.67 / 5.0

12. Do you feel better prepared to help your employer in making environmentally friendly technology and management decisions?
Response: 4.58 / 5.0

The results of these assessments demonstrated that the multidisciplinary approach to teaching this course was effective, and that the MBA students felt that they had actively benefited from taking a course taught by an engineering professor. The final question encapsulated the overall mission of the course, which was to provide students with an intellectual framework within which they could make effective and thoughtful decisions that would benefit their own company as well as society.

5. Key Take-Aways

The lessons we learned by team-teaching this course are not unique, but the way they were applied in this course is novel, and this experience can provide insights.

- **Use multi-disciplinary teams – both students *and* instructors**

Calling for the use of multi-disciplinary teams of engineering students is certainly nothing new. However, what we found to be critical is to "practice what we teach." At the most basic level MBA 602 and 603 were richly enhanced by the combination of both engineering and business professors. A Ph.D. provides, by definition, a narrow focus of expertise. To expose students to a breadth of expertise, we need to team up with colleagues.

Perhaps the most radical, and effective, example of this in the Valpo MBA program is found in MBA 604, Contemporary Legal Issues. The course is administered by a business professor who has a law degree, but the course content is delivered by about a dozen guest lecturers – each talking about his or her area of expertise – from the Valpo School of Law. The advantage of this approach extends beyond students learning from topic experts. The exposure to so many different lawyers in-and-of-itself has benefits, since students gain important experience in working with and speaking to a variety of different legal experts with different personalities and different areas of expertise.

- **Use outside experts**

Guest speakers are certainly nothing new. But in multi-disciplinary, non-technical courses, outside experts with hands-on experience play critical roles beyond their knowledge. They bring reality into the classroom and legitimize the material being taught. Unfortunately, in our narrow technical teaching environment, students often get a bit of disciplinary arrogance, believing that engineering is a much more difficult (and, therefore, more worthy) discipline than any other. Good outside speakers can do a lot to change this attitude by broadening our students' experiences.

- **Use real-world *student-driven* examples**

Few of us challenge the need for good real-world examples in our teaching. But a technique we find very helpful is to have the students find the examples and report on them in class. This has the effect of forcing students to think about the lesson thoroughly, and the examples are more personal and meaningful. Learning takes place both while searching for the examples and when explaining them in class.

- **Prepare to "learn by doing" – both students *and* instructors**

Action learning, or learning by doing, has always proven to be the most effective learning technique. But here again, we must practice what we teach. We must assure we rapidly integrate the learning we do teaching the course in course refinements. All too often, the difficulty (political and bureaucratic) of curricular reforms limits our ability (either in real of psychological terms) to make easy adjustments. When heading into an area where we have little experience, flexibility to adjust is critical.

6. The Next Step: Integrating Business into the College of Engineering

We have integrated engineers and lawyers into the teaching team of the MBA program. Our next logical step is to follow our own advice, introducing multi-disciplinary team-taught non-technical skills classes into our engineering program. Here we are looking at following the same design that our MBA program used with its law class. One of our professors with an MBA, in addition to his doctorate in engineering, will administer a class that is largely taught by guest professors from the business school. Here again, the advantage is not simply in bringing in high-powered content experts, but in the alternative perspectives they will bring into the engineering school and present to our students.

7. Conclusions

The lessons learned by teaching this MBA course to a class composed largely of engineering graduates are directly applicable to the education of undergraduate engineering students. It is assumed that such students are being provided with the technical knowledge necessary to do their jobs effectively; technical competence is the pre-requisite of ethical behavior. However, what this experience shows is that students can also be presented with an effective intellectual framework that can be used to grasp the larger societal and environmental context of their "technical" decisions.

Engineering students should be introduced to the concepts of sustainability, socio-political design constraints, and the effect of technological discontinuities on individuals and societies early in their academic careers. These issues should be addressed in courses throughout the curriculum, culminating in their major design experience. Students should routinely ask themselves not only "How can we do that?" but also "Should we do that?" Doing so will help prepare our students for a complex world in which many different design constraints affect every project, and it will make their academic experience richer and more directly applicable to the corporate world they will face upon graduation.

References

1. See, for example, the most recent Engineering Criteria required by the Accreditation Board for Engineering and Technology (ABET): http://www.abet.org/criteria_eac.html.

2. http://www.valpo.edu/cba/mba/program.php

3. R. U. Ayres, "Technological Transformations and Long Waves, Part I," *Technological Forecasting and Social Change*, vol. 37, pp. 1-37.

4. P. Anderson and M. L. Tushman, "Managing Through Cycles of Technological Change," *Research/Technology Management*, May/June 1991, pp. 26-31.

5. E.M. Rogers, *Diffusion of Innovations*, The Free Press, 1995.

6. R. N. Foster, "Timing Technological Transitions," in *Technology in the Modern Corporation: A Strategic Perspective*, M. Horwitch (ed.), Pergamon Press, Inc.

7. D. Klein, "Some Notes on the Dynamics of Resistance to Change," in W. Bennis, K. Benne & R. Chin (eds.), *The Planning of Change* (pp. 498-507). New York: Holt, Rinehart and Winston, Inc.

8. R. Chin and K. Benne, "General Strategies for Efecting Changes in Human Systems," in W. Bennis, K. Benne & R. Chin (eds.), *The Planning of Change* (pp. 111-132). New York: Holt, Rinehart and Winston, Inc.

9. S. Zuboff, "Automate/Informate: The Two Faces of Intelligent Technology," *Organizational Dynamics*, vol. 13, pp. 5-18.

10. http://www.epa.gov/ocfo/finstatement/2000ar/ar00_3dec.pdf

11. http://www.evc-int.com/she/understandingsust.htm

12. D. Tschopp, "It's Time for Triple Bottom Line Reporting," *The CPA Journal*, vol. 73, p. 11.

13. B. Joy, "Why the Future Doesn't Need Us," *Wired* Magazine, April 2000.

DOUGLAS TOUGAW is the Leitha and Willard Richardson Professor of Engineering and Department Chair of Electrical and Computer Engineering at Valparaiso University.

DEAN M. SCHROEDER is the Herbert and Agnes Schulz Professor of Management and Director of the MBA Program at Valparaiso University.