

# Preliminary Survey of Teaching Engineering Ethics

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## ABSTRACT

Engineering ethics has recently been formalized in engineering programs across the country. This paper reports a preliminary survey of how various schools handle the subject, what books are currently available, and how we experimented with the integration of engineering ethics into our existing philosophy course entitled "Technology and Human Values."

## INTRODUCTION

The engineering profession, and society in general, are becoming more attentive to the questions of ethical and moral decision-making as technology becomes more complex and pervasive in our society. Regional and specialized accreditation agencies are demanding more than technical competence of baccalaureate graduates. The Accreditation Board for Engineering and Technology (ABET)<sup>1</sup> requires that engineering graduates have "an understanding of professional and ethical responsibility ... an ability to communicate effectively, and ... the broad education necessary to understand the impact of engineering solutions in a global and societal context." Engineering licensing boards for the various states are also increasingly demanding of ethical practices among registered professional engineers. The National Society of Professional Engineers (NSPE) recently proposed a new model code<sup>2</sup> for professional registration. This model proposes a new Professional Licensing Exam, which would focus on codes, standards, ethics, and professional practice issues, rather than on technical material.

Christian Brothers University does not formally require instruction in engineering ethics in our current curriculum. Individual faculty members may include topics in engineering ethics from time to time in some courses. The first author was often invited to talk to various engineering classes on the subject. For instance, topics in engineering ethics have been addressed in some of the departmental capstone design courses. From time to time ethical issues have been included in the junior level course Economic Factors in Design.

The CBU School of Engineering relies primarily on the General Education Requirements to ensure that students have "an understanding of professional and ethical responsibility ... an ability to communicate effectively, ... and the broad education necessary to understand the impact of engineering solutions in a global and societal context." The distribution requirements consist of 6 hours of English composition and 18 credits in liberal studies, i.e., Social Studies (6 credits), Religion (6 credits), Moral Values (3 credits), and English Literature (3 credits). Students, with approval from their advisors, select courses from a list of those approved by the curriculum committee<sup>3</sup> in each of these areas. These are typically introductory courses proposed by the various departments for General Education Credit.

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<sup>1</sup> *Criteria for Accrediting Engineering Programs*, 2001-2002 Accreditation Cycle, Engineering Accreditation Commission, Accreditation Board for Engineering and Technology, Inc., November 1, 2000. The latest version is found at <http://abet.org/criteria.html>.

<sup>2</sup> *NSPE Engineering Education/Licensure Model, Frequently Asked Questions (FAQ)*, National Society of Professional Engineers. Information was viewed from <http://www.nspe.org/lc1-q&a.asp> on December 21, 2001.

<sup>3</sup> *2001-2002 Catalog*, Christian Brothers University, Memphis, TN, 2000.

In the fall of 2001, the School of Engineering acknowledged that this elective system was an unsatisfactory way to address the issues raised by ABET. We strongly feel the need to put more emphasis on engineering ethics in our programs. Many options are being tested by various institutions: stand-alone courses in philosophy or engineering, modules in technical or professional courses, and distribution across the curriculum. Before choosing a direction to take, we decided to survey a number of programs, mostly at Catholic institutions, and to examine available textbooks. Parallel to this study, we conducted a pilot project modifying the content of one of the moral values courses PHIL 324 to encompass engineering ethics. The course was team-taught by the first and second authors of this paper in spring 2002.

## SURVEY OF ENGINEERING ETHICS

Our initial survey covers four non-Catholic institutions and seventeen Catholic institutions. Thirteen of the twenty-one responded, as shown in Appendix A. Among those without an engineering ethics course, two institutions offer only general ethics courses, while three others claim to integrate engineering ethics in other engineering courses, including freshman-level introduction to engineering courses and senior-level capstone design courses. Among those with an engineering ethics course, the philosophy or religion departments at six institutions offer such a course, while the engineering departments offer the course at only two institutions.

These responses show the broad diversity of approaches to the problem of teaching ethical problem-solving to undergraduate engineering students.

## ENGINEERING ETHICS TEXTBOOKS

Through the 1960's and early 70's, most serious texts in engineering ethics were in the form of readings in technology and society. These texts collected papers on themes around technology and values from a variety of perspectives and left the interpretation to the readers. An early example of such an approach was *Technology and the Future*<sup>4</sup>, by Albert Teich. First published in 1972 as *Technology and Man's Future*, the book is now in its 8<sup>th</sup> edition. The author, director of Science and Policy Programs at the American Association for the Advancement of Science, has repeatedly revised the choice of selections to reflect current issues concerning the social and ethical implications of technology. The second author used this text for a number of years in an earlier version of PHIL 324, then called "Society and Technology."

A more recent example of such an approach is *Society, Ethics, and Technology*<sup>5</sup> by Winston and Edelbach. The text was influenced by ideas developed by the vigorous "Science, Technology, and Society" (STS) movement under the auspices of the National Association for Science, Technology, and Society (NASTS), and the New Liberal Arts (NLA) program that was sponsored during the 1980's through grants from the Sloan Foundation. The book has an introductory essay written for this text, which outlines the authors' ethical framework. Thirty essays from the literature follow, organized in two parts with sections within each part. Part I, Perspectives on Technological Society, has sections on Historical Perspectives; Social Perspectives; and Philosophical Perspectives. Part II, Contemporary Technologies and the Future, has sections on Information, Automation, and the Global Economy; Computers, Communications, and Robotics; Biotechnology and Human Reproduction; and Population, Energy, and Environmental Policy. Each essay is introduced by a summary of the paper, focus questions, and keywords. Interpretation can best be accomplished in an interactive discussion format. Despite its title, the text does not focus on "ethics" in the traditional sense but on the broader social and value implications of technology. Some readings are difficult and/or controversial. It includes both "optimistic" and "pessimistic" perspectives on technology.

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<sup>4</sup> A.G. Teich, *Technology and the Future, Eighth Edition* (Belmont, CA: Wadsworth, 1999).

<sup>5</sup> M. E. Winston and R. D. Edelbach, *Society, Ethics, and Technology* (Belmont, CA: Wadsworth, 2000).

An anthology that focuses more clearly on ethics is *Ethical Issues in Engineering*<sup>6</sup>, edited by Deborah Johnson, a philosopher who taught for many years at Rensselaer Polytechnic Institute. Ms. Johnson now holds the position of Chair of Applied Ethics in the Division of Technology, Culture, and Communications at the University of Virginia. This book includes more than thirty selections on such topics as the historical and social context of engineering, the role of professional codes of ethics, the engineer's responsibilities to society, obligations to employers and clients, and proposals for changing engineering. The authors contribute brief introductions to the various sections.

In the middle of the 1970's, philosophers found a fertile field for study in issues associated with engineering and applied sciences. Technology was expanding at a rapid rate, and our inability to answer the questions arising from this rapid expansion led to the National Project on Philosophy and Engineering Ethics, directed by Robert J. Baum. Prompted by the questions raised, the National Endowment for the Humanities funded a program in which engineers could learn about academic ethical theory; philosophers could learn more about engineering; and philosopher-engineer teams would develop ethics projects of various sorts<sup>7</sup>. *Ethics in Engineering*<sup>8</sup> by Martin and Schinzinger is one text that grew out of that effort. Mike Martin is a philosopher, and Roland Schinzinger is an electrical engineer with extensive practical experience before joining the faculty of the University of California at Irvine. They participated in a project between 1978 and 1980 when both were on the faculty at UC Irvine. Now in its third edition, the text was first published in 1983. It is written as a textbook for a typical three-hour course. However, it can be used in modular form to emphasize engineering applications as parts of courses in engineering, philosophy, business, or the social sciences. It integrates professionalism and general ethical theory with problems that arise in the practice of engineering. It emphasizes virtue ethics and includes material on duties, rights, and social utility. Problems addressed include safety, workplace issues, the global context, and various non-technical roles of engineers. In 2000 the authors published a shortened version of the text, covering most of the same topics in somewhat less detail, under the title *Introduction to Engineering Ethics*<sup>9</sup>.

*Engineering Ethics: Concepts and Cases*<sup>10</sup> by Harris, Pritchard, and Rabins is a slightly different approach growing out of collaboration among Charles Harris, a philosophy professor with a B.A. in biology and chemistry; Michael Pritchard, a philosophy professor with a traditional liberal arts background; and Michael Rabins, a mechanical engineering professor with specialties in control system design and engineering ethics. The text is in its second edition with the first published in 1994. The emphasis is on ethical or moral decision-making, i.e., doing the right thing. There is less emphasis on the judgment of the behavior of others. The philosophical approaches include utilitarianism and respect for others. Responsibility and virtue theory also come into play. This book is organized into three parts: Critical Approaches, Generic Concerns, and Special Topics. Cases permeate the material and form the primary structure for teaching and learning moral problem-solving. Codes of ethics figure prominently.

Caroline Whitbeck wrote *Ethics in Engineering Practice and Research*<sup>11</sup> in 1998. Dr. Whitbeck holds a PhD in philosophy from the Massachusetts Institute of Technology and currently teaches philosophy and directs the Online Ethics Center for Engineering and Science at Case Western Reserve University. This text has an extensive introduction to ethical concepts or theories. The focus is on ethical decision-making and moral action, i.e., the engineer as a responsible actor rather than judge. Cases are used sparingly to show examples of good or bad decisions and actions. Open-ended scenarios and case studies provide practice in recognizing and addressing ethical issues. An important analogy used throughout the book is drawn between non-trivial moral problems and non-trivial engineering design problems. The Online Ethics

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<sup>6</sup> D.G. Johnson, *Ethical Issues in Engineering* (Englewood Cliffs, NJ: Prentice-Hall, 1998).

<sup>7</sup> P.T. Durbin, *Activist Philosophy of Technology Essays 1989-99*, Chapter VI at <http://www.udel.edu/Philosophy/pdurbin/Contents.html>.

<sup>8</sup> M. W. Martin and R. Schinzinger, *Ethics in Engineering, Third Edition* (New York: McGraw-Hill, 1996).

<sup>9</sup> M.W. Martin and R. Schinzinger, *Introduction to Engineering Ethics* (New York: McGraw-Hill, 2000).

<sup>10</sup> C. E. Harris, Jr., M. S. Pritchard, and M. J. Rabins, *Engineering Ethics: Concepts and Cases* (Belmont, CA: Wadsworth, 2000).

<sup>11</sup> C. Whitbeck, *Ethics in Engineering Practice and Research* (Cambridge: Cambridge University Press, 1998).

Center (<http://onlineethics.org>) also provides a significant Web resource for teaching engineering ethics, with an extensive selection of case studies, some quite detailed, as well as a selection of codes of ethics and other materials.

## PILOT STUDY

Christian Brothers University conducted a pilot project on engineering ethics during the spring semester of 2001-2002. The School of Engineering, working with the School of Liberal Arts, used the current general education structure to put together an engineering ethics experience for students. This approach had the advantage of getting an experiment online quickly. Compromises were necessary because the course had to meet the general education requirements at the University.

All students at the University are required to take two religion courses and one moral values course as part of the general education requirements. Among the eleven courses approved for moral values credit is PHIL 324, Technology and Human Values.

### PHIL 324. TECHNOLOGY AND HUMAN VALUES

A philosophical examination of social and ethical issues relating to technology. Topics include the ethical responsibilities of engineers; ethical and social issues associated with risk assessment, environment and resources, and technology in a global context; and the impact of modern technology on human values. Prerequisite: Junior standing. One semester; three credits.

A predecessor to this course, then called "Society and Technology" was first taught by the second author in the late 1970's. The course, which for several years was team-taught with an engineering professor, now deceased, was reworked a number of years ago and retitled "Technology and Human Values" to more clearly reflect its status as a philosophy course meeting the university "moral values" general education requirement. The first two authors collaborated on a new version of the course, team-taught in the spring semester of 2002. Since this is an approved general education course, it could not stray significantly from its original description and purpose. In particular, it had to include significant material on general ethical concepts as well as particular issues arising from technology. The Whitbeck text, *Ethics in Engineering Practice and Research*, was chosen because of the problem-solving perspective of the author and the extensive introduction to ethical concepts. The relationship between moral problem-solving and engineering design was a useful metaphor to exploit in teaching moral problem-solving. The readers were most often put in the role of moral agents rather than moral judges and cases were used to demonstrate good or not so good moral action. A second book of readings, *Society, Ethics, and Technology* by Winston and Edelbach, was also required. Selected readings were assigned to supplement the understanding of modern issues involving technology and society. Other materials such as videotapes, original sources, and the Internet were also used as appropriate. The syllabus is included in Appendix B.

Most of the material for the texts was presented by the traditional lecture and discussion method with the two teachers taking the lead in turns. The class was small enough (14 students) that there was ample opportunity to address the issues. To explore the relationship between moral problem-solving and engineering design, student teams designed and built chairs out of paper products that could support 250 pounds. They wrote a design report in the usual manner, adding material investigating how engineering design relates to moral problem-solving.

Students discussed the Challenger disaster, the Citicorp Tower, and the Bhopal incident to determine the limits of responsible engineering practice. The video, *Gilbane Gold*, was used in a class exercise where the students identified ethical concepts and optional behavior at several points during the development of the story. A guest lecturer conducted a problem-solving exercise involving a water quality problem. This exercise emphasized data interpretation and problem identification from an environmental standpoint. All of these exercises emphasized moral problem-solving rather than the moral judgment of the actors.

Students wrote a midterm and a final exam in the usual short answer/essay format. There was also a short case study on the final. In addition, students were graded on the design report, in-class participation, discussion of one case study, and a term paper.

## **DISCUSSION & CONCLUSION**

While the engineering profession, and society in general, are becoming more concerned about moral and ethical education, clearly no preferred solution has come into focus. As with any nontrivial design problem, a variety of approaches to the problem are possible, with each approach having a different advantage. An assortment of texts exists to support a wide variety of these approaches. The shape of the solution depends on the constraints. In this case, that means the solution applied in a particular situation depends on the aims and objectives of the institution that are consistent with the aims and objectives of the profession and society in general. This pilot study combined engineering ethics demands with the requirements of general education at the University.

The collaboration between the first two authors in teaching PHIL 324 was fruitful for both parties. Not only did each author learn specific things about the other's areas of expertise, but they also gained a greater appreciation for the different perspectives that engineers and philosophers bring to ethical issues and ethical problem-solving. (It should be stressed, however, that both individuals had a fairly extensive prior background in the area of engineering ethics. The engineer had made presentations on ethics in various engineering courses, and the philosopher had been involved in the study of engineering ethics for over two decades and taught an ethics module in the university's engineering management graduate program.)

The background of students taking the course was also diverse, with eight majoring in engineering and six (including one auditor) majoring in diverse areas including computer science, physics, biology, psychology, and religion/philosophy. This diversity had the advantage of providing a variety of perspectives in class discussion (though not all students participated). It also meant that in most cases, teams for the design project involved the collaboration of engineering and non-engineering students. However, this also created somewhat of a challenge in teaching the course in that it was sometimes difficult to focus on ethical issues that engineers confront in their professional practice, while still making the material relevant to non-engineering students. It is important, for this and other reasons, to stress the broader context of engineering as the source of those technological developments that affect all elements of modern society and raise ethical issues with which all members of that society must deal.

## AUTHORS

### Fred Terry

**Fred Terry** received his Ph.D. in Biomedical Engineering from the Case Institute of Technology in 1967. He is a registered professional engineer in Tennessee. He is on the Board of Directors of the Memphis Engineers' Club. His areas of expertise include electric circuits, electromagnetics, energy conversion, fiber optics, and electromagnetic interaction with the human body. Other interests include undergraduate education, design, electrical safety, and engineering ethics. He team-taught a moral values course with a philosophy professor in spring 2002. Engineering ethics is part of the course. He can be reached at [fterry@cbu.edu](mailto:fterry@cbu.edu).

### Peter Limper

Peter Limper is Professor of Philosophy and former Dean of the School of Liberal Arts at Christian Brothers University. He received his Ph.D. in philosophy from Yale University in 1975. His interest in engineering ethics and the philosophy of technology dates from the 1970's, and he is the author of several papers on the philosophical, ethical, and social implications of technology. He can be reached at [plimper@cbu.edu](mailto:plimper@cbu.edu).

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**Siripong Malasri** is Professor and Dean of Engineering at Christian Brothers University. His interests include structural engineering and computer applications. Dr. Malasri serves on editorial boards for the *International Journal of Engineering Education* and the *Journal of Professional Issues in Engineering Education and Practice*. He is also a member of the TSPE/CET Blue Ribbon Committee. The group has provided recommendations to the TN A&E Board on various professional registration issues. Dr. Malasri, PhD in Civil Engineering from Texas A&M University in 1981, is a registered professional engineer in Florida and Tennessee. He can be reached via email at [pong@cbu.edu](mailto:pong@cbu.edu).

## APPENDIX A

Table 1. Survey Result Summary

Institution	How	Course Description
1. Stony Brook University (Stony Brook, NY)	No specific engineering ethics course but integrates the subject throughout all courses	N.A.
2. Texas A&M University (College Station, TX)	Required	ENGR 482 or PHIL 482, Ethics & Engineering, team-taught. Development of techniques of moral analysis and their application to ethical problems encountered by engineers, such as professional employee rights and whistle blowing; environmental issues; ethical aspects of safety, risk and liability and conflicts of interest ; emphasis on developing the capacity of independent ethical analysis or real and hypothetical cases. Prerequisite: Junior classification. 3 Credits, 2 lectures, 1 discussion.
3. Catholic University of America (Washington, D.C.)	An engineering ethics course offered by Philosophy Department	PHIL 362: Prof Ethics in Engineering An examination of professional activity as essentially related to human fulfillment, both personal and social. Also uses case studies, standards for good judgment in matters specific to engineering, including risk assessment, whistle blowing, and environmental protection. Offered only for juniors and seniors in the School of Engineering. 3 Credits
4. Gannon University (Erie, PA)	No specific engineering ethics course but covers the subject as part of Intro to Engineering course and capstone design course	N.A.
5. Gonzaga University (Spokane, WA)	Addresses engineering ethics in a philosophy course entitled "Social, Political, Legal and Economic Aspects of Engineering Profession."	N.A.
6. Loyola College (Baltimore, MD)	No specific engineering ethics course but includes, wherever possible, examples and training in ethics in engineering. This is a topical area in senior design course.	N.A.
7. Manhattan College (Riverdale, NY)	An "Engineering Ethics" course offered by the religion department. This course is among several other ethics courses, such as "Business Ethics," "Computers, Ethics, and Technology," and "Ethics in the Workplace."	N.A.
8. St. Louis University (St. Louis, MO)	An "Engineering Ethics" course offered by the philosophy department. Some engineering departments require this course.	N.A.
9. Seattle University (Seattle, WA)	No specific engineering ethics course but requires a general ethics course and addresses engineering ethics in senior design classes.	N.A.
10. University of Dayton (Dayton, OH)	An engineering ethics course offered by Philosophy Department	PHL 316 Engineering Ethics Introduction to ethical issues in engineering by developing theories or moral justification and codes of ethics for engineers, and by applying these theories and codes to moral issues in engineering.
11. University of Detroit Mercy (Detroit, MI)	An engineering ethics course offered by engineering but taught by two Jesuit priests with PhD's in the history of technology.	E 100. 2-3-0 Ethics and Politics of Engineering This course introduces engineering students to the ethical dimensions of their profession and to the interrelations of engineering projects and society. It describes the impact of technological systems on culture, especially American culture, and reactions of our culture to technology.
12. University of St. Thomas (Minneapolis/	No specific engineering ethics course. Students take a required ethics course offered by the	N.A.

St. Paul, MN)	Philosophy Department. Use the Oath of an Engineer for graduating seniors.	
13. University of San Diego (San Diego, CA)	An engineering ethics course offered by Philosophy Department	142 Engineering Ethics (3)* Examines the rights, responsibilities and social role of the professional engineer. Topics may include: conflicts of interest; the moral status of organizational loyalty; public safety and risk assessment; reproductive engineering and human dignity; preventing environmental destruction; "whistle-blowing," defective product liability; engineers and corporate power; engineers and government; codes of conduct and standards of professional competence. Case studies may include: military and commercial airplanes; automobiles; public buildings; nuclear plants; weapons research; computers and confidentiality; the use and abuse of new technologies.

## APPENDIX B

### Tentative Syllabus for PHIL 324, Technology and Human Values

DATE	TOPIC	SPEAKER	READINGS
January 8	Introduction	Limper/Terry	-----
January 10	The impact of technology on society (Video: "The Trigger Effect")	Limper	Winston 52-69
January 15	Technology and ethics: preliminary considerations	Limper	Winston 1-19
January 17	Introduction to ethical concepts	Limper	Whitbeck 1-27
January 22	Ethical concepts continued (assign design project)	Limper	Whitbeck 27-46
January 24	Ethics as design	Terry	Whitbeck 53-73
January 29	Ethics as design continued	Terry	Same
January 31	Professional responsibility	Terry	Whitbeck 74-92
February 5	Professional responsibility/professional codes of ethics	Terry/Limper	Whitbeck 92-107
February 7	Responsibility for safety	Terry	Whitbeck 108-118
February 12	Safety, risk assessment	Limper	Whitbeck 118-132
February 14	Professional responsibility: <i>Challenger</i> disaster	Limper	Whitbeck 133-146
February 19	Design project judging	Guests	-----
February 21	Professional responsibility: <i>Citicorp Tower</i> ( <a href="http://onlineethics.org/moral/LeMessurier/">http://onlineethics.org/moral/LeMessurier/</a> )	Terry	Whitbeck 146-155
February 23	Midterm examination		
February 28	Intellectual property	Limper	Whitbeck 46-51, 295-305
March 5-7	Spring break	-----	-----
March 12	Workplace rights and responsibilities (Video: <i>Gilbane Gold</i> <sup>12</sup> )	Terry	Whitbeck 156-170
March 14	Workplace rights and responsibilities	Limper	Whitbeck 170-190
March 19	Technology and work (clip: Charlie Chaplin, <i>Modern Times</i> )	Limper	Winston 159-171
March 21	Technology and developing countries "Business in Bhopal" from <i>Set Phasor on Stun</i> <sup>13</sup>	Terry	Whitbeck 189-190, 307-310
March 26	Technology and globalization	Limper	Winston 171-188
April 2	Responsibility for the environment	Terry	Whitbeck 236-246

<sup>12</sup>National Institute for Engineering Ethics, *Gilbane Gold*. Alexandria, VA: National Society of Professional Engineers, 1989.

<sup>13</sup>S. Casey, *Set Phasors on Stun*. Santa Barbara, CA: Aegean Publishing, 1993, pp. 71-88.

<b>DATE</b>	<b>TOPIC</b>	<b>SPEAKER</b>	<b>READINGS</b>
<b>April 4</b>	Environmental ethics	Limper	Whitbeck 247-251 Winston 294-302
<b>April 9</b>	Environmental effects of technology (Water quality activity handouts)	Lin	Whitbeck 252-260
<b>April 11</b>	Environmental effects of technology	Terry	Whitbeck 252-260
<b>April 16</b>	Environmental policy	Limper	Winston 284-294, 302-322
<b>April 18</b>	Conflict of interest, due diligence, and expert witness	Driver/Welch	Hand outs
<b>April 23</b>	Technology and quality of life	Limper	Winston 102- 107,148-159
<b>April 25</b>	Conclusion	Limper/Terry	Winston 107-113
	Final exam		