General Article

Technology and Ethics for Engineering Students

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Many engineering schools still do not allocate enough resources to the process of understanding the social and ethical dimensions of scientific and technological activities. This article argues that engineering curriculum in the United States should include courses that use theories and concepts from humanities and social sciences to study issues confronting the engineering profession. On the theoretical front, engineering students need to understand favorable and unfavorable consequences of technology-based progress, social and political qualities of technological designs, and the moral challenge posed by the new technologies of the 21st century. On the practical front, they need to be prepared for industrial and governmental jobs, which increasingly favor a broader social perspective, an understanding of proper management of complex technologies, and an ability to act ethically and responsibly. The Accreditation Board for Engineering and Technology 2000 has responded by introducing new requirements that the goals of course work in the humanities and social sciences also meet the objectives of the engineering profession.

To achieve excellence and diversity in engineering education, engineering programs in the United States require courses in engineering, mathematics, and basic sciences leading to a solid technical foundation, as well as elective courses in humanities and social sciences for broad education. Increasingly, educators have come to believe that engineering students should also understand their social role, grasp their ethical responsibilities, and communicate clearly to prepare for leadership in a highly technological society. The Accreditation Board for Engineering and Technology (ABET), for instance, is requesting engineering programs to include elective courses in their curriculum, so that future engineers can develop sensitivity to socially related technical problems and an understanding of the ethical characteristics surrounding the engineering profession and practice.

However, many of the electives engineering students could opt for to gain comprehensive knowledge related to their profession are not offered in several institutions. For instance, technical writing and communication courses are limited in the areas of intensive writing and oral presentation material pertaining to engineering topics. A centralized ethics course, which would engage all engineering students in a common discussion of ethics in the field, is yet to evolve. If humanities and social sciences offer some of the courses related to the engineering profession, such as history of technology or industrial revolution, often they are not recognized as electives for engineering students. More important, courses such as Technology and Society; Politics of Science and Technology; Risky Technologies; Environment, Law, and Culture; Environmental Politics and Policy; Technological Innovation and Policy; The Engineer in Society; Engineering Ethics; and Ethical Issues in Computing, which are specific to studying economic, political, social, and cultural assumptions underlying engineering and applied sciences, are simply missing in many institutions.

This article discusses a need to expand elective courses for engineering students to include theories and concepts from humanities and social sciences to study issues confronting the engineering profession today. It describes an interdisciplinary field within humanities and social sciences that is important to engineering education. It addresses why ABET 2000 is asking institutions seeking accreditation to have a general education component that complements the

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technical content of the curriculum. This article also presents a case study to show how engineering programs can expand electives, which will not only improve engineering education but also satisfy ABET requirements.

Fusing the Social With Technical

There are many reasons for students, especially those majoring in engineering, to understand the political, social, cultural, and ethical dimensions of their profession. First, technology has been profoundly transforming society since it has been viewed as the sure formula for society to progress. After World War II, the American government established science and technology (S&T) as a national asset by giving institutional recognition through laws, commissions, agencies, procedures, and financial support. Most people share a basic faith in the ultimate goodness of S&T. More than 85% of Americans believe that the world is better off due to growth in S&T, and only 5% feel that the world is worse off due to S&T (National Science Foundation [NSF], 1998). Generally, Americans think that progress in S&T can cure diseases, improve the quality of life, explore space, and develop faster modes of communication. Americans are growing up believing in a technological future that is filled with neatness and order, millions of buttons to push, endless gadgets to do all the work, superhighways, and virtual reality. The faith in and expectations of S&T need to be matched by a comparable level of understanding of the social and ethical dimensions of scientific and technological activities.

Second, the consequences of S&T have been so pervasive in recent years that they are unavoidable. Basic means of life—food, clothing, shelter, transportation, entertainment, healing, and so forth—involve some forms of S&T. Even a simple cup of coffee is technologized. For instance, coffee beans are generally picked on mountain farms in Latin America. These farms were developed after natural forests were cleared. Because it takes about 5% of a coffee tree's annual production to make two cups of coffee, many coffee trees are harvested with an extensive use of pesticides that are generally manufactured in a western country. In both countries, pesticides have contaminated the water as well as had adverse effects on workers' and farmers' health. The beans are usually shipped to the United States for roasting in a freighter. They are then packaged in four-layer bags constructed of polyethylene, nylon, aluminum foil, and polyester. The three layers of plastics are made of oil, shipped by a tanker from the Middle East. The aluminum layer of the bag is made from bauxite strip that is mined in the Far East. Bags of roasted beans are then trucked to different places in the United States. A diesel-powered crusher that removes beans from fruits, a freighter that carries the beans to the United States, a roaster that burns natural gas, and gasoline for trucks carrying the coffee all use fossil fuels directly (Durning, 1994; Hull, 1999). Perhaps people may not be aware of how drinking a single cup of coffee is destructive to biological systems and human cultures. However, Americans are increasingly required to deal with issues such as the impact of new information technology on the individual's right to privacy, moral dilemmas to create artificial life, the use of animals in scientific research, the increased cost of industrial development with the deterioration of the environment, the limits to economic growth with the population explosion, and the proliferation of nuclear and biological weapons. There is a need to understand both favorable and unfavorable consequences of technological developments.

Third, scientists and engineers themselves are confronted with new problems as they generate new S&T to solve old problems (Postman, 1997). For instance, the nuclear bombings on Japan in 1945 produced a traumatic effect not only on the victims and the people all over the world, but also on the scientists and engineers whose intelligence and ingenuity created such possibilities. Furthermore, the Manhattan project instituted a system of secrecy that has become a principal characteristic of nuclear development against the scientific tradition of free and open knowledge. Similarly, pesticides have increased agricultural production to solve food problems, but in doing so have killed wild life, contaminated food and water, damaged soil fertility, polluted the air, and endangered people's health. The automobile has solved the problem of transportation for most Americans, but in doing so has polluted the air and created traffic problems in most cities. The Internet has connected people throughout the world, but in doing so has made interaction within the family difficult, if not impossible. DDT initially eliminated malarial mosquitoes, but in doing so caused them to acquire DDT resistance. Scientists and engineers, therefore, need to learn how to anticipate unintended consequences of scientific and technological activities and proceed with great caution.

Fourth, technologies themselves have become so complex that they require proper management. Many technologies such as nuclear power plants and petrochemical industries are so interactively complex and tightly coupled that they are capable of causing serious damage to people and the environment (Perrow, 1984). Complexity of technological systems means hidden interactions that are not anticipated in the original design, branching patterns, and feedback loops; tight coupling means the interactions are mixed together with time dependence and invariant order. Whenever technological systems have failed, such as the nuclear power plant accident in Chernobyl, Russia, or the gas leak at the Union Carbide chemical plant in Bhopal, India, they have caused catastrophe. Earlier, technological systems were linear and loosely coupled, which allowed a system to recover from a setback. With complex technological systems, it is imperative for scientists and engineers to learn how to manage problems such as technical failure, lack of procedures, workers' disinterest, operators' errors, managerial negligence, profit motive, government bureaucracy, and so forth.

Fifth, the most compelling technologies of the 21st century—genetic engineering, robotics, and nanotechnology—pose a new moral challenge that the technologies that preceded them did not. Bill Joy (2000), cofounder and chief scientist of Sun Microsystems and cochair of the Presidential Information Technology Advisory Committee (PITAC), argues that new technologies can spawn whole new classes of accidents and abuses. Unlike 20th-century technologies that require large-scale activities, 21st-century technologies are capable of self-replicating (e.g., viruses and recent hacker attacks on popular Web sites). Furthermore, they are within the reach of individuals or small groups. According to Joy, the human race can drift into a position of accepting all of the machines' decisions because robotics intends to develop intelligent machines that can do all things better than human beings. Scientists and engineers making advances in such technologies, therefore, need to be concerned about ethical issues. Joy admits that for the first time in his career and his life, he is concerned about ethical issues involving new technologies.

Sixth, even though scientists and engineers are expected to have a strong ethical foundation, and the federal government has laid down the principles of ethical research, the past two decades have seen a spate of allegations of fraud in science and engineering. There have been numerous cases in which researchers find unexpected results in the laboratory, publish these results, win all kinds of acclaim, but those results cannot be repeated. The Office of Research Integrity has documented numerous high-profile cases involving research fraud that include data fabrication, plagiarism, and whistle-blower intimidation (see ORI newsletters at http://ori.dhhs.gov). In 1997, NASA canceled a joint space program with Russian scientists when 17% of the rhesus monkeys died due to experimenter error. When Duke University failed to adequately document the protection of human subjects in 1999, the Office for Protections from Research Risk shut down more than $170 million in federally funded research. The Challenger disaster in 1986 showed that engineers from the company responsible for building the solid rocket boosters had given a warning about the O-ring, but they had been overruled by their own managers, who in turn felt threatened by NASA's management who were determined to keep the launch schedule (Vaughan, 1996). Scientists and engineers, therefore, must learn the "right behavior" to proceed in moral and responsible ways.

Seventh, industry, which employs more than 50% of the total scientific and engineering workforce, is increasingly looking for those scientists and engineers who would not only be more productive, but also understand the social and ethical responsibilities of their profession. Since the 1970s, industry has come under numerous regulations of pollution control and occupational health standards. Industry is required to provide compensation for air and water pollution, waste clean up, and adverse health effects on workers and the general public. Lawsuits brought by people, environmental groups, and government against industry have increased the cost of technologies. Global competition, mergers, and downsizing have left many companies with greater responsibilities and fewer resources. Many high technology companies expect their scientists and engineers to see things from their viewpoint as well as adopt a variety of perspectives such as those of customers, competitors, colleagues, management, shareholders, government, and the general public (Kelly, 1999). They prefer scientists and engineers who are aware of codes of conduct, liability, responsibility, property rights, and so forth.

Eighth, government, which is the second largest employer of scientists and engineers, wants them to have more information on technological changes in society and the environment. Increasingly, the government has been finding itself seriously lagging behind the consequences of scientific and technological developments. Since the 1970s, government has assumed the role of regulator along with being the promoter of technology because of its involvement in the promotion of health and safety protection of people and the natural environment (Kraft & Vig 1988). To protect citizens against many technological hazards, government has passed a number of laws such as consumer protection laws, occupational health and safety laws, environmental protection laws, and tightened safety regulation of such dominant technologies as automobiles and nuclear power plants. New policies related to the proper use of information technology and the Internet are being formulated. Earlier, government tried to control certain diseases and other health hazards, and not technological hazards. The government expects scientists and engineers to be aware of the impacts of technology on natural ecosystems and social environment.

This list can be extended further. However, most examples reveal that S&T have given power to control the nature and solve social problems, but they do not ensure that scientists and engineers would automatically understand the social implications of their activities and carry them out in an ethical and responsible way. This is partially due to the fact that as students in science and engineering go through training, they learn that S&T are objective, independent of social, cultural, and political factors. They are taught to confine themselves to technical issues and to remain neutral on social and ethical aspects of S&T in the best tradition of science and intellectual impartiality. The other reason is that elective courses in humanities and social sciences seldom make the link between the social/cultural world and the technical profession. Often, courses in anthropology, history, literature, philosophy, psychology, political science, religion, and sociology are confined to issues that fall within the boundaries of their own respective disciplines.

Making General Education Specific to Engineering

Because of the nature of technologies, scale, magnitude, environmental impact, social changes, cultural significance, and ethical responsibility, education concerning technology in society has become more evident. There is a need to understand many basic issues such as the following: In what ways does technology shape the world? How do society and culture shape technology? How have the impacts and the social roles of technology changed over time? What and who are involved in bringing technology-based products into our daily lives? How can we rebuild society to incorporate the strengths of technology while avoiding its weaknesses? What responsibility do we have for future generations to live well? What responsibility do we have to communities living in a polluted site? What responsibility do we in the so-called first world have to the economic and social problems of the so-called third world? What is the connection between what scientists and engineers do and the world in which they live? How do we distribute responsibility when technologies fail? How do we ensure that scientists and engineers agreeing on abstract ethical principles are applying them in the course of their professional lives and careers?

Scholars in science, engineering, humanities, and social sciences have been encountering some of the S&T issues in their respective disciplines. From their interdisciplinary efforts over the past 30 years, a field known as science and technology studies[1] (STS) has come into existence in many institutions such as Carnegie Mellon University, Claremont Colleges, Cornell University, George Washington University, Georgia Institute of Technology, Harvard University, MIT, Pennsylvania State University, Princeton University, Rensselaer Polytechnic Institute, Rochester Institute of Technology, Sarah Lawrence College, Stanford University, University of Virginia, Vassar College, Virginia Polytechnic Institute, and Williams College. The objective of STS is to provide a platform and valuable set of concepts and theories from the humanities and social sciences for discussions of the role of S&T in society.

STS offers a unique set of courses in the social and cultural aspects of S&T and ethics and values. Generally, such courses are a part of elective requirements for undergraduates in science and engineering. They are also open to other students so they can expand their understanding of the role of S&T in modern society. Beyond STS courses, science and engineering students can choose from several nontechnical courses in humanities and social sciences. Often, undergraduates may take a number of STS courses to secure a minor in STS. In many places, students can earn STS degrees from baccalaureate to doctoral levels. STS graduates have been placed as faculty/researchers in universities; as managers/administrators; policy analysts and consultants in industrial companies, government agencies, and nonprofit organizations; and as writers/editors in publishing companies. As the number of Ph.D.s in STS increases, academic departments are being staffed with STS trained personnel. In the past, STS faculty consisted of anthropologists, historians, philosophers, psychologists, and sociologists who were interested in the role of S&T in society.

In 1975, the STS community formed the Society for Social Studies of Science (4S) to promote research, learning, and understanding in the social analysis of S&T.[2] 4S and other associations have been holding annual meetings to facilitate communication across conventional boundaries that separate the disciplines and across national boundaries that separate scholars. The official journal of 4S is *Science, Technology & Human Values*, and the newsletter is *Technoscience*.[3] The NSF has been providing financial support for social studies of S&T through the STS Program, the Societal Dimensions of Engineering, Science, and Technology Program (SDEST), as well as many NSF cross-disciplinary activities. This year, the Information Technology Research Program initiated at the NSF, based on the recommendations of the PITAC report, opened a new area of ethical and social dimensions of information technology.

By establishing the educational requirements for STS degrees within academic institutions, creating internal market for STS experts, forming professional associations to provide a forum for common discussion, publishing journals to foster the development of the field, and securing federal funds to support ongoing research, STS has established itself in the United States as well as in other parts of the world. STS has become a discipline of its own, just like philosophy, history, and sociology. Over the years, STS has been continuously adapting to accommodate changing needs and environment. Being involved in a wide variety of national and international scholarly activities, the STS community has become known for its contributions to the theoretical understanding of scientific knowledge and technological practices. Yet, many colleges and universities still do not devote enough resources to educate students on the social and ethical dimensions of scientific and technological activities. However, soon they will be forced to recognize this weakness and start initiatives in STS-related courses and activities.

Establishing Criteria for Engineering Education

Considering the issues involved with the increasingly complex technologies and the contributions of STS to engineering education in many top institutions, it is no surprise that ABET 2000, which becomes effective for evaluations in the 1999-2000 accreditation cycle, has specified the goals of course work in the humanities and social sciences to also meet the objectives of the engineering profession. Its engineering criteria expects programs seeking accreditation to demonstrate, among other things, that their graduates have

> (f) an understanding of professional and ethical responsibility, (g) an ability to communicate effectively, (h) the broad education necessary to understand the impact of engineering solutions in a global and societal context, (i) a recognition of the need for, and an ability to engage in life-long learning, (j) a knowledge of contemporary issues. (ABET, 2000b, p. 37)

Through such guidelines, ABET is hoping that engineering students will be well equipped to conduct their stewardship of a complex technological society like the United States. They will have the capacity to delineate and solve the problems of society that are susceptible to engineering treatment, develop a sensitivity to the socially related technical problems that confront the profession, have an understanding of the ethical characteristics of the engineering profession and practice, and exercise responsibility to protect occupational and public health and safety (ABET, 2000b).

ABET guidelines are important because one cannot accept any engineering degree printed impressively on parchment. ABET, a private association, creates demand for education and training of prospective engineers. It identifies programs offered by the institutions of higher education that meet the criteria for accreditation and provides guidance for the improvement of the existing as well as the development of future educational programs in engineering, technology, and related education in the United States (ABET, 2000a). The U.S. Department of Education recognizes ABET as the sole agency responsible for accreditation of educational programs leading to degrees in engineering, engineering technology, and related engineering areas. The ABET list of accredited programs is widely accepted by the National Council of Examiners for Engineering and Surveying and by most boards of licensure and certification, professional engineering societies, employers, and institutions themselves.

If an engineering program should lose its accreditation from ABET, it would be under close scrutiny from the institution. Without accreditation, an institution is likely to lose a large proportion of its students and even face difficulty in having its representatives gain access to high schools to recruit new students. Employers are unlikely to hire job seekers with credentials from unaccredited institutions. The state may not issue certificates or licenses to those who do not have a degree from an accredited institution (e.g., math or science school teachers). The state itself relies on private accrediting associations such as ABET for laying down educational requirements. Similarly, the federal government provides extensive economic benefits only to accredited institutions. Therefore, ABET approval is important for the institutions of higher education, especially for those that do not have the prestige and standing like Cal Tech, Harvard, MIT, and Stanford.

Establishing Technology Ethics Courses

Instead of quantitative measures such as number of faculty, the length of the educational program, and the size of endowment, ABET has produced more general qualitative guidelines for accreditation so that programs can be protected from outside pressures and afford sufficient flexibility. The ABET criteria for accreditation provides a loose framework for more concrete evaluation of individual engineering programs. Along with mathematics, basic sciences, and engineering topics, ABET requires course work in humanities and social sciences for broad education in society and culture. ABET 2000 is requesting engineering programs seeking accreditation or reaccreditation to not only meet the objectives of a broad education, but also to meet the objectives of the engineering profession.

In the short run, ABET may not object to the broad education currently in place in many institutions because it likes engineering programs to fulfill the requirements within their institutional goals. In the long run, however, it would be difficult for the engineering programs to justify elective requirements to ABET by showing how general humanities and social sciences syllabi also address technical/social issues. Increasingly, more educators are moving toward the linkage, not toward the separation, between technical and general education. Without systematic and expert guidance, engineering students are being left on their own to make the connection between technical education and social values. With STS-related courses, the engineering programs would not only be catching up to what other reputable engineering programs have accomplished and to ABET requirements, but would also be at the forefront of engineering education.

A case study of the University of New Mexico (UNM) illustrates one possible way to establish STS courses in a public Research I university.[4] UNM has approximately 24,000 students in its main campus and another 6,000 in branch campuses (*University of New Mexico: Information Overview*, 1999). It is an ideal place to offer STS-related courses. As the largest institution of higher learning in New Mexico, it is committed to being a "University for the Americas." Due to proximity, it has close interactions with key private (e.g., Intel Corporation), local, and state organizations, and federal and national laboratories. As a public research university with science, technical, and medicine orientation, it offers teaching and research expertise important in the social study of S&T.

The School of Engineering (SOE) at UNM is ideal to provide a platform for STS-related courses. Engineering education is unique because it uses basic knowledge of sciences and mathematics to design technical artifacts that fit societies or social institutions. The SOE houses approximately 1,400 undergraduate and 600 graduate students, offering degrees in chemical, civil, computing, electrical, mechanical, and nuclear engineering and computer science. In 1999, the SOE at UNM ranked 40th in the *U.S. News and World Report*. The SOE believes in excellence in engineering education. In his 1999 presentation to U.S. Congresswomen Heather Wilson, Dean Paul Fleury stated that the SOE's vision is to prepare new engineers "through comprehensive, affordable education based on intimate interaction with the creators and practitioners of new technologies," encourage them "to actively engage with all segments of industry, government, and academia," and provide them interactive learning "in a vibrant physical, intellectual and cultural environment." The SOE believes that

> when breathtaking technological advances are commonplace and the impacts of technology are widely recognized, engineers and computer scientists require ever greater breadth and depth of mathematical and scientific cognition, combined with a sympathetic appreciation of social, economic, ecological, and human values. (*University of New Mexico Catalog*, 1999-2001, p. 335)

The SOE requires 18 hours of humanities and social science electives for an engineering bachelors' degree. Prior to 1999, the SOE had a long list of elective courses at introductory and nonintroductory levels. In 1998, however, UNM passed a core curriculum,[5] which all undergraduate students, including engineering, must complete as a part of their baccalaureate program. Its goal is to give all students at UNM "grounding in the broad knowledge and intellectual values obtained in a liberal arts education and to assure that graduates have a shared academic experience" (Faculty Senate, 1998, p. 1).

Considering that the core curriculum at UNM is designed for basic broad education, rather than general education that is specific to the engineering profession, STS-related electives have to become a part of the core so that engineering students can take such courses. The SOE can find out which departments in humanities or social sciences would be interested in offering STS-related courses and work with them to orient such courses toward engineering topics. With some financial support from the SOE, these departments are likely to offer such courses. Alternatively, the SOE could offer its own general courses on science and technology in society and engineering ethics, with the faculty trained in STS. It should be noted that very few faculty members in each individual discipline are as well prepared as interdisciplinary STS faculty who go through a strong theoretical and methodological base and a broad orientation. The STS faculty can have their main appointment in humanities or social sciences and a joint appointment in the SOE.

Both routes require a partial financial commitment from the SOE. The second route, however, is better for engineering education because the STS faculty is basically interested in teaching about S&T to science and engineering students; humanities and social sciences faculty members tend to be interested in expanding their departments. Furthermore, there is a need to have a partnership between the SOE and those teaching STS courses, so that specific needs of engineering education can be addressed, instead of individual departments providing a service to the SOE. Also, the second route is more economical because revenue generated in the form of tuition credit hours will go to the SOE. Generally, STS courses are very popular among students majoring in science and engineering. Students who have taken STS courses tend to have high regard for the experience gained. Classes are usually full. For instance, Science and Technology in Society at Rensselaer Polytechnic Institute (RPI) has more than 300 students every year. Unlike RPI, the University of Arizona is not a technical university. Yet, it attracts more than 170 students for general STS courses, even though these courses are not required.

With STS courses offered by engineering programs, the breadth of intellectual vision and dedication to engineering education will serve engineering students well into the future. Engineering students must learn about ethics and the social aspects of their profession. Engineers' pledge—to place service before profit, the honor and standing of the profession before personal advantage, and the public welfare above all other considerations—alone is no longer adequate in terms of the advancement and betterment of human welfare. The social and ethical issues involved with technologies in modern society, like any other knowledge, must be learned.

Notes

1. Different institutions use different names for STS-related programs, such as *science, technology, and society*; *science, technology, and culture*; *science, technology, and values studies*; *studies of science and technology*; *science, technology, and environment*; *technology and policy*; and so forth.

2. There are many STS-related associations such as the National Association for Science, Technology and Society; the History of Science Society; Philosophy of Science Association; Society for the History of Technology; the Society for Risk Analysis; the European Association for the Study of Science and Technology (EASST); and Environmental Studies Association of Canada (ESAC).

3. Other journals and popular publications in the STS field are *Social Studies of Science*; *Science in Context*; *Science Communication*; *Science as Culture*; *Science, Technology and Society*; *Science Studies*; *Environment and Behavior*; *Knowledge and Technology in Society*; *Technology and Culture*; *ISIS*; *Prometheus*; *Research Policy*; *History of Science*; *Philosophy of Science*; *History and Philosophy of Science*; *Minerva*; *Public Understanding of Science*; *Radical Science Journal, Issues in Science and Technology*; *Science and Public Affairs*; *Technology Review*; *Bulletin of Science, Technology & Society*; *Metascience*; and *Scientometrics*.

4. The Carnegie classifies a university as Research I if it offers a full range of baccalaureate programs, is committed to graduate programs through the doctoral degree, gives high priority to support of research, receives annually at least $40 million in federal support, and awards at least 50 Ph.D. degrees each year.

5. The elective core consists of lower division courses in four areas: social and behavioral sciences (6 credit hours), humanities (6 credit hours), second language (3 credit hours), and fine arts (3 credit hours). Approximately 40 electives to choose from provide basic introductory knowledge of different disciplines such as American studies, anthropology, art history, classics, comparative literature, dance, economics, English, foreign languages, history, geography, linguistics, media arts, music, philosophy, political science, psychology, religious studies, sociology, and theater.

References

Accreditation Board for Engineering and Technology. (2000a). *Accreditation policy and procedure manual*. Baltimore: Accreditation Board for Engineering and Technology, Inc.

Accreditation Board for Engineering and Technology. (2000b). *Criteria for accrediting engineering programs*. Baltimore: Accreditation Board for Engineering and Technology, Inc.

Durning, A. T. (1994, October). The history of a cup of coffee. *World Watch*, *7*(5), 20-22.

Faculty Senate. (1998). *Implementation of core curriculum*. Albuquerque: University of New Mexico, Office of the Registrar.

Hull, J. B. (1999, August). Can coffee drinkers save the rain forest? *The Atlantic Monthly*, *284*(2), 19-21.

Joy, B. (2000, April). Why the future doesn't need us. *Wired*, *8*(4), 238-246.

Kelly, R. E. (1999, October). How to be a star engineer. *IEEE Spectrum*, *36*(10), 51-58.

Kraft, M. E., & Vig, N. J. (1988). *Technology and politics*. Durham, NC: Duke University Press.

National Science Foundation. (1998). *Science and engineering indicators*. Washington, DC: Government Printing Office.

Perrow, C. (1984). *Normal accidents*. New York: Basic Books.

Postman, N. (1997). Defending ourselves against technology. *Bulletin of Science, Technology & Society*, *17*, 229-233.

University of New Mexico catalog. (1999-2001). Albuquerque: University of New Mexico, Office of the Registrar.

University of New Mexico: Information overview. (1999). Albuquerque: University of New Mexico, Office of the Registrar.

Vaughan, D. (1996). *The Challenger launch decision: Risky technology, culture, and deviance at NASA*. Chicago: University of Chicago Press.

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