Ethics, Technology, and Society in the Heartland: Their Role in Engineering Education

David A. Rogers, Member, IEEE
Department of Electrical Engineering
North Dakota State University
Fargo, ND 58105-5285

Paulo F. Ribeiro, Senior Member, IEEE
Babcock & Wilcox
Product Development Department
Naval Nuclear Fuel Division
Lynchburg, VA 24505-0785

Abstract—For those who are committed to the importance of the full and integrated spectrum of knowledge, teaching and working in engineering and science offer many opportunities or obligations for sharing this vision with students or colleagues. For the educator this might be done in formal courses dealing with the impact of technology on society or engineering ethics. At North Dakota State University two courses on the impact of technology on society have been offered for about twenty years. A new course in engineering ethics has been required for most engineering majors since 1992. For the practicing engineer this may be done by continuous reflection on a broader perspective and the societal implications of each technological project, product, and object that is being developed.

I. INTRODUCTION

Through the years engineering educators and professionals have encountered a multitude of problems in personal and professional relationships in academic (see Shils [1]) and engineering environments. Over the past few years there has been a growing interest among engineering educators [2]-[4] in the importance of the improvement of professional relationships as a prime ingredient in the continuation of good engineering programs both inside and outside of the academic world. In the early 1990's, at the invitation of the academic vice president at North Dakota State University, Rogers, one author of this paper, spent three years as part of the NDSU Faculty Seminar funded by the Bush Foundation. With one faculty representative from each college, the Seminar explored methods of involving the whole University in a commitment to interdisciplinary studies, diversity, and internationalization. This paper’s other author, Ribeiro, after teaching engineering full time for several years, currently is a practicing engineer. Ribeiro and Rogers have collaborated on some engineering education projects in which the historical context of the research and technology was used as motivation for and preparation in research. Teaching engineering and, especially, engineering design exposes students and faculty to a range of problems involving societal responsibilities. Design education offers the student a chance to think about career and life planning, professional ethics, relationships to colleagues, and the obligations involved in making a profit. This helps to provide some balance in a curriculum that is normally intensely technical in orientation.

In the context of society and culture, technology should be regarded as “medicine,” not “food,” nor “poison.” When one considers technology as food, one becomes insensitive to the difficulties that can be created by technology and its remedial rather than absolute role in society. If, on the other hand, one mistakes it for poison, the consequences could be alienation or even irrational acts of violence. Therefore the engineering educator has the responsibility to convey a rational or balanced view of technology to their students. Such a perspective points to the fact that technology should be no more than an individual and societal prosthesis as it contributes meaningfully to all cultural sectors [5].

Engineering education should help students to understand things from a broader perspective as opposed to the sometimes straightforward or problem-solving approach of the traditional engineering lecture course. Design leads people to mature through interacting with people with different perspectives or attitudes. Technology and society courses serve as additional gateways to the reality of life and work that students and faculty face.

II. COLLEGE COURSES

Engineering educators and the engineering curriculum have continued to experience various pressures from both the profession and society. Even though engineering is inherently a technical vocation, human issues and problems serve to focus its development on improvement of the human condition. Even the instructor teaching a sophisticated technical course will find opportunities through examples or through humor, perhaps, to share heartfelt concerns. The coffee break or pre-class small talk might be the occasion for significant communication and motivation for change. Issues in ethics and technology can serve as rich resources for making education and careers more exciting and meaningful.

In 1992 the administration at NDSU assigned Rogers the task of introducing an engineering ethics course. Eventually
the College of Engineering and Architecture’s technology and society courses became his responsibility as well.

Faculty in colleges of engineering, science, or technology are fortunate if they can be actively involved in courses like the above. Considerable attention must be given to their high quality presentation if they are to have their appropriate place in the educational experience. These courses challenge students and faculty alike to strive for lifelong personal cultural and professional enrichment and pursuit of a high road of human conduct as they face the challenges of life in an age that is critically dependent on changing technologies.

Contributions of individuals like Adams [6], [7] have been very significant in the continued development of these courses. Adams [7] uses the humanities as a natural or integral part of his engineering teaching. He also teaches technology and society courses and has developed course syllabi that are worthy of study by colleagues at other institutions.

Developing and teaching courses dealing with the impact of technology on society and engineering ethics offers great opportunities and challenges for the engineering profession and its educators. At North Dakota State University the two courses on the impact of technology in society (ENGR 311-312, “Impact I and II,” as students commonly refer to these courses) have been offered for about twenty years. A new course in engineering ethics (ENGR 402) has been required of most engineering majors since 1992. Some aspects of these courses have been shared in regional and national engineering education meetings [2]-[4].

These courses find homes in various departments at universities and colleges around the country. In some schools they are found in civil engineering or technical communication departments. At NDSU they are the responsibility of the engineering college as a whole.

While Impact I considers mainly what technology has done, Impact II emphasizes what technology should do. Both courses consider the basic meaning of science and engineering and the importance of a rational analysis of problems and a mature knowledge of human values and attitudes in relation to nature and technology. The influence of world religions in shaping human convictions concerning nature and technology is considered. Technological developments are studied in their historical context in both of the technology and society courses. The course in engineering ethics focuses some of the broad concerns of Impact I and II on the ethical practice of engineering.

Impact I and II were approved as University general education classes in 1994. Impact II also serves to satisfy the global perspectives requirement of the University. Engineering Ethics and Social Responsibility (ENGR 402) is required of engineering majors. Enrollments each semester in ENGR 311, 312, and 402 are, approximately, 110, 70, and 150 students, respectively.

The impact of technology on society and engineering ethics courses serve to satisfy both the general education requirements of the University’s students and the specific needs of individual engineering curricula. A major challenge is to continue to interest and educate these students under the changing educational, political, and social conditions of this decade.

III. THE ENGINEERING ETHICS COURSE

At North Dakota State University ENGR 402 is a one-credit required course in engineering ethics and social responsibility. The University catalog description is as follows: “History of ethics and social responsibility in engineering design and decisions. Codes of ethics, history and case studies.” The course philosophy, outline, and content overview have been reported previously [2]-[4]. Johnson [8] continues as the preferred textbook. Inspiration and philosophical background discussions are available in [9]-[11]. As reported earlier, engineering educators must encourage students to think clearly about the broad ethical implications of the work they are and will be doing [2]. The principles learned in an engineering ethics and social responsibility course flow out of human history and experience. The goal is to promote a lifelong interest in this area so that students will always be growing in their commitment to a high road of human conduct.

The focus of the ethical practice of engineering should be the practice of engineering in an environment of trust and competence [12] by engineers who know the limits of their competence and are trustworthy in the use of their craft. Practical ethical concerns are approached as applications of principles learned in the human struggle to develop a civilized, just, and sustainable society. We encourage students to personally integrate their own philosophical, social, and religious convictions into a constructive approach to the ethical practice of engineering.

The course continues to develop and now includes the following concepts (see [8], [9]) interwoven into the outline reported in [2]:

1) The unique position of a professional: the individual approaches the engineer with a problem but doesn’t necessarily have a solution in mind. The customer is in a vulnerable position.

2) A common ethical problem reported by practicing engineers is the conflict between engineering plans and management desires. However, practicing engineers do say they benefit from the existence of business policy statements and professional or company codes of ethics.

3) There are two important problem classifications in engineering ethics: line-drawing problems and conflict problems [9].
4) Resolving problems in engineering ethics through a profound technical and human understanding of the choices involved.
5) Ethical job hunting.
6) Life-span human development.
7) Fostering personal ethical development.
8) Situations requiring engineers to speak out or resign.

Engineering ethics instruction is developing in the direction of appealing to general principles. This offers hope for greater insight into ethical dilemmas and avoidance of ethical blunders that can be disastrous to careers.

IV. FIRST TECHNOLOGY AND SOCIETY COURSE

"Impact I," as students refer to the first technology and society class, was approved by the University in 1994 as a class open to any student as a general education class. It includes the history of technology since the American Revolution. Moreover, it considers early agricultural history going back about 10,000 years to the transition from hunter-gatherer to primitive farmer. Selected topics from the history of technology up to a few thousand years ago are included when they contribute to understanding a current theme. Contributions and challenges from inventors of many cultural backgrounds are studied. Strands of the history of technology in the course include military technology, the computer, public transportation, space technology, the impact of technology on work [13], and elements of environmental impact.

Rudi Volti's _Society and Technological Change_ [14] is used in both courses. Volti presents the philosophical and ethical background for the area along with some historical material. _Technology in America_ [15], edited by Carroll W. Pursell, provides historical material on the roots of technology in eighteenth-century America and the development of American technology through the atom bomb, the space program, and the personal computer.

The course can be outlined as follows:

1) Philosophical and historical background.
2) Technology in life and work in the nineteenth century.
3) Technology as applied science.
4) Technology develops life and work in the twentieth century.

The intended course outcomes for Impact I can be stated as: (a) comprehension of the development of technology and its impact on societies, including historical, scientific, and human dimensions; (b) understanding of the influence that technology has had in shaping the entire human environment; and (c) improvement of abilities in examining critically the broad social, economic, and institutional impact of technology as it has evolved and continues to evolve, both nationally and internationally.

V. SECOND TECHNOLOGY AND SOCIETY COURSE

While Impact I considers mainly what technology has done, Impact II emphasizes what technology should do. While continuing some historical studies especially from World War I to the present and a special focus on the media, the student is presented with technological backgrounds to societal and environmental problems around the world. As noted earlier, the course continues the study of the basic meaning and methods of science and engineering and stresses the importance of a rational analysis of problems and a mature knowledge of human values and attitudes in relation to nature and technology. The influence of the world's religions and philosophies in shaping human understanding of nature is a major course emphasis.

Certain countries throughout the world are studied as examples: Brazil, Zimbabwe, Thailand, Denmark, Sweden, and the United Kingdom. The indigenous peoples of Brazil are presented as an example of the conflict of technology with a primitive culture. Ethical problems in agricultural engineering in the United States are also of interest. Choices in agriculture can have a significant impact on profitability, the environment, and the community.

The remainder of Rudi Volti's _Society and Technological Change_ is used in Impact II. Ian G. Barbour's recent Gifford Lectures volume, _Ethics in an Age of Technology_ [10] is the dominant textbook. Barbour's _Technology, Environment, and Human Values_ [11] and _Engineering Ethics_ by Harris, Pritchard, and Rabins [9] serve as references in this course as well as in the ethics course.

The course outline follows:

1) Nature of technology
2) Hard choices
3) Attitudes toward nature
4) Attitudes toward technology
5) Human values
6) The media
7) Weapons
8) Energy options
9) Technology and culture
10) Technology and organizations
11) Government and technology
12) Environmental values
13) Resources and growth
14) New directions.

In Impact II there is a strong emphasis on environmental issues and global perspectives. In his written presentation to the NDSU General Education Committee, former ENGR 312
instructor Rurik Ekstrom (Professor of Architecture) wrote that the global perspective component was "based upon an analysis of worldwide issues illustrating the interdependence of the world and its people. The lectures and texts focus strongly on the development of a global perspective with respect to the relationship of technology to conditions in the world today and the possibility of applying technology...to the task of creating a just, sustainable and participatory world." Consequently, events and contemporary issues that develop during a semester are the focus of periodic class discussions.

VI. ASSIGNMENTS

Written assignments and class participation are required in these technology and society courses. In Impact I assignments include development of bibliographies dealing with inventions and discoveries in the past two hundred years or current problems in the impact of technology. Students also write papers on a topic discovered in their bibliographic studies. Several single-paragraph reactions to class discussions are also requested.

A question pool is under development for each of these courses. Student suggestions for questions and contributions are recognized as part of the written-communication component of the course. The goal is to develop a pool of several hundred questions for each test in each course. The current pool is available to students for study.

In Impact II students frequently review journal articles or books related to the course material. Student papers have required library research to determine a topic of interest followed by the development of the written review. In the process the students are required to learn to use the on-line search techniques available at the University.

VII. CONCLUSION

Engineering education can no longer afford to relegate the teaching of the relationships and interactions involved with the areas of ethics, technology, and society to a second level of importance. Engineers as developers of technology need to be able to think about the broader implications of their products, systems, or studies as they develop the competencies they will need to guarantee appropriate designs for each technological object they produce. The responsibility of the engineering educator goes far beyond that of clearly teaching their traditional engineering discipline.

Colleges of engineering, science, or technology should be encouraged to nurture and sustain their own individual faculty members or groups of their own faculty committed to courses like Engineering Ethics and Impact I and II. Considerable attention must be given to high quality presentation of these courses if they are to have their appropriate place in the a student's educational experience.

VIII. ACKNOWLEDGMENTS

The work reported here was partially supported through the North Dakota State University Faculty Development Institute by the Bush Foundation. Special note should be made of administrators, professors, and colleagues who have influenced the development of these courses: J. Stanislao, W. A. Bares, E. C. Bernnoll, D. Richard, D. A. Smith, R. Ekstrom, A. C. Cater, L. Lubka, M. Mazaheri, and H. W. Gernand at NDSU, C. C. Adams at Dordt College, and Brazilian colleagues A. J. Giarola and R. F. Souza.

IX. REFERENCES


David A. Rogers (S’58, M’65) is Professor of Electrical Engineering at North Dakota State University. His specialty is applied electromagnetics. He received the B.S.E.E. (cum Laude) from the University of Washington in 1961, the M.S.E.E. from IIT (Chicago) in 1964, and the Ph.D. (E.E.) from Washington in 1971. His Ph.D. thesis dealt with remote sensing of upper-air wind velocities using forward scatter of microwaves. In 1966 he received the M.Div. (cum Laude) in Ministry from Trinity Evangelical Divinity School (Deerfield, IL). He was an associate engineer at Ford Aeronutronic in summer of 1961. Served as a Second Lieutenant in the U.S. Army Signal Corps in 1961-1962. Conducted research for IIT Research Institute in 1963. Contributed to the development of the doctoral program in microwaves at the Universidade Estadual de Campinas (UNICAMP), Brazil, with research in fiber optics and digital microwave radio supported by Telecommunicações Brasileiras from 1972 to 1980. Rogers is a registered P.E. in Washington and has been at NDSU since 1980.

Paulo F. Ribeiro (M’79, SM’88) received the B.S.E.E. from the Federal University of Pernambuco, Brazil, in 1975, completed the Power Technology Course (PTI) in 1979, and obtained his Ph.D. (E.E.) from the University of Manchester (UMIST), England in 1985. He is a registered European Engineer (Eur. Ing.), member of the IEE (UK), senior member of the IEEE, registered professional engineer in the State of Iowa, and a longtime member of the International Working Group 36-05 (Voltage Quality) of CIGRE. Ribeiro is an advisory engineer with Babcock & Wilcox, Product Development Department, Lynchburg, VA. His assignments include supervision of power system and power quality studies for the Superconducting Magnetic Energy Storage (SMES) Program and other high power electronics devices. Before joining B&W, Dr. Ribeiro worked as a consultant with Jacobs Sirrine Engineers, performed research at EPRI and NASA, taught electrical engineering in Brazil and the US, and worked as a transmission system planning engineer for nine years in Brazil.