Engineering Ethics Education at Texas A&M

Charles E. (Ed) Harris, Jr.

Professor of Philosophy, Texas A&M University, Emeritus

Sue and Harry Bovay Professor of the History and Ethics of Professional Engineering, Texas A&M University, Emeritus

My work in engineering ethics began in the late 1980s. Over the years it has included creating and teaching in the engineering ethics course at Texas A&M, co-authoring a textbook, participating in grant-funded projects, giving talks at professional meetings in engineering and philosophy, and publishing in the area. I will not cover all of these activities here, but in thinking about this history, I can identify two themes of special importance. First, in my experience, the reception of the developing academic field of engineering ethics has had both encouraging and discouraging aspects, with the encouraging aspects predominating. Second, in my own work at least, there has been an evolution from what I call preventive ethics ("Do no harm.") to what I have called aspirational ethics ("Promote the human good.")

In this essay I first chronicle the evolution of the engineering ethics course at Texas A&M and consider some of the encouraging and discouraging experiences along the way. I then discuss the history of the textbook, *Engineering Ethics: Concepts and Cases* and how the issues that emerged in writing the textbook relate to engineering ethics education. In the remaining sections I describe my increasing interest in aspirational ethics and how this orientation can contribute to the continuing vitality of the discipline of engineering ethics and to engineering ethics education.

History of the Engineering Ethics Course

My involvement with engineering ethics education began on a very ordinary day in the late 1980's, when a gentleman walked into my office and said my department head sent him my way, because I had published a textbook in applied ethics. (Harris 1986). Michael J. Rabins, Professor of Mechanical Engineering, said that he and some engineering colleagues were working on a grant proposal to the National Science Foundation (NSF) and were told by a NSF representative that they needed a philosopher on the project. The other co-Principal Investigators turned out to be Raymond. W. Flumerfelt in chemical engineering and Charles. H. Samson in civil engineering. The proposal was to develop ethics case studies for use in required undergraduate engineering courses and was eventually funded by the NSF in 1990 for $107,730. In the ensuing years I have been a part of several successful proposals to the NSF, amounting to more than $450,000.

Several of these grants reflected the two major approaches to teaching engineering ethics. Developing ethics cases for engineering classes was intended to contribute to the ethics-across-the curriculum approach, where instructors present ethics material in their engineering courses. Other grants to train engineering instructors to participate in a course in engineering ethics and to develop appropriate material for such courses were intended to contribute to the free-standing-course approach. At Texas A&M, engineering administrators decided early on that the ethics-across-the-curriculum approach was not appropriate for this campus, because of the size of the College of Engineering and the consequent problems that would be incurred in administering such a program. One of the administrators responsible for this decision was Professor Don Russell, a member of the National Academy of Engineering who later became the Bovay Professor of the History and Ethics of Professional Engineering in the College of Engineering. Professor Russell has been a dedicated supporter of the engineering ethics program from the beginning to the present.

The engineering ethics course began in the early 1990s when Professor Rabins and I initiated a "Special Topics" course in engineering ethics, which enrolled approximately 25 students the first semester. The course soon became a regularly-scheduled course and grew to an enrollment of approximately 150 students each semester, consisting almost entirely engineering majors. When the College of Engineering required all engineering students to enroll in the course as a fulfillment of one of their humanities requirements in the core curriculum, the course quickly doubled in size to approximately 300 students each semester.

Professor Rabins and I were the only instructors in the course for many years. In order to serve the large number of students, we adopted a format of two one-hour lectures and a recitation session on Thursday or Friday led by Teaching Assistants (TAs). The TAs were all philosophy graduate students in the beginning, but, later, engineering graduate students came in to help staff the recitation sections. While the engineering students often had to be tutored in issues related to ethical methodology, they were highly motivated and usually became very successful TAs. They were selected because they had done well in the undergraduate course at Texas A&M and showed a strong interest in the subject matter. The engineering TAs were also able to help the philosophy TAs better understand the engineering aspects of the course.

The two lectures on Monday and Wednesday covered basic material which was presented either by Professor Rabins or me, or by engineering instructors who had shown an interest in the engineering ethics program. Some of the engineering instructors came in to present special lectures, while others eventually became co-instructors in the course. The original vision was to have engineering and philosophy instructors dialogue during the lectures, but this vision did not work out successfully. Usually either an engineering or philosophy instructor presented the entire lecture. Sometimes an engineering instructor would present a case and the philosophy instructor would discuss the case and other material in the next lecture. Because the lecture sessions had more than 300 students, we were not able to have as much discussion as we wanted. The present format of the course, described shortly, has turned out to be much more effective in eliciting student participation.

The Friday sessions, comprised of approximately thirty students each, covered a variety of issues: reviews of, or supplements to, the lectures; new material presented by the TAs; preparation for the in-class multiple choice exam; systematic discussion of issues relevant to the term paper due at the end of the semester; presentations by students on ethics cases; and other material helpful to the students. The Friday sections had far more student participation, and students generally found the sessions very helpful. In fact, many students preferred them to the lectures, and the TAs often received high ratings at the end of the semester. In addition to teaching, the TAs had the responsibility of grading the essay part of the mid-term exams and the term papers. The multiple choice part of the mid-term exams, prepared by the instructors, was machine graded, and the final exams were all multiple choice, since final grades in the course were due only a few days after the final exam. Students sometimes complained that the multiple choice exams were "tricky," but we often found that the complaints resulted from an insufficient mastery of the material.

In the fall of 2014, after my retirement in July of that year, another significant change occurred. As a result of a mandate from the Dean of Engineering, all lectures in engineering courses (including the ethics course) were reduced to a maximum of 100 students each. With only two full-time philosophy instructors available and an enrollment of more than 800 students, each instructor took responsibility for four "lectures," which are now called "face-to-face" (F2F) sessions, to emphasize the importance of class participation. Each F2F session lasts 75 minutes, and the recitation sessions, still conducted by the TAs, are two hours in length. Each instructor appears in the classroom four times each week. With additional students taught in summer classes, the course now accommodates approximately 2000 students each year.

Another modification, introduced before 2014, became an integral part of the new course format. Students are required to view one on-line presentation each week before the F2F session. The on-line sessions cover some of the basic material for the upcoming F2F session, and students take a graded on-line quiz on the material. The on-line sessions may be viewed at the student's discretion, as long as the viewing is before the F2F session. Given the nocturnal habits of many students, some of the viewings are done late at night or in the early morning hours.

The use of the online material has turned out to be very popular with the students. They generally seem to enjoy the videos, some of which I produced, and the pre-F2F exposure to the basic ideas to be covered in lecture ensures that students come to the F2F sessions with some knowledge of the material. With the size of the sessions reduced from over 300 to 100 students, and students prepared ahead of time for the sessions, discussion has become an important part of the of the F2F—hence the term "F2F" instead of "lecture." The sessions often begin with a brief review of the material or with discussion of a case relevant to the material, usually presented by an engineering instructor. Student response to these innovations has been very positive.

Varying Degrees of Support for the Engineering Ethics Program from Students, Faculty, and Administrators

From the beginning, many students gave a positive response to the course. They acknowledged the importance of the subject for their professional career, and many considered it a welcome relief from their required technical courses. Insofar as they were not supportive, some of the criticism was directed at the large size of the lectures and the multiple choice exams, which are indeed not entirely appropriate for liberal arts courses. However, almost from the beginning, the mid-term exams had an essay component. The multiple choice exams, furthermore, covered primarily the factual material presented in the course. Term papers written outside of class and short written assignments in the recitation sections were also a part of the course. Since the change to F2F sessions, however, student reaction to the course seems to have become much more—and in fact predominantly-- positive.

Another source of student complaint about the course was that some students, especially computer science majors, did not see the relevance of the class to their major. Again, there was some basis for this objection. We did find a few cases in which computers played a central role, but most of the cases were from civil and mechanical engineering. Very frustrating to instructors, however, was the seeming inability of some students to generalize from one area to another. "Can't they see," I would often ask myself, "that issues of conflict of interest, or confidentiality, or professionalism can also come up in computer science, even if the case at hand is about a civil engineer?" We are now in the process of developing a course in cyber ethics which may draw out students in computer science from the larger course. With majors from twelve engineering programs in the course, however, it is not possible to develop a specialized course for each major.

Another factor that has affected the student reaction to the course is the changing nature of the student body at Texas A&M. Now drawing primarily from Houston, Dallas, Austin, and other metropolitan areas, instead of rural areas, students seem more attuned to social and ethical issues and more open to taking a critical attitude toward the value and effects of technology. Engineering students are now not put off by a discussion of the downsides of technological advancement and the need to modify technology in order to remedy, if possible, the downside effects.

The reactions of faculty, both in philosophy and engineering, have varied widely. For many years, I was the only faculty member in the philosophy department who wanted to teach the course. Several other members of the Department tried their hand at the course when I was on a development leave or had other responsibilities, and their reaction was usually negative—towards the engineering students, the engineering faculty involved in the course, and the subject matter of the course. One colleague who had not taught the course but taught engineering students in his classes complained that the students would not think in terms of principles. If a principle was accepted in one moral argument, the same principle could be rejected in another moral argument, with no concern for consistency. Another faculty colleague called me a "saint" for teaching the course and vowed never to teach it again. While some faculty have come to appreciate the value of the course, even now only a very few, other than the two present instructors, want to be involved in it. No doubt much of this reluctance is because the course departs too much from their own professional interests.

In the College of Engineering, we found that many instructors were uncomfortable with teaching ethics material and were happy to hand off the job to interested faculty members in engineering or to Liberal Arts instructors. The assumption was that they would do whatever is needed to meet the requirements of the Accreditation Board for Engineering and Technology (ABET), which mandates some exposure of engineering students to issues in ethics and social responsibility. Support varies widely from one engineering department to another. In the early days, the Department of Mechanical Engineering—Professor Rabins' department—was the primary supporter. Later the Department of Civil Engineering became (and continues to be) the primary supporter of the program, probably in part because many civil engineers go into private practice or must have the Professional Engineer (P.E.) designation in their work. Faculty members in some departments, by contrast, seem to make it a point to tell their students that they do not need the P.E. license.

From the beginning, some engineering faculty have been enthusiastic supporters of the course. In addition to the support of Professor Russell, Professor Mark Holtzapple, a chemical engineer, was an important part of the course for many years, presenting the lectures on environmental ethics and eventually becoming an engineering instructor in the course. Professor Walter Daugherity, a computer scientist, Professor John Poston, a nuclear engineer, Professor Robin Autenrieth, a civil engineer, and several other engineering faculty have been enthusiastic participants in, and supporters of, the course. Professor Ray James, a civil engineer, provided essential computer support for many years, and served as an instructor in the course. Eventually he became a co-author of the textbook.

Support for the program on the part of administrators in engineering and Liberal Arts has varied. In the earliest days, engineering administrators such as Professor Russell, gave considerable support. More recently support by the deans of both engineering and Liberal Arts has declined, probably due in part to the expense of paying for the large number of TAs needed to staff the course. Outside the University, many have given support and friendly criticism. Philosopher Professor Michael Davis, psychologist Professor Muriel Bebeau, and many members of APPE have written material used in the course and the textbook.

Special mention must be made of the support of Mr. Harry E. Bovay, Jr. of Houston, Texas. Mr. Bovay, a civil engineer and member of the National Academy of Engineering, established an endowment for the Bovay Professor of the History and Ethics of Professional Engineering in the Philosophy Department, which I occupied, and later a similar position in the College of Engineering. He also established a similar position at Cornell University, his alma mater. Mr. Bovay and his assistant, Mr. Mike Patrick, now the President of the Harry E. Bovay, Jr. Foundation, have also supported the program with their time, attending the Bovay lecture whenever possible and hosting the engineering ethics faculty in Houston for meetings and other events. Mr. Bovay's financial support was also instrumental in the founding of the Online Ethics Center at the National Academy of Engineering.

At Texas A&M, Mr. Bovay's gift of $500,000 constituted the core financial base of an endowment for the engineering ethics course. In the early days of the course, the endowment enabled students to attend and compete in the Ethics Bowl at the APPE conventions and elsewhere. More recently, the endowment has enabled us to invite outstanding engineers and other figures to give the Bovay Lecture each semester. My all-time favorite Bovay lecturer was Dr. Bernard Amadei, civil engineer and founder of Engineers Without Borders (EWB). During his visit, he told the story of the incident that was instrumental in his founding EWB. While traveling abroad, he saw a little girl carrying water from the village well to her home. He assumed that the girl would be locked into a cycle of poverty, partially because of chores such as carrying water. He also knew that undergraduate engineers could create a water purification and transportation system that would vastly improve her quality of life. As I remember his words, he said, "That little girl changed my life."

The Textbook, *Engineering Ethics: Concepts and Cases*

Working through six editions of our textbook has been an adventure! Having secured a contract from Wadsworth Publishing Company, I immediately brought in as co-authors Professor Mike Rabins, my colleague from mechanical engineering, and Professor Michael Pritchard, a philosopher from Western Michigan University. After the death of Professor Rabins, his place was taken by Professor Ray James. Still later, Professor Elaine Englehardt , a philosopher from Utah Valley University, joined our list of co-authors. From the beginning, writing responsibilities were divided by assigning individual chapters in the various editions to different co-authors. The engineering authors had a special responsibility for the cases and for ensuring that the entire book was congruent with engineering knowledge and practice. My experiences with the co-authors over the years has been one of the most rewarding aspects of my career. Although we sometimes had disagreements, they were resolved amicably and usually resulted in improvements in the book.

The content of the book has evolved from a primary focus on preventive ethics, to inclusion of some aspects of aspirational ethics. Preventive ethics has to do with preventing harm to the public through professional misconduct such as having conflicts of interest, or preventing technology-based threats to the health, safety and welfare of the public by better engineering standards and practices. One of the ultimate preventive actions is, of course, blowing the whistle.

Aspirational ethics has to do with the use of technology to promote the welfare or quality of life of the public.

In the early years, engineering ethics was strongly influenced by engineering codes of ethics and by engineering disasters, such as the *Challenger* crash. The content of the first edition reflected this preventive-ethics orientation, giving a large amount of space to such issues as professional responsibility and impediments to responsibility, professional honesty, risk, safety, liability, employer-employee relationships, professional societies and their responsibility for enforcing ethics, preventing disasters, and whistleblowing. Even in the first edition, however, there was a chapter on the environment and discussions of ethical theories and techniques. The second edition continues the strong emphasis on preventive ethics and professionalism, but widens the scope of professionalism to include for the first time a chapter on international engineering professionalism. The content of this chapter included discussions of bribery, grease payments, nondiscrimination, human rights, paternalism, exploitation, and giving and accepting gifts.

The third edition has, for the first time, a chapter on computer ethics, covering issues such as individual privacy versus social utility, as it relates to intellectual property. The fourth edition has a full chapter on "The Social and Value Dimensions of Technology," covering topics such as the social consequences of technology, the interactions of technology and society, and the importance of designing with society and the environment in mind. This chapter might be considered one of the early appearances of the aspirational ethics theme. In the sixth edition the aspirational theme is emphasized even more. Chapter 1 is titled, "Engineers: Professionals for the Human Good," giving greater prominence to the aspirational ethics theme. This chapter brings forward the observation that in the 1970s engineering codes showed a profound shift of emphasis, from giving primacy to loyalty to clients to serving the public good.

The Subject Matter of the Engineering Ethics Course at Texas A&M

In a very general way, the changes in the subject matter of the engineering ethics course also reflected the move from preventive ethics to at least some aspects of aspirational ethics. In the early years, the focus was on (1) the "disaster cases" or what my colleague Professor Rabins called "media-splash cases," and on (2) core professional issues in engineering ethics, as outlined in the codes, such as conflicts of interest, confidentiality, not practicing outside one's area of expertise, and professional registration. The most important disaster case was, of course, the *Challenger* disaster. Roger Boisjoly visited our class for a Bovay Lecture, and we came to appreciate the sincere, unpretentious, and passionate nature of this good man, who sacrificed so much for professional integrity.

Especially in the early days of the course, we encountered more than a little student hostility toward moral reasoning, especially as it involved using classical moral theories. Ethical reasoning was "subjective"—the kiss of death for engineering students—in contrast to the "objective" and numerical content of their engineering courses. In an attempt to respond to this charge of "subjectivity," I developed several methodological approaches that I believe were helpful.

First, I developed further a set of distinctions, originally presented in an earlier publication (Harris, 1986), that are useful in understanding the types of issues that can come up in moral deliberation. I argued that most of the issues in a case could be classified as factual issues, conceptual issues, application issues, and what I sometimes called moral issues in the narrow sense, or perhaps better, conflict issues.

Many engineering students assumed that questions of fact are resolvable in an objective way, whereas questions about values are endlessly controversial. But questions about the facts relevant to resolving a moral problem are often highly disputed and sometimes cannot be settled satisfactorily. Still, a decision must be made. Engineers often have to make decisions in the face of partial ignorance, and they have to learn to make ethical and professional decisions under similar circumstances. I provided some guidelines for thinking about factual issues, which are often the most disputed aspects of an ethical controversy.

Conceptual issues are questions about the meaning or definition of an ethically-relevant concept. Engineers may have different definitions of "conflict of interest," and this difference can result in discussants passing one another in the dark, eliminating any chance of achieving a consensus. Rather than giving up on ethical controversies as "subjective," the conceptual issue needs to be resolved. Sometimes authoritative definitions can be found in professional literature or the law, but often this is not the case. Then an engineer (or a student in the class) must identify the conceptual issue in play and offer a definition of her own.

An application issue arises when there is a question about whether a concept applies to a given situation. Disagreement can arise either as a result of disagreement about the definition of the concept, or disagreement about the factual description of the situation, or both. In determining whether a situation counts as a conflict of interest, for example, inability to arrive at a consensus may come from one or both of these sources. In attempting to resolve the disagreement, disputants must produce a hypothetical of the following form: If we accept these facts and this definition of conflict of interest, then the situation is (is not) a conflict of interest.

Finally, it is possible to disagree on the moral evaluation of a situation, even after factual, conceptual, and application issues have been resolved. Such disagreements are commonly over the moral weight that should be attached to the relevant considerations. In deciding how much protection to accord intellectual property in a technical area, some may put more weight on protecting the results of one's creative work, while others may place more weight on the social utility of wide dissemination of technical knowledge. Such disputes about the proper moral weight that should be attached to certain considerations in a moral argument may be difficult to resolve. If argumentation does not produce a consensus, creative middle ways (discussed shortly) can be useful.

Second, I adopted the method of casuistry , which I called the “line drawing” method, for use in the course and the textbook. This technique can be used to resolve both application problems (for example, whether a situation involves a conflict of interest) and conflict problems (for example, whether an engineering manager should dismiss an engineer for one instance of having a conflict of interest). In the line-drawing method, a morally problematic case (a “test case”) is compared with cases that are similar in many ways, but where the moral evaluation is clear and not problematic. Looking at the similarities and differences between the test case and the unproblematic cases can aid in the decision about what should be done in the test case.

Third, I developed a method for finding what I call a “creative-middle-way” solution to a moral problem. Often moral problems involve conflicts between two or more competing and apparently incompatible moral demands, such as the right of a creator to profit from her own creations and the importance to society of broad access to new ideas in order to advance technology. The creative middle way, or what we might call a compromise solution, attempts to honor in some way, though perhaps not fully, all of the important moral considerations.

Fourth, I developed a series of “tests” for applying utilitarian and Kantian ethics, which I called the ethics of “respect for persons” or RP morality, that are still used in the course and the textbook. While recognizing that these large-scale theories are often not necessary and may even be counter-productive in moral deliberation, I pointed out that they can be useful in understanding and resolving some moral controversies, especially controversies about social policy issues such as the proper amount of protection to be given to intellectual property.

Several years ago my approach to the use of moral theories was further advanced as a result of a collaborative effort with engineer Dr. Donald Searing. Again, the approach was developed in part to address the often-repeated objection of students that moral theories are “subjective” because they do not always lead to the same answer to a moral dilemma.

We began with the observation that scientists and engineers are accustomed to using models, but also to recognizing a model’s limitations. We proposed that ethical theories are designed to model what is often called “common morality,” or the stock of moral beliefs to which most of us subscribe, but that these ethical models, like models in science and engineering, have well-known limitations. Given the limitations, it is useful to apply both theories to a complex issue. If the theories call for different courses of action, creative middle ways may sometimes be helpful in making a final decision about what is to be done.

Again, all of these developments can be seen as attempts to at least partially meet the charge of “subjectivity.” They are attempts to show that some so-called “moral” disagreement comes from either a deficiency of analytical clarity about precisely where the disagreement lies, or ignorance of methods of arriving at resolution or consensus. While I cannot claim that the methods deflected all criticisms, I believe they helped to show that moral reasoning has a strongly rational component and that many sources of disagreement can be identified and resolved.

Aspirational Ethics

In order to flourish, a discipline needs a steady supply of younger scholars who will continue the work of their predecessors. A possible concern in this regard is the relative paucity of young scholars in engineering ethics. At the APPE conventions, the academic home of engineering ethics, one sees too many gray heads! This contrasts with conventions for the philosophy of technology and Science and Technology Studies (STS), where younger scholars abound. I advance the following possible explanation for this situation: in contrast to philosophy of technology and STS, younger scholars do not see sufficient room for further research and development in engineering ethics. Looking at engineering ethics, they may be saying something like this to themselves: "There is only so much that one can say about the nature of professionalism (even if it is extended to the international arena), engineering registration, conflicts of interest, whistleblowing, preventing disasters, and the like. This does not seem like fertile ground for a lifetime commitment."

Another way of formulating this objection is to say that a discipline focused exclusively on preventive ethics may not be open-ended enough. In my opinion, enough truth exists in these concerns to warrant expansion of engineering ethics to include more topics in aspirational ethics. In contrast with preventive ethics, explorations into the nature of well being, the effects of technology on society and individual well being, designing for well being, and related topics seem to promise an almost endless horizon. Placing more emphasis on aspirational ethics may result in some convergence of engineering ethics with philosophy of technology and STS, but this may not be a bad thing. At any rate, I shall devote the rest of this essay to describing further my forays into aspirational ethics.

I have already said that aspirational ethics has to do with using technology to promote the public good. While it may be true that approximately 80% of the NSPE code—and most other engineering codes--is devoted to preventive ethics, statements in virtually every code point to a more positive task for engineers. A in the NSPE code says that "engineering has a direct and vital impact on the quality of life of all people." The Association of Computing Machinery (ACM) code says that members must "contribute to human well-being." The code of the American Society of Civil Engineers (ASCE) encourages its members to "work for the advancement of the safety, health and well-being of their communities…." The code of the Institute of Electrical and Electronics Engineers (IEEE) recognizes "the importance of our technologies in affecting the quality of life throughout the world."

Further evidence for the importance of aspirational ethics comes from the National Academy of Engineering (NAE). In 1999, the NAE engaged in a project to select the 20 greatest engineering achievements of the 20th century. The criterion was to be "the significance that each engineering achievement had on our quality of life during the 20th century." (Constable and Somerville 2003, p.242)

Aspirational ethics not only has a different aim from preventive ethics, but it calls for different, or at least additional, ethical concepts. Instead of emphasizing adherence to rules, many of them negative in character, aspirational ethics stresses the promotion of human well being, allowing considerable discretion and judgment as to how this is achieved. Thus, the element of personal motivation and commitment is more prominent, resulting in an a more intense focus on professional character. Character traits such as beneficence must be cultivated in engineers and manifested in promoting the human good. The long tradition of virtue ethics is probably more compatible with this orientation, and so I have emphasized virtue ethics in some of my later work. (Harris, 2008, 2013)

My **Bovay Lecture**

A venue for further development of aspirational ethics was my March, 2018, Bovay Lecture, a talk given to the Texas A&M engineering ethics class of approximately one thousand students. The title was "Making Life Hard Again: What We Can Learn from the Amish About the Complex Relation of Technology to Well-Being." In the lecture, I made the observation that, despite engineering commitment to promote well being or quality of life, an account of well being is not forthcoming from the engineering profession, nor is there any analysis of how technology promotes (or perhaps does not always promote) well being. These tasks seem to have fallen on philosophers, psychologists, sociologists, and economists.

Many accounts of well being exist, but there is considerable overlap and similarity. For the lecture, I selected Abraham Maslow's hierarchy of needs as the basis of my account of well being, making the assumption that the satisfaction of basic needs gives rise to (or perhaps is equivalent to) well being. Toward the end of his life, Maslow added a sixth level of self-transcendence to his hierarchy of needs, making six levels in all. Dividing Maslow's list of needs into three groups and giving each group a name, I came up with the following account. The first group, Physical Well Being, consists of needs for food, water, health, physical safety, and the like. The second group, Social Well Being, consists of needs for a sense of belonging, of love, and esteem. The third group, Personal Well Being, consists of needs for self-actualization and finally self-transcendence.

I proposed that as we move up Maslow's hierarchy, the relationship of technology to human needs becomes more problematic, or at least more complex. With regard to Physical Well Being, technology has been a major factor in lifting millions out of poverty, malnourishment and disease, due to poor sanitation, bad water, and deficient agricultural production. Most of us would consider these achievements to be goods of enormous importance. With regard to Social Well Being, while such technological innovations as social media can help people connect with and support one another, they can also have negative effects. With respect to Personal Well Being, technology's contributions to self-actualization and especially self-transcendence may be still more problematic.

My interest in the Amish is based on their thoughtful and critical attitude toward technology. Aware that technology is not value neutral, they understand that it affects the way we live and therefore our well being and quality of life. Their primary criterion for evaluating a technology is whether it promotes the well being of the community, and they have been remarkably successful in applying this criterion to promote their well being. In Amish communities, cancer and suicide rates are half of the national rate, and depression is low, despite a ten-fold increase over two generations ago in the general population and a 40% rise in teen depression just since 2011.

Many of the healthy features of Amish life probably come from their close family and community ties, but some may derive from their careful evaluation and use of technology. For example, while the NAE lists electrification as the most important single technological achievement of the twentieth century, the Amish see it as fraught with dangers to individuals and the community. Connection to the grid is to be avoided at all costs, and research gives some validity to their concerns.

Telephones eliminate exposure to body language and facial expressions, which are important in developing empathy. When young people are taken off cell phones, they quickly get better at identifying facial expressions and body language. The deleterious effects of television are well known, and the stress relief it promises stops when viewing stops. Social media can lead to depression and less developed social skills. Electric lighting can lead to distortion of circadian rhythms, and less exposure to the natural world reduces mental efficiency. A 4-day wilderness experience, leaving social media behind, can improve creative thinking and problem-solving by a whopping 50%. Spirituality and an experience of realities beyond the individual ego can reduce anxiety and depression and help a person to cope with stress and depression. Such experiences are often associated with the natural world, but technologies, such as electronic media, automobiles, the comforts of air conditioning, and other technologies, often tempt us to an indoor life.

Even though these ideas represent some degree of what scholars call "technological pessimism," our engineering students are now receptive to these illustrations of the downsides of technology. Technological pessimism is not an end in itself, however, but a stimulus to further advances in technology to eliminate the downsides. Our experiences with our students, especially in the last decade, indicate that it is acceptable to introduce themes from aspirational ethics into our courses and discussions; this stimulates thought about the ultimate purpose of the engineering profession and what the professed commitment of the engineering profession to well being and quality of life might mean.

The Future for Aspirational Ethics

The further development of aspirational ethics provides an agenda which will occupy me in the post-retirement part of my career, and which I believe would be enticing to some younger scholars. I suggest three parts to an agenda for aspirational ethics.

First, exploration of the nature of well being, especially as it relates to technology, must continue. Some think we can avoid doing this. In the preface to *A Century of Innovation*, astronaut Neil Armstrong attempts to side-step the need to explore the nature of well being by claiming that, while there can be various definitions of well being, "most of us would probably acknowledge that certain living conditions are essential to a preferred quality in our own lives. (Constable and Somerville, 2003, p. vi) Presumably the "living conditions" he has in mind are the result of the engineering achievements enumerated in *A Century of* Innovation. But is this always the case? While the NAE lists one of these achievements (electrification), as the most important, the Amish regard it as perhaps the technology most likely to have harmful consequences and therefore most in need of careful scrutiny and restriction. So perhaps there is a need after all for some careful thinking about well being and its relation to technology.

While in the Bovay lecture I proposed a three-part account of well being based on Maslow's hierarchy of needs, in an earlier discussion I proposed a similar four-part account of the elements of well being based on Martha Nussbaum's list of basic capabilities. My own grouping of the capabilities is: Physical Capabilities, Capabilities for Human Relationships, Social/Political Capabilities, and Capabilities for Self-Transcendence and Meaning (Harris, 2015). Even though these accounts of well being come from very different sources, they are remarkably similar. So there is reason to believe that a general consensus on the content of well being is possible.

Second, methods of evaluating the well being impact of technologies must be devised, much as engineers are already required to assess the environmental impact of technologies. Engineers prefer quantitative measures. As we pointed out in the textbook, the third phase of Life Cycle Analysis already requires identification and quantification of the most important environmental impacts of a project, including resource use, human health and ecological consequences, and any greenhouse gas emissions. The task of evaluating well-being impact may be more challenging, and some of the impact assessments may have to be qualitative, at least in the beginning. But empirical research may be able to quantify some effects of technology on well being, such as the effect on circadian rhythms of certain technologies. Perhaps effects on depression and stress can also be quantified. It is clear, however, that the social sciences and probably philosophical analysis will be necessary to do this—much more than in assessing environmental impact. Whether or not numbers can be attached to all aspects of well being impact, evidence may still be sufficient to warrant modification of technologies in the light of negative well being impact.

Third, engineers will then have the challenge of modifying technologies to improve their well being impact. The task of designing for well being will often be difficult. Tradeoffs will often be required. A modification of a technology might improve well being impact in one area and diminish it in another. Certainly there can be disagreements on the proper weights to assign to various types of well being impact. Again, assigning weights will require contributions from philosophy and the social sciences. Engineers and managers must also take into account the marketability of their products; improvements in well being impact might make a product less valuable in the marketplace.

Even this brief outline shows that the agenda suggested by aspirational ethics is broad, complex, and open-ended. It should be of interest to all engineering majors, who will be the primary creators of technology. It provides challenges for research that are both demanding and exciting in an area that is of great consequence for humankind.

While the formal, institutional aspect of my career has ended, my commitment to engineering ethics continues. The past has not been without difficulties, but the future contains much promise. Without question, the field embraces issues of great moral and social importance.

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