ENGINEERING ETHICS IN TECHNOLOGY AND SOCIETY COURSES

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ENGINEERING ETHICS

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Introduction

University technology and society courses provide students with the opportunity to study professional or engineering ethics, but ethics seen in a different context from that of a formal engineering ethics course. Ethics can be the unifying core for such courses. The formal professional ethics course might follow one or more of several possible approaches: (i) use of relevant moral virtues as guides to making decisions, (ii) emphasis on consequences to all stakeholders, or (iii) application of rules or codes that must be followed. These approaches can lead to conflicting solutions. An ethical issue in technology is often like an engineering design problem in which the risks to the community and the responsibilities of the designers might suggest a pathway to the resolution of ethical conflicts. Following the thread of ethical concerns through technology and society courses can improve the student's background in dealing with the tension or discord experienced in making design choices.

The Engineering Ethics Course

Human values play an important part in technologies, and these include values related to what we consider to be good or bad things. These are moral or ethical values. Ethics is a domain in philosophy that deals with moral values and issues. There are also aesthetical values related to what we consider beautiful or ugly.

Engineers are faced with moral dilemmas that need to be analyzed and which are not just a matter of feelings and preferences, but include rational and moral reasoning. Engineering ethics involves more than simply teaching maxims: do not bribe, spy, or commit sabotage. It involves issues related to safety, environmental impact, privacy, and military use, each of which contains many potential moral dilemmas.

Technology from the design phase to its implementation and use is not a neutral activity, which has not been properly recognized by engineers and engineering education, and which often is missing in courses in which future engineers are taught to deal with ethical issues. The accreditation organization ABET identifies "an understanding of professional and ethical responsibility" as one of its required student outcomes.[1] There are different approaches to dealing with ethical or moral issues. One approach to ethical issues is based on virtues, that is, to take as a reference the moral qualities engineers should have, such as honesty, compassion, respectfulness, etc. Each decision is judged against these qualities or virtues. The decision that seems to be most in line with the relevant moral virtue(s) is considered to be the best decision, even if it means that certain rules are broken with negative consequences. These approaches can be found in the ethical codes of professional engineering organizations such as the *IEEE Code of Ethics*.[2] Another approach is based on consequences,[3] which requires an estimation of the totality of effects on all players involved. The best decision is considered the one which makes most of the players happy, and should involve the following steps:

1. Decisions are made about which technology will be the focus of the study.
2. A description of that technology, including its expected developments, is presented.
3. An analysis will be made of all social factors that are involved in the process.
4. An analysis will be made of all effects that can be expected.

The third approach is based on guidelines and rules which must be obeyed, independent of the situation. However, the rules are not necessarily exact and may only suggest possible directions for solutions.

Caroline Whitbeck[4] has suggested a creative approach to solving ethical issues as if they were design problems. Design problems and ethical problems have in common that they are not well defined.

Two additional issues need to be considered when dealing with ethical problems in engineering and its consequent educational implications: risks and collective responsibility.

Finally, a less prominent, but important aspect of technological development is the aesthetical side, since it evokes positive feelings like the experience of beauty and happiness and can use some normative criteria and logical reasoning in finding an adequate solution.

The fact that proper logic and norms can be used in ethics and aesthetics of technology is the surprising element in teaching and learning about technology, and students should be encouraged to discuss these aspects when designing engineering systems and products.

We have discussed three common ethical approaches. The ethics of rules puts special emphasis on the structure of activities; the ethics of consequences is geared towards the results of the actions in a specific context; and the ethics of virtues concentrates on the actors, looking at the question of how to give directions. When we look at the three different ethical approaches, it seems that a clear connection can be made with the concept of practice. The ethics of rules focuses mainly on the constitutive side of practice. The ethics of consequences, on the other hand, looks at the contextual side of operational practice. The ethics of virtues is focused on the regulative side of operational practice. These different perspectives are summarized in Table 1.[5]

Table 1. Different Perspectives about Ethics

Ethics of	Perspective of action	Dimension of the action	Side of practice
Rules	Activity	Structure	Constitutive side
Consequences	Situation	Context	Contextual side
Virtues	Actors - Stakeholders	Direction	Regulative side

The teaching of ethics can be rooted in broadly accepted philosophical or religious values (as discussed above), or it can be can be rooted in human history and experience. This observation leads us to consider the history of technology course.

The History of Technology Course

Two of the authors of this work teach history of technology courses at different universities, and, as it might be expected, have different approaches and emphases. We report here our combined experience. Sometimes the history of technology course has a North American focus. There will be discussions about nineteenth and twentieth century American inventors and their inventions such as Eli Whitney and his system of manufacturing, Cyrus Hall McCormick and the reaper, Thomas Alva Edison and the light bulb, and Peter L. Jensen and the loudspeaker, to name just a few. There will also be discussions of the historical importance of education, patents, and government, factors that drive the development of technology. It is often the instructor's wish that at the end of the term the student will appreciate some of the contributions of the men and women who over the years were important in shaping current technology. The history course emphasizes the excitement of innovation and the benefits that new products bring to the consumer.

By examining the history of technology we discover why technology is now such an ever present and ongoing force in this country. We look at the history of human use and development of tools, technology, and whole systems. To provide a context, we go back to the development of crop agriculture in the Middle East some 10,000 years ago since this and the later development of the same by Amerindians heavily influenced the cultures of the peoples of the Americas both native and immigrant. We also look at scientific developments in Europe and Asia and their influence on parallel developments in the U.S. Some courses emphasize biographical studies of the inventors when these are known. The student is introduced to their lives, interests, and motivations. Men and women such as these in many ways model the virtues of work and creativity that have been the foundation and driving force for the emergence and evolution of technological progress. We highlight the creative work of many distinguished individual scientists, engineers, and technologists. We might examine idiosyncrasies (i.e., Edison's disdain for alternating current and Lindbergh's opposition to U.S. entry into World War II) that were a significant part of human experience.

In much of the course we applaud the technological developments we study, but as we move through the twentieth century and beyond, we consider the challenge of a growing technological military capability, the challenge of proper use of resources, and the impact of computer devices on contemporary culture.

Students will see human culture as they received it as permeated with the creations of many individuals. Since it is not possible to undo this, the citizen strives to understand it and learn new ways of coping with a technological culture.

The course exists in the university curriculum since it explores cultural and intellectual forces that have shaped society, individual creative activity, and human values. It is hoped that it will give the students the concepts and perspectives necessary for coping with contemporary life. It will be part of their growth in their abilities to see the connections that exist between peoples and technologies.

Not every history of technology course includes ethics, at least formally. What we often do is to analyze historical events in comparison with related current developments and, informally, look into their ethical aspects. For example, Chinese efforts to repair bridges and roads circa 700 AD, frequently done as an act of penitence for individuals, relate to the current infrastructure crisis in the U.S. and to the ethical dilemma involving spending billions of dollars in solving this crisis versus investing in new developments. Another example relates the "green revolution" that introduced fertilizers and insecticides to the "genetically engineered food" issue that evolved from that and the ethical decisions that we face today. Other examples would be the abusive labor practices that characterized the beginning of the Industrial Revolution in England and the not-so-different practices used today by multinational corporations in developing countries. Yet other examples involving ethical considerations are campaigns against the destruction of the rain forest in South America or air pollution in China and Russia, when those practices were accepted in the past and, as some allege, critical to the industrial development of Europe and the United States.

As taught by one author of this paper, these courses have been offered under different titles to freshmen, as part of their core courses, to "Global Honors" students, and to engineering and technology students. It has been proposed to be part of the university's study abroad programs. Arnold Pacey's *Technology in World Civilization*[6] has been used, with additional materials from different sources, including the Web. Reference sources that are only descriptive, like the *National Geographic Concise History of Science and Invention*[7] have been incorporated as well.

The format of the courses usually includes presentations by the students who, in groups of two or three, prepare the material for each class and discuss it with participation of the instructor and all students. A second component includes a number of on-the-spot written essays done in class in which students are asked to comment on an article or statement taken from the media or the Web, that normally involves taking an ethical position regarding a current affair (Net neutrality, fracking, and transfer of technology are good examples). And the most important part of the course, and a key component of the grading, is a research paper where students choose their own themes. In that paper, for example on nuclear energy, students need to address the history of that technology, its impact on society, the future perspectives, and the ethical implications of that technology. Important parts of this research paper are peer-review before the final version of the paper is turned in and presentation to the class at the end of the course.

Below, is a list of topics chosen in the 2013-2014 academic year by students in the Global Honors program:

1. Everyday Services, Complex International Politics
2. The Future of Printing: 3D Bioprinting
3. Genetically Modified Technology and Food
4. Geographical Information Systems
5. Advances in Prosthetic Technology
6. Music and Therapy: What is real? What is folklore?
7. The Printing Press
8. The Development of Nuclear Weaponry
9. Unraveling the Filaments of Batik
10. Healthcare Revolutionary: Electronic Medical Records

11. Khipu Language of the Incas.
12. Terracotta Army: March on to the Contemporary World

The topics selected in 2014-2015 were quite different:

1. From the Post Office to Globalization: How the Airplane Changed the World
2. The Decentralization of Connectivity
3. Prosthetics as a Global Technology: Crossing Demographic Borders
4. Telemedicine in Global Context
5. Social Networks: Effect on a Globalizing World
6. Smartphone Social Takeover?
7. The Global Relevance of Genetically Modified Organisms
8. Radio Frequency Identification: New Contribution to Global Economy
9. E-Commerce
10. Fiber Optics
11. Social Media and Human Rights
12. Cloud Computing: Applications and Corporate, Social and Global Concerns

As it can be seen from the topics chosen, the ethical aspects of new technologies were a common theme in most if not all the papers submitted. Because most of the Global Honors students come from non-technical areas (business, education, social science, etc.), the objectives of the course included a focus not only on the ethical concerns of the new technologies, but also on an understanding of the technologies. As the course is scheduled again for next academic year, a new textbook and a new approach for the presentations and the research project will be used.

The university central administration conducted an assessment of this course. In the 2014-2015 academic year, students were asked to complete various statements:

The course was: excellent (33%), very good (25%), good (33%), fair (8%).
The intellectual challenge was: excellent (33%), very good (42%), good (25%).

With a possible high rating of 7.0, the average intellectual challenge question was 5.5. A final question dealing with the amount of effort required to succeed in the course yielded an average of 5.8 out of 7.0. For the previous academic year, the numbers were generally higher. For the first statement the percentages were excellent (73%) and very good (27%). The numbers for the second question were excellent (82%) and good (18%). The intellectual challenge question gave an average of 5.9 and the effort question resulted in a 5.8. The instructor surmises that blame for the declines shown should be shared by the students and instructor alike.

Lectures and discussions in the history of technology course often lead to conversations with students about the moral dilemmas highlighted by technologies and human events. Often these conversations are secondary to the principal focus that is the description of the technology being considered and its sources. However, as seen in the next section, the technology and society course has technology related moral dilemmas as its primary focus. Technology history does, of course, continue as a significant secondary emphasis

The Technology and Society Course

The technology and society course analyzes the behaviors and consequences of technology as viewed as a human endeavor, considers the structures and constraints created by the technological enterprise, and exposes the conflicts technology creates in society. Topics in the social impact course include the influence of technological media, the increased mechanization and automation of warfare, cultural change promoted by new technologies, and the reshaping of the earth itself through technology. Such studies lead to the question of whether or not the human impact can be devastating on one hand or liberating on the other hand. This course is taught with a world vision even though a local or regional focus is helpful in order to connect with the student.

An understanding of the social impact of technology on human life can make engineering ethics more relevant and vital to an engineer's career. The student develops ethical discernment through criticism of technological development and observation of its progress and consequences nationally and internationally.

In the Fall Semester 2014 offering of the technology and society course at a different university, we approached assessment from a different perspective. We conducted a voluntary survey of student opinion as to what topics dealing with ethics were covered in the course. The students were given freedom as to how they would respond: an essay, a list, a list with each topic discussed, etc. The responses were then coded. There were 111 different distinguishable topics mentioned by the 34 students that took part in the survey.

The results were arranged in a spreadsheet that was 34 columns wide by 111 rows. The spreadsheet was sorted by the total number of responses per student and the total number of selections for each distinguishable topic. The students gave a total of 277 responses or an average of 8.15 items per student. The number of student responses ran from 1 to 17 per student. The topics were selected from a low frequency of once to a high of 12 times with an average of 2.50 selections per topic.

If the authors were to analyze the technology and society course on their own based on the textbooks and course content, they probably would not have done as thorough a job of selecting content items or topics as the 34 students did. The instructor in the course attempts to present the course in a conscientious manner, but the intent is not to spend the entire semester teaching ethics. The course detailed plan includes many topics such as:

1. The Natural World
2. Application of Engineering Tools Urban Problems
3. Rachel Carson and the Environment
4. The Social Impact of Radio and Television
5. Total Mechanized Warfare
6. The Atom Bomb and Its Consequences
7. Three Mile Island, Chernobyl, and Fukushima Daiichi
8. Mega Dams for Hydroelectric Energy
9. Genetically Modified Organisms
10. Global Climate Change.

Certainly discussion of ethics is done, consciously or unconsciously, but the results are still genuinely surprising. Students on their own recognized moral content in a large number of the topics covered in the course. Early in the semester there is a unit on ethics, commonly held human rights, and ideals or virtues admired commonly among humans. Examples are shown in the student selections such as professional ethics, duties to others, and human rights, when one considers the number of responses greater than the average.

The general course outline can be discerned of going through the list, especially when focusing on those subjects chosen at least four times (see Table 2). Even topics mentioned by students only two or three times (Table 3) were, for the most part, related to the topics mentioned four or more times (Table 2).

There are some topics that were hardly mentioned in the course, but were still noticed by the students. Some examples are prisoners of war (only mentioned in exam study questions), land mines (brief mention in a film), cloning (from one of the textbooks), ageism and sexism (might have been mentioned when workplace ethics were discussed), humane treatment of animals (mentioned briefly in a film), and Roosevelt's Four Freedoms (mentioned on course website). The remaining responses are shown in the Appendix as Tables 4 and 5.

We can draw on professional ethics for insight on finding solutions to the problems technologies can create for human society. Thoughtful consideration of these approaches can lead to a concept of duty to others that can undergirds our efforts to find solutions to societal issues presented by modern technology. This concept is introduced early in the technology and society course. Professional ethics leads to consideration of business social responsibility and to the idea of duty to society. Further motivation comes from a study of virtues, rights, and the perspectives of one's cultural heritage, represented, for example, by the writings and speeches of leaders such as Abraham Lincoln. In the material that follows, we will outline the various ethical perspectives that are used in the course and could serve as sources of the student observations.

For people of many religious or philosophical traditions, any object or system designed by a human has built-in values. Almost any object can be used for evil, but most objects by their very nature have an obvious value, good or evil, which may speak louder than the natural value. This helpful perspective is due to Adams.[8]

Over the years students in the course have asked one instructor what his basic convictions were. This led to the formulation of a set of basic human rights, some suggested by students, to be used in the course, which has been called Basic Human Rights. Currently there are five:

1. Treatment for Pain
2. Essential Food
3. Education for Participation in Government
4. Clean Air, Water, and Land
5. Treatment by Others with Dignity and Respect.

Table 2. Topics mentioned by students with frequencies of 4 to 12.

No.	Topic	Subtopic	Frequency
1	Atomic Bomb	Morality of Use	12
2	Chemicals	Insecticides and Herbicides	12
3	Hydro Dams/Three Gorges	Human Impact	11
4	Genetic Engineering in Agriculture	General	9
5	Nuclear Energy	General	9
6	Genetically Modified Organisms	Farming	7
7	Drones	Morality/War	6
8	Hydro Dams/Three Gorges	Cultural Antiquities	6
9	Maxim Machine Gun or Gatling Gun	Morality	6
10	Rights	Human	6
11	Carson	Rachel Carson/*Silent Spring*	5
12	Chemicals	Chemical Warfare	5
13	Duties	To Others	5
14	Atomic Bomb	Testing	4
15	Cell Phones	General	4
16	Electronic Media	General	4
17	Ethics	Professional	4
18	Internet	General	4
19	Internet	Responsible Use	4
20	Lincoln	Lyceum Speech/Other Speeches	4
21	Smart Weapons	General	4
22	Social Networks	Cyberbullying	4

Contemporary thought is shared as a motivation for students. Sider[9] approached this problem from a more general perspective that he calls "Seven Principles for a Political Philosophy":

1. Everybody should have power, not just a few.
2. The poor deserve special care.
3. Every person should have the capital to earn a decent living.
4. Maintain the balance between freedom and justice.
5. Always think globally.
6. Protect the separation of church and state.
7. Understand the limits of politics.

Table 3. Topics mentioned by students with frequencies of 2 or 3.

No.	Topic	Subtopic	Frequency
23	Atomic Bomb	Exposing of Military in Testing	3
24	Atomic or Hydrogen Bomb	General	3
25	Cell Phones	Improving Life - Low Income Countries	3
26	Cloning	General	3
27	Energy	Electricity	3
28	Energy	General	3
29	Fossil Fuels	Environment	3
30	Fossil Fuels	Health	3
31	Land Mines	Use	3
32	Rights	Right to Know, Privacy, Safety	3
33	Robots	Benefits	3
34	Value-laden	General	3
35	Values, Self	General	3
36	Weapons	Bombing Civilians	3
37	Weapons	Dum-Dum Bullet	3
38	Ageism	Business	2
39	Coal	Global Climate	2
40	Coal	Health	2
41	Distributive Justice	Politics	2
42	Environmental Values	General	2
43	Ethics	Dilemmas - Resolution	2
44	Ethics	Professional, Handout	2
45	Food	Production	2
46	Fossil Fuels	Extraction - Use	2
47	Genetic Engineering	Dangers	2
48	Hydro Dams/Three Gorges	Benefits	2
49	Hydro Dams/Three Gorges	Flooding	2
50	Morals	Human	2
51	Nuclear Energy	Dangers/Waste	2
52	Professional	Decision-Making – How to Decide	2
53	Professional	Unique Position	2
54	Safety	Business	2
55	Sexism	Business	2
56	Social Networks	Improvements	2
57	Transportation	Growth	2
58	Values, Human	General	2
59	War	General	2
60	Weapons	Evolution	2

Sider's principles are quite general, but most support the concerns of the technology and society course: wise use of technology, safety, distributive justice, and practical efforts to improve life for all.

In his book *The Living Planet*, David Attenborough[10] shares an environmental philosophy that points out critical issues that can be helpful to students. In his "World Conservation Strategy," he states three imperatives:

1. We shouldn't so exploit natural resources that we destroy them.
2. We shouldn't interfere with the basic processes of the earth upon which all life depends, in the sky, on the green surfaces of the earth, and in the sea.
3. We should preserve the diversity of life.

The rights and duties we have mentioned above were reflected to some extent in the 111 distinguishable topics garnered in the study of class opinions (Tables 2 through 5). Class discussion can be drawn away from a battle between politicians on the left and right and focused on the actual outcomes of policies or actions by engineers and technologists. For example, Pfeiffer and Forsberg[11] highlight virtues that students can model: honesty, gentleness, fidelity, autonomy, confidentiality, and lawfulness. They also introduce various concepts of justice. When studying technology and society, distributive justice is a major concern: How are society's benefits and burdens to be distributed among the population?

Abraham Lincoln's thought has been helpful in pointing out the historical commitment to certain principles commonly shared by many. Lincoln demonstrated a thoughtful appreciation for nature in his Niagara Falls essay.[12] He spoke passionately about the importance of protection of one's homeland[13] that can be interpreted to include environmental concerns. In terms of political rights, he was convinced that modern democratic political systems should be preserved in order to benefit all future generations. Even today the respect of Lincoln is widespread enough that his thought can serve as common ground for students and faculty. It is the rare comedian that will chance a joke that denigrates Abraham Lincoln.

A Reflection

A few years ago one of the authors of this paper went to a grocery store and was examining some fruit. Surprisingly, the fruit was labelled as having come from an area where he, years before, had worked on an irrigation project. Subsequently, it became clear that this project had led to a social transformation through the economic benefits brought to the region. From this we can see that a successful engineering project engaged in for the benefit of our fellow humans has a positive effect in its own right as well as bringing joy and satisfaction to the responsible engineers. Ethical application of engineering skills is more than simply obeying the laws of the community. It has social consequences. If the engineering student will "buy into" this, she or he can more easily connect with the philosophical and ethical analyses and tools that are being taught and should be able to enhance the probability of completing future projects successfully, especially if both short-term and long-term results are considered.

Teaching Professional Ethics

The authors are enthusiastic about introducing or improving the teaching of engineering ethics for our students. A top priority is to have an engineering ethics course required for all engineering majors. Next, we hope that many will see the value of offering a course dealing with technology and society similar either to the history of technology course or to the social impact of technology course described in this paper. We see both of these courses as being very valuable preparation for the formal engineering ethics course.

The courses taught by the authors are examples of what should be useful in other institutions. However, the topics covered will vary widely from instructor to instructor and from institution to institution. Choosing a textbook is a challenge. We recommend considering Pacey[6] and Volti.[14]

Future Challenges

In general, the effectiveness of what we would characterize as a concerned but low-key effort to motivate students to enter their engineering careers with some tools to deal with the complex issues in ethics they will face shows at least some hints of effectiveness. We don't imagine changing our approach or methods of teaching at present as a result of this study. We do think that future studies of student impact will be worthwhile both by repeating the type of survey presented here and perhaps by more direct studies of student opinions.

Conclusion

When taught as part of the approved university general education core curriculum or as part of the university global honors program, these courses offer a unique opportunity for connection of students to significant concerns in the ethical practice of engineering. Future technical innovations will become part of the fabric of human existence on this planet. Study of the wise use of technology contributes to the education of engineers who can deal responsibly with the ethical challenges that new experiences and new technologies will bring.

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Appendix I. Additional Details about Student Responses

In the Technology and Society Course

Table 4. Topics 61 to 85—each one was mentioned once.

No.	Topic	Subtopic	Frequency
61	Agriculture	General	1
62	Animals	Humane Treatment	1
63	Atomic bomb	Development	1
64	Atomic bomb	International Impact	1
65	Automobile	Efficiency	1
66	Culture	Tech Effects	1
67	Electronic Weapons	Missiles	1
68	Energy	Renewable	1
69	Energy	Renewable – Wind, Solar	1
70	Ethics	Business	1
71	Ethics	Engineering	1
72	Ethics	Whistleblowing	1
73	Everything	Covered in Course	1
74	Food	Rich vs. Poor Countries	1
75	Four Freedoms	FDR	1
76	Free Speech	General	1
77	Genetically Modified Organisms	Patents	1
78	Greenhouse Gases	General	1
79	Human Life Quality	Parks/Parking Lots	1
80	Hunger	World	1
81	Interaction	Organizations and Technology	1
82	Interaction	Resources and Growth	1
83	Internet	Fake Identities	1
84	Internet	Plagiarism	1
85	Justice	Types	1

Table 5. Topics 86 to 111--each one was mentioned once.

No.	Topic	Subtopic	Frequency
86	Lesser Developed Countries	Difficult Survival	1
87	Manufacturing	General	1
88	Minerals	Use	1
89	Native Americans	Culture	1
90	Nature	Tech Effects	1
91	Nuclear Energy	Fukushima	1
92	Patents	Early Disputes about TV	1
93	Pfeiffer/Forsberg	Politics	1
94	Politics	Principles of a Political Philosophy	1
95	Pollution	General	1
96	POWs	Treatment	1
97	Rights	Future Generations	1
98	Rights	Individual - Public	1
99	Robots	Dangers	1
100	Science	Development	1
101	Social Networks	Privacy	1
102	Social Programs	Tech Company	1
103	Technology	Ethics of Use to Extend Life	1
104	Textbooks	All	1
105	Textbooks	Barbour	1
106	Virtues	Autonomy	1
107	Virtues	General	1
108	Virtues	Honesty	1
109	Virtues	Lawfulness	1
110	War	Rules of Engagement	1
111	War	Technology	1