Session 2561

Engineering Ethics at Drexel University

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I. Introduction

Criterion 3 of the new ABET Engineering Criteria 2000[1] has the potential to change the way that *engineering ethics* and *science technology and society studies* are taught in the engineering undergraduate major. One concern voiced by critics has been the shift in the humanities and social studies component from the previous "course requirements model" to a progressive model focused on assessments and outcomes. While some have regarded this change as a threat to the humanities and social sciences component of the engineering curriculum, others, including us, have regarded this change as an opportunity for curricular innovation and new pedagogical focus.

Among other requirements, criterion 3 dictates that engineering students demonstrate (a) an understanding of professional and ethical responsibility; (b) an understanding of the impact of engineering solutions in a global and societal context; (c) knowledge of contemporary issues; (d) the ability to communicate effectively; and (e) recognition of the need for, and an ability to engage in, life-long learning. Criterion 3 thus mandates the inclusion of professional ethics in the engineering program. No less important is the focus on the understanding of the social responsibilities of engineers, as well as the cultural, environmental and global impact of engineering and technology. Indeed, criterion 4 places emphasis on the larger, social impact of engineering, and, in addition, requires students to be aware of the political impact of engineering. It mandates that "a major design experience…must include…the following considerations: economic; environmental; sustainability; manufacturability; ethical; health and safety; social; and political."

In ABET's "Conventional Criteria," under the heading of "Curricular Content: Humanities and Social Sciences" one finds the following principle:

> In the interests of making engineers fully aware of their social responsibilities and better able to consider related factors in the decision-making process, institutions must require course work in the humanities and social sciences as an integral part of the engineering program. This philosophy cannot be overemphasized. To satisfy this requirement, the courses selected must provide both breadth and depth and not be limited to a selection of unrelated introductory courses.[2]

To meet this requirement, programs can choose from "traditional" subjects such as philosophy, history, literature, anthropology, religion, etc., or from "nontraditional" subjects such as "technology and human affairs," history of technology, professional ethics, and social responsibility.[3] Hence, the new criteria emphasize individual moral responsibility and professionalism on the one hand, and societal, environmental and political impacts of engineering and technology on the other, and therefore programs in engineering ethics need to interweave both themes into the curriculum.

The ABET mandated focus on professional and social responsibility in the engineering curriculum is arriving at an opportune time. Indeed, we are experiencing an unprecedented growth in the academic field of engineering ethics, witnessed by a “critical mass” of specialists working and publishing in the field,[4] a number of successful conferences on engineering and technology ethics (e.g., the *International Conference on Ethics in Engineering and Computer Science*, March, 1999, Cleveland, Ohio, sponsored by the *Ethics Center for Engineering and Science*), as well as the establishment of academic journals devoted to the subject (*e.g.*, *Science and Engineering Ethics*).

Taking advantage of the growing academic interest in the field, and informed by a critical assessment of much of the recent literature on engineering ethics, we at Drexel University have constructed a new comprehensive program for engineering ethics education. While the impetus for revising our engineering ethics curriculum was not necessarily the new ABET requirements (but internal needs related to Drexel’s cooperative education program,) our attempts to meet many of the obstacles to curricular and pedagogical reform in engineering ethics instruction, can stand as a model for meeting both the spirit and the letter of the new ABET Criteria.

If the vision for engineering ethics education articulated in ABET’s new criteria is to become a reality, however, certain major obstacles will have to be overcome. Elucidation of the problems to overcome, as well as the description of the curricular reforms instituted to meet these challenges, will be the main focus of this essay.

II. Engineering Ethics Courses at Drexel University

At the heart of our ethics-in-engineering program is a multidisciplinary approach that relies on the field experience of practicing engineers, the conceptual analysis provided by philosophers and ethicists, along with drama, literature, history, and social sciences as resources. Our program is tied to topical classes that engineering students take elsewhere in the curriculum, and to parallel components in history of technology. Our team includes instructors from Engineering, Philosophy, History and Politics, and Literature, all bringing their particular areas of expertise to bear on the entire range of issues discussed. The program requires that the student participate in essay writing, oral presentations, dramatic re-enactments of famous (or notorious) ethical case studies, and in-class debates. We aim to provide experience which is multidimensional, and which presents ethics not as another isolated discipline that requires mastery, but as the backbone for all engineering activities.

All sophomore students in Drexel’s College of Engineering (CoE) are directed to take twenty weeks of “Evaluation and Presentation of Engineering Ethics”. This 8-credit two-quarter class includes four components: (1) a topical laboratory (three hours per week) - covering classical experiments in systems theory, strengths of materials, and physics (energy and thermodynamics); (2) a history of technology component, which accompanies the experiments with the relevant historical and societal background (one hour per week); and (3) and a two-hour weekly meeting on engineering ethics, which, among other elements, discusses issues of presentation and evaluation of data from an ethical perspective. About two hundred and fifty students enroll in the class, which is offered twice a year, and they are divided to groups of various sizes for the three activities (25 in a group that performs lab experiments; 50-75 for an ethics meeting; 125 for a history of technology meeting.) The aim of this class is to provide the laboratory, history and ethics experience as one unit, having the various components draw and rely on each other. In their third, pre-junior year[1], all engineering undergraduates take, in addition, a freestanding ten-week course in engineering ethics offered by the philosophy department. At present, between 10-12 sections of the philosophy course are offered each year. During the same year, students are also required to attend a freestanding one-quarter course in the history of technology, offered by the history department.

Overall, this program thus allows for thirty weeks of instruction in engineering ethics. This allowance provides the opportunity to develop a curriculum with a breadth of topics and a depth of analysis that are often missing in other schools' curricula. Almost no topic in the growing literature on engineering ethics is left unaddressed. Among the advantages of this arrangement is the availability of ample time for introduction and discussion of case studies, both micro-level cases focusing on individual moral dilemmas, and macro-level cases that focus and reflect on the social and ecological impact of technology. The breadth of topics and depth of analysis provided are consistent with the "conventional criteria" referenced above.

The first quarter of the ethics component in the sophomore year introduces the students to the concepts of professionalism, engineering codes of ethics, code-based reasoning, and case-based reasoning strategies. Many micro-case studies are referenced and analyzed during classroom discussion[5], and a major case study in professionalism is then studied and analyzed in detail. Examples of such "major" case studies are the "59 Story Building" case, involving the Citicorp Center in New York City, and the history of "Cold Fusion." In addition, the students read a play that illustrates a major issue in professional ethics. Among plays read in the past were George B. Shaw's "Major Barbara" and David Mamet's "Glengarry Glenross."

The students are given weekly quizzes, which cover the reading material, written case-study assignments, and a paper on the play. The last two weeks are devoted to student presentations. These are 10-minute public debates; the objective is to analyze an engineering question with ethical ramifications (*e.g.*, should I-95 and the Pennsylvania Turnpike be connected in Northeastern Pennsylvania?) Debaters are instructed to be confrontational, and present the two opposing viewpoints on the issue. Students are further asked to use the codes of ethics and the moral theories discussed in class to enrich their arguments.

The second quarter of the ethics component in the sophomore year moves closer to issues of data analysis and data presentation, ethical issues in engineering R&D, and to social impact topics. Students are also introduced to the concept and methodology of moral problem solving. Numerous cases are presented and discussed, using the logic of moral reasoning. In addition,

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[1] Drexel's engineering is a cooperative education program; students spend 18 months in industrial assignments. The program therefore requires five years to completion, and is thus divided into freshman, sophomore, pre-junior, junior, and senior classes.

students are introduced to *engineering law* through the review of contract law and product liability law. Case studies are referenced to illustrate the subtleties of legal matters. In addition to the on-going analysis of micro case studies, a major case study involving engineering law and engineering ethics is studied in detail. In the most recent past we have used the J. Robert Oppenheimer "affair" of 1952-1953 for this "major" case study. In previous terms we have used the "Baltimore Affair" for that purpose. Plays that we have read in the second term included Bertolt Brecht's "Galileo," and Friedrich Duerrenmatt's "The Physicists."

The third course (for Drexel's third year pre-juniors) analyzes the broader social responsibilities of the engineering profession, and addresses the macro and political issues concerning the impact of technology on society. The course represents a critical reflection on the nature of engineering and technology, as well as a critical reflection on the ethical obligations and responsibilities unique to the engineering profession. Topics covered include: the place and purpose of engineering codes of ethics; the social responsibilities of engineering, the ethics of whistle blowing and organizational (dis) obedience; ethical issues of risk perception, analysis, assessment and management; the interactions between science, technology, and human values; and socio-historical analysis of the impact of technology on society and culture. Of particular importance here is the concept of *Risk*. Indeed, few topics are more germane to the relationship of contemporary technology and human values than risk assessment and equitable risk management. These topics contribute to an understanding of the interactions among science, technology and society, by raising questions about acceptability of risk, the appropriateness of technical versus cultural perceptions of risk, equity issues in the distribution of risk, and the ethical responsibilities of individuals, corporations, and governments concerning the safe and beneficial operation of complex sociotechnical systems.[6]

The three courses are coordinated through the efforts of the course directors and are integrative to the extent that they encompass both "in-house" courses offered by the College of Engineering (and required of all undergraduate majors in the CoE) as well as stand-alone courses offered by the philosophy program and the department of history and politics (these are also required of all undergraduate majors in the CoE). In addition, the sophomore-class instruction in ethics is coordinated closely with the laboratory and the history of technology component of "Evaluation and Presentation of Engineering Data." Coordination among the core faculty results in curricular planning that is integrative in Herkert's sense of integrating an entire range of topics that span the literature: from professionalism and engineering ethics, through the history and sociology of technology, to technology policy studies and onto what are called "science-technology-society" (STS) studies.[7]

III. Methodology

Researchers in the field of engineering ethics have identified at least four major problem-sets that need to be overcome in the implementation of a comprehensive engineering ethics program. They are: 1) curricular questions concerned with the most adequate implementation model;[8] 2) pedagogical questions concerned with the best method of instruction;[9] 3) conceptual questions concerned with proper course content and subject matter;[10] and 4) theoretical questions concerned with the nature of engineering ethics as a discipline—how to understand and explain the philosophy of engineering ethics.[11] We have attempted to solve these four major obstacles by designing a program that is

- Integrative in the choice of its implementation model;
- Pluralistic in its pedagogical methodologies;
- Extensive in its choices of subject matter; and
- Broad in terms of its interpretation of the nature of engineering ethics

<u>Rationale for the "integrative approach" to curricular implementation</u>. Davis has identified eight ways to implement engineering ethics in engineering programs[12]; Rabins has identified six[13]; both Lynch and Herkert have identified four implementation methods.[14] Nevertheless, the various strategies can be reduced to four general implementation models, each with their own benefits and drawbacks. One method involves the introduction to humanities subjects in segments of various parts of the core technical curricula. This is referred to as the “modular” approach. A second model relies exclusively on stand-alone courses in engineering ethics, either elective or required. A third model is the “across-the-curriculum” approach, which aspires to full integration of ethics in technical programs.[15] This is accomplished by offering a series of seminars to all engineering faculty in engineering ethics, taught by professional ethicists. The goal is to “teach the teachers” of engineering to incorporate ethical concerns in all engineering courses, including design courses, but also into the science and technical courses. Finally, a fourth model recommends integration of engineering ethics and science-technology-society studies into the standard engineering curriculum. We have chosen the fourth model, which has as its goal the integration of ethics/professional studies components with various social implications of technology components. The topics are introduced in stages and spread out over three quarters (= thirty weeks of instruction).

The selection of this model grew primarily from challenges that the engineering program at Drexel University faced as a result of its mandatory cooperative education (“co-op”) programs. Students who returned to school from co-op assignments, their employers, and school officials involved with co-op, have alerted the curricular committees to the clear need to revisit and strengthen the ethics programs in the college. Our students faced challenges in the work place that they felt unequipped to deal with. Our students’ employers felt that a host of issues related to professional behavior, respect for proprietary information, communication skills, needed to be addressed. The rebuilding of the programs in response to these challenges coincided with the emergence of the ABET 2000 Criteria. The multifaceted approach of the criteria was in tune with our view that ethics instruction should be given “in context,” and be closely related to other planned activities in the students’ curriculum (*e.g.*, laboratories in the sophomore years.) Moreover, the choice of this model reflects our belief that the combination of ethics instruction in professionalism and individual responsibility, along with extended treatment of themes, concepts and categories for dealing with the social, political, and environmental context of engineering practice is an effective curricular model for responding to the ABET Criteria 2000.

<u>Rationale for a pluralistic approach to pedagogy and testing</u>. Many authors have addressed pedagogical problems associated with the strategic methods of instruction needed to teach ethics. Is a “case-based” approach better than a “theory-based” approach? If so, why? Is a

"moral reasoning" approach better than a "case-based" approach? Is a combination of approaches the best way to teach engineering ethics? If so, how is the best combination to be achieved?

According to Whitbeck, engineering ethicists have become dissatisfied with the traditional "applied ethics" approach that starts with abstract moral universals or principles and then reasons deductively from these first principles to determine how they would apply to particular instances.[16] Instead, they have shifted focus toward case-based reasoning that starts from particulars, and then argues inductively to first principles. The general consensus among engineering ethicists emphasizes (1) the importance of familiarity with realistic cases, a concern with practical actions that could be taken by real engineers rather than disabling moral "dilemmas," and (2) incorporating ethics into engineering design processes rather than focusing exclusively on abstract moral justification. According to Harris, extensive discussion and analysis of cases involving ethical issues in the technological field is the key to the learning process.[17]

While we rely heavily on cases, at least in the beginning, we do recognize the limitations of case-based reasoning as the sole method of teaching individual and social responsibilities in courses in professional and applied ethics.[18] Indeed the review of cases should be made in the context of the engineering codes of ethics and the moral theories that the courses introduce, and the style of our instruction calls for moving back and forth between cases and "theory". One of the mechanisms to achieve this integration is to introduce several cases at the beginning of each term, and to revisit them and re-analyze them once additional "theoretical" tools have been accumulated. The role of principles in advanced stages of moral reasoning does help to clear up potential deficiencies of case-based reasoning, or casuistry. Focusing on cases is developmentally necessary, even primary; yet this does not imply ignoring moral theory or codes of ethics. Our approach to the logic of moral reasoning and open textured application of principles suggest a "theory modest" rather that "theory free" method.

Empirical evidence[19] has shown that engineering students will have a tendency to look at ethics courses as a burdensome requirement unless their application to a particular field of interest is elucidated (at least in the beginning). There is no denying that students will benefit from the knowledge of ethical theories and by studying the works of the moral philosophers, but, as researchers point out, they will stand to benefit more if this knowledge is used as background information in analyzing and debating case studies involving ethical problems and dilemmas involving professional conduct.[20] Students are simply more responsive, and show better motivation, if they are required to take courses that cover ethical issues as they relate to their discipline or area of interest.[21] From our experience, teaching the larger, social and political responsibilities of the engineering profession are also best introduced by way of "macro" case studies such the Challenger incident, the Bhopal catastrophe, the Chernobyl disaster, and other public interest case studies treated in the popular media. In sum, our experiences show that optimum-learning benefit occurs when ethical issues are discussed first in the context of engineering topics directly relevant to the students' practical needs.

We believe that students should present test cases and offer their views and thoughts on these cases during discussions in the classroom. These discussions should be followed by formal written assignments. As more “theory” is accumulated, past cases should be revisited. The students should be required to provide concrete steps leading to the resolution of the ethical problem on hand, and justify these steps. We cannot accept evasive answers such as “this is a very difficult issue and every person should resolve it according to his/her personal preferences”. During class debates (and in the following written essays) students are directed to conduct several thought experiments. The intent is to have them come to realize the open-ended nature of most engineering ethics problems (as opposed to the quantitative and deterministic nature of many textbook engineering problems,) and to appreciate differing viewpoints. Still, it is important to insist on selecting a course of action at the conclusion of the discussion. Students must understand early that ethical questions require concrete responses; delays and “do nothing” approaches constitute actual responses to the ethical dilemma, and often these responses are unsatisfactory.

Our solution to the problem of determining the best method of instruction is to implement a plurality of methods, including code-based reasoning, case-based reasoning, moral problem-solving approaches, as well as sociological analysis concerning the politics of technology. In addition, we use different media--such as dramatic re-enactment of cases and reading of plays--that has the additional advantage of breaking the tedium of frontal lectures, and increasing overall interactivity in the classroom. This “methodological pluralism” proves to be very effective, both in the communication of information, as well aiding in the students' development of critical reasoning skills and complex moral problem strategies.

The method of moral problem solving is a model that nicely integrates a case-based approach with more traditional moral theory, and hence is a potential solution to the need for both in engineering ethics teaching. The approach is to use traditional moral theories as paradigms, through which one can analyze various ethical problems. This approach is analogous to the use of “models” or paradigms in the social sciences.

Teaching students <u>code-based reasoning</u> increases their knowledge of standards of conduct. It instructs the (future) professional on his/her duties and obligations as defined, both by informal or personal codes, as well as formal and professional codes. In addition, it draws on the professional’s understanding of societal standards of conduct and the resulting duties and obligations. Teaching <u>case-based reasoning</u> increases ethical sensitivity to complex issues by stressing the particulars of each case and the (often open-ended) problems and complex moral ambiguities and ethical uncertainties surrounding engineering practice. Teaching <u>moral problem solving</u> methods increases the capacity for ethical judgment, and facilitates critical scrutiny of the logic of moral reasoning.

Teaching the <u>social and political responsibilities</u> of engineers increases awareness of the complex ways technology impacts upon society, both positively and negatively. It increases the professional’s sense of empowerment with respect to the choice of engineering as a potential career. Students become aware that, as engineers, they have the potential to do both great social benefit, but also to do grave social harm. In this context it is important to avoid the antiengineering bias that we sometimes detect when "outsiders" write about or teach engineering ethics. We found that it is vital to discredit explicitly the perception that engineers are fundamentally potential "evil doers" which society must continually monitor and punish lest they create more harm. Over-emphasis on engineering projects as harmful, and on the need to "punish" engineers for failures (especially for the failure of innovative designs) is intrinsically wrong, as well as counterproductive as a tool for ethics instruction.

As Davis has pointed out[22], increased knowledge, sensitivity, judgment, and empowerment are relatively easy to assess and measure. The more students can successfully answer adequately questions about the rationale, application, and interpretation of codes of ethics and the role of professionalism in support of one's convictions, the more knowledge they have about ethics and professionalism. The more ethical issues, stakeholders, and potential solutions students can identify when posed with a case study, the more sensitive they become to ethical issues. The more morally creative are the solutions that students offer when asked to solve moral problems, the more ethical knowledge they bring to bear on the choice. The more ethical issues their choices take account of, the better the ethical judgment they demonstrate. The more students see the important impact engineering and technology has on society, the more empowered they become. Moreover, this focus on outcomes and assessments is consistent with the ABET Criteria 2000.

We note that some have questioned the very concept of teaching ethics.[23] They have argued that the ethical outlook of an individual will have been based on the complex system of values and judgments that usually depends on family background and the individual's upbringing. The ethical judgments that an individual makes will depend on his/her value system, a system of values, which, although consisting of a combination of cognitive and affective traits, will be "fixed" in childhood or shortly thereafter. Our experience shows us, however, that even though familial value-structures are strongly embedded in individuals, learning experiences in the University do exert a strong influence on the value systems of students. As Lynch notes, we are not trying to 'teach' ethics[24]; rather, as teachers, we seek to achieve the following: 1) provide students an opportunity to discuss and debate ethical issues; 2) create an awareness of ethical issues in the technical field; 3) provide the students with an exposure to these issues; and 4) encourage students to think about the broader, ethical, social, and environmental consequences of their work. In fact, empirical research shows that moral-reasoning skills can, to a certain extent, be measured, and that moral problem solving can be increased in engineering ethics classes.[25]

We explain to our students that, while personal moral beliefs are at the core of the individual's response to ethical challenges, these beliefs are not the only source that professionals draw from when an ethical dilemma presents itself. The community of professionals has developed a common view of the ethical principles by which it is guided. Professionals must take this view into account when they contemplate their actions, and remember that in many cases the communal values, as expressed by the codes of ethics, may take precedence over personal convictions. Thus a professional may have to refrain from taking an action, which personally s/he deems perfectly appropriate, because the communal code of ethics forbids it. In addition, society often imposes a "collective ethic" that may or may not always coincide with one's personal beliefs about right and wrong.

Rationale for the "four-tiered approach" of introducing ethics and social issues. Should engineering ethics be focused on micro-level issues surrounding professionalism and individual responsibility or should engineering ethics be dealing with macro-issues surrounding social ethics and social responsibility? We have addressed this question by introducing ethics in "stages." Our model has four stages.[26]

1) Engineering Professionalism and Individual Responsibility—an understanding of the nature of ethical responsibilities and an introduction to code- and case-based reasoning, and how these help to determine appropriate courses of action, especially when responsibilities are either not clear or come into conflict (sophomore year - first quarter).

2) Engineering and Society—an understanding of the professional nature of engineering and the implications of the social responsibilities of engineering; relations between engineering ethics and the law (sophomore year - second quarter; pre-junior year).

3) Technology and Society—an understanding of the complex interrelationships between technological development and societal and individual well-being; the relation between engineering and the environment (sophomore year-second quarter; pre-junior year).

4) Technology and Public Policy—an understanding of the politics of technology assessment, the socio-techno-politics of risk, and the role of the engineer in the management of technology (pre-junior year).

The first stage includes the issues that impact most immediately and directly on engineers in practice, whether employees, independent entrepreneurs, or consultants. These issues include matters of individual responsibility related to technical competence, legal liability, or causal responsibility. The second stage includes issues that are not so clear-cut, and are often associated with difficult questions such as individual versus collective responsibilities.[27] Among those are controversial cases of whistle blowing, reproductive technologies, and changing technologies that affect the workplace. The third stage considers ethical responsibility in its full "social" sense. Typical problem-sets at this stage exemplify both collective and individual responsibility, and are typically extremely complex. Nuclear weaponry, biotechnology, world hunger, or the ethics of technology transfer are typical examples. The fourth stage focuses on the public policy ramifications of engineering, both through explicit action of engineers, and the political reaction to engineering innovation. A typical example here is the effect of changes in information technology and communication technology on the law and on the societal role of computers and mobile phones.[28]

Determination of content. How does one go about deciding what topics and materials to include in an ethics course sequence for engineers? One set of observations comes from a review of the "professional practice/ethics" literature. Prior to the 1980s, the primary focus for professional ethics tended to be "internalist" in nature. The primary focus was with interpersonal behavior among professionals or between professional and client. Relevant topics included codes of conduct, conflict of interest, questions of fair advertising and improper competition.[29] Since then, the scope of professional ethics has broadened to include responsibilities of individual practicing engineers to society,[30] as well as the larger, social responsibilities of engineers.[31] This broadened sense of professionalism and ethics implies broad responsibilities for professional engineers, such as ensuring the safety, health, and welfare of the public in the practice of their professional duties, protecting the environment, and, generally, guarding the interest or welfare of society in all aspects where engineering activity might have an effect. Although not everyone subscribes to such a broad definition of engineering responsibility, the literature is growing in this direction.

The second set of observations comes from an examination of the "social responsibilities/social impacts" literature. All theorists seem to agree that a reasonable primary objective of the *social impacts* component of the course must deal with the responsibilities of engineers at the interface between the technical world and other realms. These other realms are politics, law, economics, and public policy. The objective is to create an awareness of the diverse and often contradictory technological, legal, political and societal forces that affect, and are affected by, the engineering profession. The practice of engineering and the role of the engineer are explored from this perspective, with particular emphasis on professional and ethical issues. A unified underlying goal arises from this approach, defining the social role and social responsibilities of the practicing engineer. The most important problem to consider is the degree to which engineers and technical people, because of their technical expertise and positions of authority, can assume a positive leadership role in helping to decide complex engineering-related issues in society. What is the formal role of the engineer in the process? What is the actual role of the engineer in the process? Which decisions are primarily in the domain of legislators and politicians, and which are primarily the engineer's? How does the engineer inform decision makers and agents (especially public officials and lawyers) of the technical aspects of proposed actions and their potential impact?

<u>Rationale for including philosophical and political issues as part of the content of the courses.</u> Should we be training students in the fine art of "serving" the public, clients, and the profession, or should we rather teach future engineers about the politics of engineering and technology? Some feel that a prevailing technological ideology, which responds to technological imperatives, ignores many humanistic and ecological imperatives.[32] Indeed engineers are often accused of failing to appreciate the negative aspects of their creations, and on making predictions that over-emphasize the benefits of large project and ignore potential harm. It is therefore desirable to provide engineers with professional training that includes the questioning of technocratic ideology, as well as a deeper understanding of the legal and political arena in which decisions about engineering and technology often take place. For some, the case study approach is totally inadequate to deal with such larger, socio-political issues.[33] According to Winner, so called ethics case studies usually point to specific troubling incidents within what are assumed to be otherwise harmonious patterns in the various institutions engineers work and deal with. The case study approach avoids the difficult underlying questions involving technology-oriented professions. One only needs to look at the history of the engineering profession to see how closely engineering schools and large corporations work together to tailor an engineering

curriculum suited to the immediate needs of the military-industrial complex. The tacit premise of the case study approach is, as Winner puts it, "that as one enters a profession, one simply embraces the existing commitments, institutional patterns, and power relations the profession contains."[34] The case study approach is not critical in its approach. It affirms the ideology that engineering and technology are neutral, and it gives the impression that someone else will raise the important questions concerning the politics of technology. Introducing techniques of philosophical and political reflection will, we hope, educate engineers to create technology that responds better to humanistic and ecological imperatives, not just the technocratic and economic constraints.

IV. Conclusion.

We have described the curricular, pedagogical, and methodological objectives that the Drexel program in engineering ethics aims to meet. Designed initially to respond to practical needs of students and their employers in Drexel's co-operative education program, these objectives (and our methods of addressing them) offer one possible implementation of the ABET 2000 criteria. At the core of our approach is the belief that an engineering ethics course should not just fulfill an ethical vacuum or become a "tacked on" supplement, which is designed to meet externally imposed criteria. Rather, it should be interwoven into an integrated engineering curriculum, and relate closely to other analytical and hands-on activities of the engineering student, in the classroom and in the lab. The study of ethics should supplement, clarify, and modify the values acquired during professional socialization, and draw on real-life experiences collected by the student in the school and the workplace. Only through deliberate integration can students be taught meaningfully about the way technology affects human life, society, and the environment.

It is expected that a program of this nature is but a foreshadowing of the kind of engineering education likely to emerge as the profession grapples with 1) the theoretical and practical implementation of the ABET Criteria 2000; and 2) the design, implementation, and management of technological development as it impacts on the political and cultural aspects of modern society.

Appendix I: Major Topics Covered in the Engineering Ethics Courses at Drexel

- The Case Study Method
- Professionalism and Ethics
- Codes of Ethics
- Code-based reasoning
- Case-Based Reasoning
- Moral Problem Solving
- Engineering and the Law: Contract Law
- Engineering and the Law: Product Liability
- Engineering Ethics in Historical Perspective
- Collective and Individual Responsibility in Engineering Practice
- Engineering Ethics, Organizational Dynamics, and the Role of Professional Societies
- The Social Responsibilities of Engineers
- Engineering Ethics, Environmental Ethics, and Computer Ethics
- Engineering Ethics, Weapons Development and Biotechnology
- Ethical Issues in Risk Perception, Assessment, Communication, and Management
- The Politics of Engineering and Technology
- Engineering Ethics and the Philosophy of Technology
- Engineering, Technology, and Society
- Case Studies of Engineering and Technological Failures

References and Notes

1. ABET. 1998. *Engineering Criteria 2000*. Available on the World Wide Web at http://www.abet.org/eac/EAC_99-00_Criteria.htm#EC2000.

2. ABET. 1998. *Engineering Criteria 2000*. Available on the World Wide Web at http://www.abet.org/eac/EAC_99-00_Criteria.htm#EC2000. Either set of criteria may be chosen by a particular institution during comprehensive program review, up to the year 20002, at which time all reviews will be conducted under "Engineering Criteria 2000."

[3] *Ibid*.

4. Herkert, J.R. 1997. "Engineering Ethics Education Finally Reaches 'Critical Mass'." *The Institute* (News Supplement of *IEEE Spectrum*) (December): 2. Available on the World Wide Web at http://www.institute.ieee.org/INST/dec97/ethics.html. Cf., also, Herkert, J.R. 1997. "Making Connections: Engineering Ethics on the World Wide Web," *IEEE Transactions on Education* 40 (4): CD-ROM Supplement. Republished by the Online Ethics Center for Engineering and Science at http://onlineethics.org/essays/herkert.html.

5. The textbook by Harris, Pritchard and Rabins *Engineering Ethics: Concepts and Cases* 2nd Edition (Wadsworth, 2000) is the book used in the Sophomore-level courses. The book's eleven chapters are supplemented by the inclusion of over 50 case-studies, which provide ample opportunity for the presentation and analysis of case-based reasoning (to be discussed below).

6. Herkert, J. and Viscomi, B. (1991). "Introducing Professionalism and Ethics in Engineering Curriculum." *J. Prof. Issues Engrg. Educ.Practice* 117 (4), pp. 383-387.

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