AC 2008-765: INTRODUCING ETHICS IN BIOENGINEERING

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INTRODUCING ETHICS IN BIOENGINEERING

Introduction

Engineering applies technical knowledge to solve human problems. More completely, engineering is a technological activity that uses professional imagination, judgment, integrity, and intellectual discipline in the application of science, technology, mathematics, and practical experience to design, produce, and operate useful objects or processes that meet the needs and desires of a client. Today engineering is seen as a profession which refers specifically to fields that require extensive study and mastery of specialized knowledge and a voluntary and abiding commitment to a code of conduct which prescribes ethical behavior.

A response of the engineering profession to the challenges of security, poverty and under-development, and environmental sustainability is described. Ethical codes, which govern the behavior of engineers, are examined from a historical perspective linking the prevailing codes to models of the natural world. A new ethical code based on a recently introduced model of Nature as an integral community is provided and discussed. Applications of the new code are described using a case study approach. With the ethical code based on an integral community in place, a new design algorithm is developed and also explored using case studies. Implications of the proposed changes in ethics and design on engineering education are considered.

To speak of a profession, particularly the profession of engineering implies the following five characteristics, which are useful in distinguishing professions form nonprofessional occupations.[i] First, entrance into a profession requires a mastery of some set body of knowledge and thus involves an extensive period of intellectual training. Second, the professionals' knowledge and skills are seen as vital to the well being of the larger society. Third, professions typically have a monopoly or near monopoly on the provisions of their particular set of professional services. Fourth, professionals routinely have an unusual degree of autonomy in the workplace. Fifth, professionals claim to be regulated by ethical standards, usually embodied in a code of ethics. It is this last characteristic, the existence of ethical standards set forth in a code of conduct which is the focus of the present work.

A one credit hour course has been developed as part of the professional skills portion of the undergraduate bioengineering program at Binghamton University. By the end of the course, students are able to:
- Identify the three challenges the modern world faces
- Describe the value laden dimension of the engineering profession
- Understand the importance of an ethical code
- Understand the connections between ethics and philosophy
- Explain the present day engineering codes of ethics
- Explore various models of the natural world
- Explore the significance of a morally deep world
- Explore the implications of a morally deep world in engineering

- Explore the responsibilities of the engineering profession with respect to the impoverished segments of society

Review of Present Day Codes

At the start of the 21st century, there are as many different codes of conduct in engineering as there are engineering disciplines and specialties. One professional society, the National Society for Professional Engineers (NSPE), has offered one general code which is widely employed today in all the disciplines as well as in engineering education. The NSPE Code of Ethics consists of a preamble followed by a listing of fundamental canons and then rules of practice.[ii] The very first canon cautions engineers in the fulfillment of their professional duties, to "hold paramount the safety, health and welfare of the public." As a result, the first rule of practice states that engineers shall "hold paramount the safety, health, and welfare of the public." Note that the explicit requirements focus on the public though there is no indication as to who is considered to be part of the public. Nor does the code refer to any of the challenges outlined as critical in the previous section. There is no indication that peace and security ought to be considered or issues related to poverty and the under-developed world nor environmental sustainability.

The American Society of Mechanical Engineers (ASME) sets forth a similarly constructed code of ethics with fundamental principles followed by fundamental canons.[iii] The first principle states that engineers uphold and advance the integrity, honor, and dignity of the Engineering profession by using their knowledge and skill for the enhancement of human welfare. The supportive fundamental canon states engineers shall hold paramount the safety, health and welfare of the public in the performance of their professional duties.

The American Society of Civil Engineers (ASCE) does at least mention the environment in its code.[iv] According to ASCE, Engineers uphold and advance the integrity, honor and dignity of the engineering profession by using their knowledge and skill for the enhancement of human welfare and the environment (fundamental principle) and <u>shall</u> hold paramount the safety, health and welfare of the public and shall strive to comply with the principles of sustainable development in the performance of their professional duties (fundamental canon). There is no explanation of what is meant by the enhancement of the environment. In November 1996, the ASCE Board of Direction adopted the following definition of sustainable development: "Sustainable development is the challenge of meeting human needs for natural resources, industrial products, energy, food, transportation, shelter, and effective waste management while conserving and protecting environmental quality and the natural resource base essential for future development." [v]

The Institute of Electrical and Electronics Engineers (IEEE) Code of Ethics states that its members accept responsibility in making engineering decisions consistent with the safety, health and welfare of the public, and to disclose promptly factors that might endanger the public or the environment.[vi] Here, an interesting notion of responsibility

towards the environment is described. It is not in opposition to the IEEE code to endanger the public or the environment only to not disclose promptly factors that might endanger the public or the environment.

The Institute of Industrial Engineers[vii] (IIE) endorses the Canon of Ethics provided by the Accreditation Board for Engineering and Technology (ABET) whose first principle is that engineers uphold and advance the integrity, honor and dignity of the engineering profession by using their knowledge and skill for the enhancement of human welfare and whose first canon is engineers shall hold paramount the safety, health and welfare of the public in the performance of their professional duties.[viii] ABET is the accrediting body for all engineering and engineering technology programs in the United States and thus has an important impact on the training of tomorrow's engineers and engineering educators.

Members of the American Institute of Chemical Engineers (AIChE) are challenged to uphold and advance the integrity, honor and dignity of the engineering profession by being honest and impartial and serving with fidelity their employers, their clients, and the public; striving to increase the competence and prestige of the engineering profession; and using their knowledge and skill for the enhancement of human welfare.[ix] To achieve these goals, AIChE members shall hold paramount the safety, health and welfare of the public and protect the environment in performance of their professional duties. There is neither elaboration on the idea of protecting the environment nor an identification on from whom or what shall it be protected.

Many other engineering disciplines exist, each with their own codes for ethical conduct. As can be seen from this review, a large percentage of the codes do not explicitly identify the environment as an important stakeholder in discussions of the ethics of engineering choices. Equally as troubling, those codes that do mention the environment refer to the idea of enhancing nature or promoting sustainable development, which is based solely upon meeting human needs. A select few number of codes do mention a responsibility to protect the environment but without identifying from whom or from what. There is no reference to the challenge of peace and security. In addition, there is no reference implicit or explicit to the challenge of poverty and the under-developed world. A comparison of many different codes is presented in Table 1.

There are many other engineering disciplines at present, each with its own code of conduct or ethics, which describes the responsibilities of the profession. Most focus heavily on the sense of responsibility engineering has towards employers, society in general and towards other professional engineers.

Engineering as a value-laden profession seeks to codify ethical behavior with various codes of conduct as put forth by different engineering societies. There are differences among the different codes but there are some striking similarities. The similarities exist in what has not been included in the ethical codes. While each does speak to the importance of holding paramount the public safety, issues associated with the intimate connection between engineering and war industries and terrorism are not discussed. In addition, no code speaks to the challenge of world poverty and the plight of the under-developed

CODE OF CONDUCT	RELEVANT CANONS AND PRINCIPLES	ATTITUDES TOWARDS SECURITY	ATTITUDES TOWARDS POVERTY	ATTITUDES TOWARDS NATURE
NSPE	Hold paramount the safety, health, and welfare of the public.	No explicit reference	No explicit reference	No explicit reference
ASME	Uphold and advance the integrity, honor, and dignity by using their knowledge and skill for the enhancement of human welfare.	No explicit reference	No explicit reference	No explicit reference
ASCE	Hold paramount the safety, health and welfare of the public and shall strive to comply with the principles of sustainable development	No explicit reference	No explicit reference	Sustainable development linked solely to meeting human needs
IIE	Accept responsibility in decisions consistent with the safety, health and welfare of the public, and to disclose promptly factors that might endanger the public or the environment.	No explicit reference	No explicit reference	Endangering environment not explored
IIE (ABET)	Shall hold paramount the safety, health and welfare of the public in the performance of their professional duties	No explicit reference	No explicit reference	No explicit reference
AIChE	Hold paramount the safety, health and welfare of the public and protect the environment	No explicit reference	No explicit reference	Protecting the environment not explored

Table 1.   Comparison of Attitudes towards Security, Poverty and Nature among Various Engineering Societies.

world. With one exception, that of ASCE, the challenge of environmental sustainability is completely ignored.

If we as engineers are to face these important challenges of our time, it may require a significantly different ethical code, one that can only come about if we view our professional responsibilities in a much broader way. The question then becomes how can we view our sense of ethics in a different way?

The era of modern engineering begin during the Renaissance and flourished as a result of the Industrial Revolution during the 18th and 19th centuries. One of the most important concurrent developments in ethical theory is termed Utilitarianism. Utilitarianism (from the Latin utilis, useful) is a theory of ethics that prescribes the quantitative maximization of good consequences for a population.x It is a single value system and a form of consequentialism and absolutism. This good to be maximized is usually happiness, pleasure, or preference satisfaction. Engineers are by and large utilitarians, seeking to maximum the good that is done.xi Engineering codes of conduct demonstrate the strong influence of utilitarianism on our sense of responsibility. While utilitarianism has been useful in developing our sense of ethics within engineering, it has not permitted us to

broaden that sense of responsibility to include peace and security, the challenge of poverty and the under-developed world and of environmental sustainability.

Utilitarianism was developed at a time when the world was imagined to be a machine which ultimately could be analyzed and divided into its many parts. Nature, the Earth, the Universe were all thought to be governed by immutable laws which we sought to uncover. Yet science has changed dramatically since the era of the mechanical universe. Perhaps we need to examine our sense of ethical responsibility in light of a newer scientific paradigm, one more indicative of the science of the 21st century rather than the 18th and 19th centuries.

Engineering in a Morally Deep World

A new approach to engineering ethics is developed, one based on the notion of a morally deep world. The morally deep world was first developed within the context of environmental ethics. A key element in its development in environmental ethics is the identification of an integral community. The present section makes the case for extending the identified integral community to include not only the environment but also other segments of society which have not been included in engineering ethics cases in the past.

In A Sand County Almanac[xii], Leopold declares: "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise." According to Leopold, acting ethically is a matter of concern both for us and for others with whom we are in some sort of community. The notion of a community deserves some discussion. We perhaps are most comfortable with community referring to a body of people having common rights, privileges, or interests, or living in the same place under the same laws and regulations; as, a community of Franciscan monks. In biology or ecology, community refers to an interacting group of various species in a common location. For example, a forest of trees and undergrowth plants, inhabited by animals and rooted in soil containing bacteria and fungi, constitutes an integral community. Extending the notion of community in this way is consistent with the pattern evidenced in human society over the centuries. We have progressively enlarged the boundaries of our understanding of community and recognized the membership of slaves, foreigners, etc., those for whom membership was not extended at earlier times in history. Leopold's land ethic then "simply enlarges the boundaries of the community to include soils, waters, plants, and animals, or collectively: the land."

Johnson discusses how non-sentient land can count morally and focuses upon the concept of a living being.[xiii] For Johnson, a living being is best thought of not as a thing of some sort but as a living system, an ongoing life-process. A life-process has a character significantly different from those of other processes such as thermodynamics processes for example. Our character, as living beings, is the fundamental determinant of our interests. Johnson adds further that:

"The interests of a being lie in whatever contributes to its coherent effective functioning as an on-going life-process. That which tends to the contrary is against its interests….moral consideration must be given to the interests of all living beings, in proportion to the interest. Some living systems other than individual organisms are living entities with morally considerable interests. …All interests must be taken into account."

A shift to a morally deep world-view in engineering would have a profound impact on the sense of ethical responsibility that the engineering profession would embrace.

A criticism of a morally deep world perspective is that it prevents any action that will affect a community. On the contrary, though a morally deep perspective does assert actions that violate vital interests of the community or erosion of it self-identity should be avoided, it requires active participation in the protection of the essential functions and the maintenance of the viability of life processes. Rather than calling for inaction, a morally deep world perspective suggests contemplation followed by a direct and specific response.

A New Engineering Ethic

Given a shift to a morally deep world paradigm, a new engineering code of conduct is outlined. The majority of existing codes are structured in similar if not identical ways with fundamental principles supported by fundamental canons. That same structure will be incorporated into the present work. For a morally deep world, the first fundamental canon and rule of practice is specified as:

> ***Engineers, in the fulfillment of their professional duties, shall hold paramount the safety, health and welfare of the identified integral community.***

The fundamental difference between an ethical code based on a morally deep world versus the present codes is the replacement of the "public" by the "identified integral community." The important difference this substitution makes can be seen in the following case.

The U.S. Army Corps of Engineers, a federal agency has sole authority over the design and construction of metro New Orleans' flood protection and water management as authorized by Congress in the Lake Pontchartrain Hurricane Protection Project in the Flood Control Act of 1965. The U.S. Army Corps of Engineers now admits that faulty design specifications and substandard construction of certain levee segments, not a hurricane was the primary cause of the flooding damage in the New Orleans area. Responsibility for the levee design failures rests squarely on the U.S. Army Corps of Engineers and on the federal government including both the executive and legislative branches. This means that the Corps and the federal government bears a major responsibility for the deaths of over 1300 people and the destruction of hundreds of thousands of homes and livelihoods in metro New Orleans.

The reality of life in New Orleans today stands in contrast to the excitement generated by the speech made by President Bush in Jackson Square in New Orleans President Bush promised New Orleans would be at the center of the government's plan. "This great city will rise again,"[xiv] Bush said. He outlined several initiatives that would provide tax breaks for area businesses, along with federal funds for rebuilding roads and bridges damaged by the storm and the flooding that followed. The president also reached out to the communities that have been the most visibly hit, pledging to ensure that minorities and those who were living in poverty even before Katrina struck would take part in -- and benefit from -- the rebuilding effort. Today, sixteen months after flood waters surged through New Orleans' 9th Ward following the landfall of Hurricane Katrina and the bursting of levees, the devastated section of the city "remains all but vacant,"[xv] Prior to Katrina, the newspaper reports, the ward had 5,601 homes. Now, "demolition permits have been obtained on about a quarter of them, the highest percentage citywide." Only 3 percent of the ward's homeowners have applied for electrical permits -- "enough to power only 152 houses." There are small clusters of FEMA trailers and returning residents in the ward, according to the *Times-Picayune*, "but unruly weeds are all that have sprung up on lots where demolition first offered the false promise of rapid recovery."

The failure of the levees that were built to protect the City of New Orleans raises a host of important questions for the engineering. Though the problems created were not the sole responsibility of engineers, our profession did play an important role in the tragic events. The first questions deals with responsibility—who was responsible for the faulty design specifications and substandard construction of certain levee segments? Was it the result of insufficient technical expertise? Or was due to a restricted view of professional and ethical responsibility? Was it an individual failure or an institutional failure or both? Was it a political failure? The second set of questions is more directly linked to the existence of poverty in New Orleans. The regions of the city which suffered the greatest loss of lives were the poorest sections, particularly the 9th Ward. What are our responsibilities as engineers when we know that those who will suffer the most from our mistakes are those among us who have the least? Do we have the same responsibility to those who can leave the city using their own personal transportation as well as for those who rely on mass transit or bicycles or on foot? Who speaks for the poor in situations such as these? Are decisions for evacuation, for example, based upon the abilities of the rich, the middle class or the poor?

Another important question is raised by the flooding in New Orleans. Through the construction of levees and various shipping canals, much of the coastline is washing away, leaving the city and the residents of south Louisiana in a much more precarious condition. Louisiana is losing her coastal land (both wetlands and flatlands) at a catastrophic rate. The U. S. Army Corps of Engineers estimates that the present rate of coastal land loss is 25 square miles a year. The U. S. Fish and Wildlife Service places that figure even higher at about 34 square miles a year. The latter number is based on measuring the loss in coastal land area between 1978 and 1990. What are the responsibilities of engineers and engineering organizations towards the residents of Louisiana, particularly the poor, the sick and the enfeebled? Are there lessons to be learned from the very notion of attempting to control Nature?

Discussion

Thomas Berry[1] has concluded that the modern corporation and the notion of commercial values in nature are threatening life on the planet has developed his ideas into a set of *Twelve Principles for Understanding the Universe and the Role of the Human in the Universe Process*.[xvi] According to Berry, a philosopher in the tradition of Teilhard de Chardin,[2] the universe, the solar system, and the planet Earth, in themselves and in their evolutionary emergence, constitute for the human community the primary revelation of that ultimate mystery whence all things emerge into being.

In his works,[xvii,xviii,xix] Berry provides a new intellectual-ethical framework for the human community by positing planetary well-being as the measure of all human activity. Drawing on the wisdom of Western philosophy, Asian thought, and Native American traditions, as well as contemporary physics and evolutionary biology, Berry offers a new perspective that recasts our understanding of science, technology, politics, religion, ecology, and education. He shows us why it is important for us to respond to the Earth's need for planetary renewal, and what we must do to break free of the *technological trance* that drives a misguided dream of progress. Only then, he suggests, can we foster mutually enhancing human-Earth relationships that can heal our traumatized global bio-system.

Berry's most famous quotations is:

The Universe and thus the Earth is a communion of subjects, not a collection of objects.

I will examine some of the implications of this statement for engineering's sense of responsibility for the Earth and also for the poor. By communion, Berry was referring to intimacy or a feeling of emotional closeness, a connection, especially one in which something is communicated or shared. The shift from object to subject[3] is also profound. An object is something visible or tangible; something that can be seen or touched, a focus of somebody's attention or emotion; or a goal or purpose. By subject, the reference is to

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[1] Fr. Thomas Berry C.P (born 1914) is a Catholic priest of the Passionist order, cultural historian and eco-theologian (although cosmologist and geologian — or "Earth scholar" — are his preferred descriptors). Among advocates of deep ecology and "eco-spirituality" he is famous for proposing that a deep understanding of the history and functioning of the evolving universe is a necessary inspiration and guide for our own effective functioning as individuals and as a species. He is considered a leader in the tradition of Teilhard de Chardin.

[2] Fr. Pierre Teilhard de Chardin, S.J., (May 1, 1881 – April 10, 1955) was a French Jesuit priest trained as a paleontologist and a philosopher. Teilhard's primary book, *The Phenomenon of Man*, set forth a sweeping account of the unfolding of the cosmos. He abandoned a literal interpretation of creation in the Book of Genesis in favor of a metaphorical interpretation.

[3] In *Physicist Conception of Nature,* Werner Heisenberg's underlines the fundamental chance in the status of subject/object relationship, brought about by the quantum theory (and the Copenhagen interpretation of it). Newtonian physics has a clear-cut distinction between object and subject. When an XIX century physicist was approaching the study of the nature, he was hopping to unveil the law of it; the subject of his study was nature "itself". After quantum physics this is no longer possible - there is no "nature itself". The process of observation for ever changes the observed. The observer and the observed are interacting. Heisenberg writes: "We can no longer speak of the behavior of the particle independently of the process of observation." The laws we formulate are not about the nature itself, but about our knowledge of it.

the essential nature or substance of something as distinguished from its attributes. In other words, borrowing from Buddhism,[4] the essential nature, the Buddha nature, is taught to be a truly real, but internally hidden, eternal potency or immortal element within the purest depths of the mind, present in all sentient beings.

Let us then consider the implications of this view for engineering. According to Berry, our new community is a very special one, that is, it is one in which the various elements are bound together as subjects having interests rather than one in which some have interests while others are simply resources to be utilized. In my view, viewing the Universe including both the natural environment and the poor as a communion of subjects rather than a collection of objects has important, even revolutionary significance for the engineering profession. Firstly it eliminates from the outset that we ever again can remain aloof from the consequences of our projects. Polar bears are rapidly disappearing from the Arctic regions in part due to the technologies we continue to produce. The poor in New Orleans suffered beyond our understanding in part due to decisions we as engineers and engineering organizations made and continue to routinely make. If we can begin to see the connection we have with the health of the Arctic ecosystem and thus with the well-being of the polar bears, recognizing all that we share, they like the rest of Nature have much greater importance when we are formulating our criteria whereby we make decisions. Even more importantly, if we can begin to view the poor, rather they live in the 9th Ward of New Orleans or the Pine Ridge Reservation in South Dakota, as connected to us and as possessing an entire spectrum of potentialities and possibilities then too our criteria for decision making as engineers is broadened importantly. Those potentialities and possibilities are as important to the ongoing dynamic process of creation in the Universe as those that reside within us as each of us plays an integral role in the communion of subjects.

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[i] Ernest Greenword, "Attributes of a Profession," **Social Work**, July 1957, pp 45-55.

[ii] **NSPE Code of Ethics**, National Society for Professional Engineers, http://nspe.org/ethics/eh-1code.asp

[iii] **ASME Code of Ethics of Engineers**, American Society of Mechanical Engineers,

http://asme.org/asmeorg/Governance/5431.doc

[iv] **ASCE Code of Ethics**, American Society of Civil Engineers,

http://www.asce.org/inside/codeofethics.cfm

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[4] Buddhism is a dharmic, non-theistic religion, a philosophy, and a system of psychology. Buddhism is also known in Sanskrit or Pali, the main ancient languages of Buddhists, as Buddha Dharma or Dhamma, which means the teachings of "the Awakened One". Thus was called Siddhartha Gautama, hereinafter referred to as "the Buddha". Early sources say that the Buddha was born in Lumbini (now in Nepal), and that he died aged around 80 in Kushinagar (India). He lived in or around the fifth century BCE, according to recent scholarship. Buddhism spread throughout the Indian subcontinent in the five centuries following the Buddha's passing, and thence into Central, Southeast and East Asia and Eastern Europe over the next two millennia.