

AC 2007-38: THEORY AND PRACTICE OF HUMANITARIAN ETHICS IN GRADUATE ENGINEERING EDUCATION

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Theory and Practice of Humanitarian Ethics in Graduate Engineering Education

Abstract

The engineering education ethics focus on individual and social responsibilities has overlooked an important dimension of engineering practice that deserves clearer ethical articulation and curriculum development: the role of engineers in humanitarian activities. Additionally, reform initiatives in science and engineering (S&E) graduate education have yet to realize their potential for integrating ethics into curricula. Addressing such challenges, this paper will describe activities to date of an interdisciplinary faculty team at the Colorado School of Mines (CSM) working on the development of graduate-level curriculum in humanitarian engineering ethics (HEE). The HEE faculty team has 1) reviewed and critically assessed relations between humanitarianism and engineering in order to develop an applicable concept of humanitarian ethics (HE) in engineering education and practice; 2) researched barriers and opportunities in the development and implementation of humanitarian-related curricula in a number of engineering schools; and 3) undertaken the development and implementation of HE initiatives in graduate engineering education. The paper outlines the literature review and philosophical analysis conducted in different areas related to humanitarianism, how these activities were incorporated in a faculty development workshop, and how they are being used in curriculum development and implementation of a Humanitarian Engineering Ethics Introductory Seminar and electrical and environmental engineering courses.

Overview

Humanitarianism and engineering

As has been previously outlined by Mitcham, Lucena, and Moon ^[1], the social philosophy of humanitarianism developed during the same time frame as professional engineering, and was first applied to organizations such as the International Red Cross/Crescent, founded in 1864. From its beginnings, humanitarianism was allied with an ethical vision for the use of science and technology (initially in the form of medicine) for the benefit of all human beings irrespective of nationality, race, or other restrictive grouping.

In 1971, however, humanitarianism took a new turn with the formation of “Médecins sans Frontières” (MSF or Doctors without Borders). Having now become the largest non-governmental humanitarian relief agency in the world, MSF grew out of dissatisfaction with the inability of the Red Cross/Crescent to act independently of national government controls and to venture beyond safe boundaries. The idealistic physicians of MSF pioneered new ways of bringing medical science and technology to people in crisis and of speaking for human rights ^[2]. Stimulated by similar ideals, in the early 1990s engineers took up the challenge and independently organized a number of groups going under some form of the name “Engineers without Borders”: Ingénieurs Sans Frontières (France) – Ingénieurs Assistance Internationale (Belgium), Ingeniería Sin Fronteras (Spain), Ingenierer uden Graenser (Denmark), Ingenjörer och Naturvetare utan Gräns-Sverige (Sweden), Ingegneria Senza Frontiere (Italy), and others.

In 2003 these groups organized “Engineers Without Borders – International” as a network to promote “humanitarian engineering ... for a better world,” now constituted by more than 41 national member organizations (<http://www.ewb-international.org/members.htm>).

The work of civil engineer Fred Cuny may serve to illustrate this new form of humanitarian engineering. Following his education at Texas A&M University and relief work in Biafra (1969), Cuny sought to use his engineering skills to respond to earthquake disasters in Central American (1971 and 1976), Sudan (1985), Iraq (1991), Somalia (1992), Sarajevo (1993-1994), and Chechnya (where he was assassinated in 1995). Cuny’s book *Disasters and Development* (1983) argued for what has become known as the “Cuny approach,” an effort to respond to disasters not just by returning people to their pre-disaster state, but as opportunities to help people improve their lives beyond what might have been possible before^[3]. (see also <http://www.onlineethics.org/moral/cuny/intro.html>)

Like Cuny, although seldom as radical, many engineers are rethinking their exclusive commitment to corporate goals and foreign policies^[4,5]. At the professional level, however, engineers have not engaged in the philosophical and ethical dimensions of their humanitarian interventions as other professions have done^[6]. At best there has been a symbolic recognition that some engineers have engaged in civic service and humanitarian work, as reflected by the Hoover Medal established in 1929 to “commemorate the civic and humanitarian achievements of engineers [which] is conferred upon an engineer whose professional achievements and personal endeavors have advanced the well-being of humankind.” (http://www.asme.org/member/awards/hover_medal/index.html).

Contrasting the sparse appearance of engineers as individuals in humanitarian activities throughout most of the 20th century with the recent surge of professional and student activities in those same endeavors led us to explore how the humanitarian ideal might challenge and perhaps change engineering practice, education, and ethics.

Humanitarianism and engineering education

That engineering exists in tension between public and private interests has been widely documented in the history and sociology of technical work^[7-9]. In the United States, this tension helps explain the emergence of certain kinds of ethics education for specific purposes (business, computer, leadership, management) and the minimal treatment or neglect of other types of ethics (environmental, humanitarian) in the professional context. Yet in spite of the constraints brought by engineers’ location between public and private interests, some advocates of engineering have made the case that engineering can always be put to humanitarian ends^[10] but have failed to explain what this might mean for engineering education.

In its recent report, *The Engineer of 2020: Visions of Engineering in the New Century*, the National Academy of Engineering (NAE) has predicted a world with increasing population growth and sustainability needs that calls on future engineers to play a more significant role in assisting underdeveloped communities worldwide. “We aspire to a future where engineers are prepared to adapt to changes in global forces and trends and to *ethically assist the world* in creating a balance in the standards of living for developing and developed countries alike”^[11].

Yet the report provides no guidance on the theory or practice of such global engineering ethics other than references to rather standard national traditions of engineering ethics that have yet to integrate the experiences and insights of humanitarian practices.

Recently we have witnessed the emergence of nationwide student organizations such as Engineers for Sustainable World (ESW, based in Ithaca NY and now with more than 20 student chapters), Engineers Without Borders (EWB-USA, with more than 100 student chapters), and local organizations such as Engineers in Technical and Humanitarian Opportunities of Service (ETHOS, Iowa State University), Technology Assist by Students (Stanford University), Engineering World Health (EWH, Duke University), and Engineers for a Better World (EBW, Colorado School of Mines).

Outside the U.S., curriculum innovations have also taken place. For example, the Tokyo Institute of Technology in Japan now offers undergraduate and graduate programs in International Development Engineering to help “students become engineers who have ability, courage, and leadership, and can solve the problems” in international development projects. Its extensive curriculum combining engineering and international development includes courses such as “Science and Society: Writing and Analytical Skills” and “Principles of International Co-existence,” which focuses on differences in culture, climate, and legal systems. But there is no evidence the program includes the ethical dimensions of international development work (<http://www.ide.titech.ac.jp/index.html>).

Related curricular efforts in the U.S. include Engineering Projects in Community Service (EPICS, Purdue University), Engineering for Developing Communities (EDC, University of Colorado-Boulder), and Humanitarian Engineering (Colorado School of Mines). Nationally recognized this year with the Gordon Prize at the National Academy of Engineering (NAE), EPICS aims to “create partnerships between teams of undergraduate students and local community not-for-profit organizations to solve engineering-based problems in the community” (<http://epics.ecn.purdue.edu/>). For its part, the EDC program educates “globally responsible engineering students and professionals who can offer sustainable and appropriate solutions to the endemic problems faced by developing communities worldwide” (<http://www.edc-cu.org/>). A 30-credit master’s level program, EDC offers courses in environmental engineering, chemistry, sustainable design, and social science electives such as “Natural Capitalism for Engineers” and “Natural Resource Economics.” Yet in neither EPICS nor EDC is there a graduate-level engineering ethics component drawing on humanitarian traditions of practice and knowledge. At Colorado School of Mines, an undergraduate humanitarian project funded by the Hewlett Foundation is aimed at educating undergraduate engineering students on how to bring technical knowledge and skill to bear on the real-world problems of underserved populations in order to promote the development of the common good. Motivated by some of the experiences of this undergraduate project, the authors of this paper have sought to develop and implement an initiative at the graduate level with a focus on enhancing engineering ethics through an interaction with humanitarianism.

Humanitarianism as a missing dimension of engineering ethics

Our HEE curriculum project aims to build a bridge between humanitarianism and engineering ethics for the benefit of both. Humanitarianism can benefit from appreciating what engineers do and the traditions of engineering ethics; professional engineering ethics can be enhanced by appreciating the role of humanitarianism in a globalized world increasingly dependent on advances in science and technology.

Humanitarianism is itself a controversial topic that has only recently become a theme of extended ethical and political philosophical reflection. Conventionally defined as the commitment to promote human welfare independent of national or sectarian identification, humanitarianism is nevertheless subject to numerous visions of precisely how this promotion should be pursued and what exactly is meant by human welfare. Humanitarian action does not limit itself to concern for the good or interest of any one class, nation, or race. But this attempt to escape the limitations of traditional social bonds gives rise to its own problems, discussion of which has developed its own tradition of reflection^[2, 12-16].

Despite its popular appeal and international importance, humanitarian ethics is underdeveloped in relation to ethics in general and to professional engineering in particular. In relation to philosophical ethics in general, humanitarian ethics raises a series of questions: What is the relation between humanitarianism and classical cosmopolitanism? Christian charity? Enlightenment humanism? The idea of a humanitarian ethics, as it emerged in the 19th century, drew in an eclectic manner on these various traditions, as did the 20th century development of the notion of universal human rights^[17]. But critical reflection on these various strains and the development of a philosophically respectable tradition of humanitarian ethics remains an unfinished project.

In relation to professional engineering ethics, humanitarian ethics is a largely unarticulated but nevertheless influential presence. As in science, the basic ethical foundation of engineering is that it is of human benefit. However, this foundation can be questioned when engineering is of a destructive character (e.g., some military engineering) or limited to specific national communities (e.g., British engineering, French engineering, etc.). Yet in the revision of engineering codes of professional conduct that occurred during the last half of the 20th century, the primary obligation was commonly understood to be protection of “public health, safety, and welfare” — a phrase that clearly implies some relation to humanitarian ideals.

Humanitarianism has not received proper attention in the field of engineering ethics. In his comprehensive survey of engineering ethics education in the U.S., Herkert analyzed the content of engineering ethics instruction as mainly focused on the concept of professional responsibility toward society in the forms of public safety and welfare, risk and the principle of informed consent, conflict of interest, whistleblowing, etc.^[18, 19]. At the same time, he included references to criticisms of engineering ethics for not going far enough to include, for example, “a willingness to engage others in the difficult work of defining what the crucial choices are that confront technological society”^[20]. According to Herkert, responses to such criticisms have attempted to broaden engineering ethics to include public policy, sustainable development, globalization, health care, and information technology^[18], increasing attention to the institutional and cultural dimensions of engineering practice^[21], or replacing individual ethics by a new paradigm that encompasses the social relations of engineering expertise^[22]. More generally, the

argument has been made that engineers have a duty *plus respicere*, to take more things into account that traditional professional ethics has required^[23]. This last argument provides a foundation for including humanitarianism as a significant ethical dimension of engineering practice and education.

A conference on Ethics and Social Responsibility in Engineering and Technology sponsored by Gonzaga University in 2003 resulted in a special issue of *Science and Engineering Ethics* on Integrating Ethics into Engineering Education and Practice (April 2004). This proceedings collection provides a good overview of the state of engineering ethics education in the U.S. and offers important insights into the importance of institutional culture on creating an ethical environment^[24] and the systemic barriers to ethics education^[25] for curriculum development. In Europe, the European Ethics Network has produced a comprehensive map of theoretical frameworks for and specific examples of social responsibility in engineering^[26]. A multinational and interdisciplinary research group based in Denmark has also been exploring relations between engineering education and that form of classical humanities education known in German as *Bildung*^[27]. However, what continues to be missing from such efforts is a systematic effort to relate engineering ethics to the traditions of humanitarianism. What remains to be done is to explore the ways in which existing engineering ethics can be enhanced by association with humanitarian principles.

Scholarship from international studies in the areas of human rights and ethics of humanitarian intervention will help develop sharper and conceptually interesting questions here^[6, 17, 28-37]. For example, on what philosophical grounds might engineers intervene internationally to help respond to a humanitarian crisis that was not created by the systems that they designed? Do they have an ethical obligation to intervene because of their privileged position with respect to technological knowledge and systems that could prove critical in a particular humanitarian intervention? If so, what ethical framework might they use to justify an intervention in a crisis that they did not create? If invited to intervene by a sovereign state or by an international organization (which may itself be intervening because the state has failed to guarantee the basic human rights of its citizens), what are the engineers' responsibilities to the human rights and autonomy of the communities involved? If the opportunity to intervene comes through members of a community in need (grassroots) or through a corporation that might see intervention in its (shareholder or stakeholder) interest, what are the engineers' responsibilities to national sovereignty or the natural environment? It is through a critical engagement with such questions that the CSM HEE project is attempting to ground humanitarian ethics in engineering practice at the nexus of human rights, communal autonomy, technology, national sovereignty, organizational interests (private, public, non-governmental), and the natural environment.

Enhancing graduate education in science and engineering (S&E)

Our HEE project also seeks to contribute to emerging reforms in graduate S&E education. A number of influential organizations have argued that received models for graduate S&E education have been outdated by the termination of the Cold War and the rise of globalization, including problems associated with global terrorism. Graduate S&E education needs to be re-designed to meet a new social context and prepare for new career paths^[38-44]. For example, the National Academies have recommended that S&E graduate programs "provide options that

allow students to gain a wider variety of academic and other career skills [in order] to produce scientists and engineers who are versatile”^[38], p. 78]. They have also called on private and public funding agencies to adjust their support mechanisms to include new forms of funding for this purpose. The NSF has in part responded to such calls with the creation and continuation of the Interdisciplinary Graduate Education Research Training (IGERT) program. A thorough review of the IGERT database (both at <http://www.igert.org/> and at <http://www.nsf.gov/home/crssprgm/igert/igertprojects.htm>) has identified both valuable lessons for curriculum development (described below) as well as the lack of in-depth treatment of ethics in graduate S&E education. Some IGERT programs have included research and professional ethics education in their introductory seminars, but none have ventured into the ethical dimensions of applying research to societal needs, let alone into humanitarian ethics.

Recognizing that the transformation of graduate education is a problem that cannot be addressed by the federal government alone, high-profile foundations and research centers on higher education have funded initiatives to re-shape graduate education. For example, the *Responsive PhD Project* organized by the Woodrow Wilson National Fellowship Foundation proposes new paradigms and practices needed in the education and training of future doctoral students. The new paradigms include interdisciplinarity and scholarly citizenship. “For the scholar-citizen, the doctorate's real power consists of both rigorous scholarship and *creative action throughout and beyond the educational realm*” (<http://www.woodrow.org/responsivephd/>) (emphasis added). Opportunities to connect graduate engineering and humanitarianism are surely one way to contribute to such a new agenda.

A survey of over 4,000 doctoral students from 27 universities explored how well doctoral programs prepare students to be researchers^[45]. In preparation for interdisciplinarity, 61% of the respondents reported a strong interest in collaborating across boundaries, yet only 27% felt prepared for such endeavors. Given that more research and education activities in both academia and industry are organized as interdisciplinary endeavors (e.g., most of NSF’s major new initiatives are expected to be interdisciplinary), we early on concluded that interdisciplinarity would be a required feature of our curricular developments.

Furthermore, in preparation to understand the ethical dimensions of research, 55% of the doctoral students surveyed reported having received instruction on the use of copyright material and 12% in avoidance of conflict of interests^[45], p. 14]. Although research ethics has been gradually incorporated in graduate education, particularly on sites that receive NIH funding, education on the ethical dimensions of applying S&E research to societal needs exists only in a handful of programs now funded by NSF’s Ethics Education in Science and Engineering (EASE) (e.g., Penn State, University of Texas, and University of Virginia). Our HEE project seeks to adopt the best practices of such reform efforts and to bring ethical education in the application of research to societal needs by developing and implementing new curricula in humanitarian engineering ethics.

Methods and procedures

Literature review

A necessary initial task was to review literature and gather information concerning the historical, social, and philosophical development of humanitarianism and humanitarian ethics. Such a review focused on four areas: origins and basic theories of humanitarianism, contemporary critical assessments of humanitarianism, contemporary humanitarian organizations and practices, and humanitarianism in relation to science and technology.

The literature review on the origins and basic theories of humanitarianism included examination of the relations between pre-modern cosmopolitanism, modern nationalism, and humanitarianism; diverse views and justifications for humanitarianism (e.g., religious and secular); and tensions among humanitarian intervention, community autonomy, national sovereignty, private interests, and the natural environment.

Finally, the review of humanitarianism in relation to science and technology has included reflective analysis of the ethical ideals of science, technology, engineering, and medicine in relation to humanitarian ethics; and selected case studies of humanitarian activities and projects with significant science and technology components.

Humanitarianism in context

Humanitarianism is not so much a well-defined doctrine or tradition of ethical reflection as it is a general stance that reflects a progressive emergence within the modern historical period of a commitment to the importance of human welfare as an end in personal conduct and political action^[30]. In this sense it has been important to analyze HE in relation to ethics in general, to review the relations between engineering ethics and ethics in general, and to consider humanitarianism in relation to various forms of professional ethics, particularly engineering ethics. The method here has consisted of reflective, critical analysis that has led to the presentation of conference papers, exchanges with colleagues in both ethics and engineering, the writing of scholarly articles, and development of course curricular materials.

First, with regard to humanitarianism in relation to ethics in general, a working hypothesis is that many traditions of ethics, from virtue ethics (in the pre-modern period) to various forms of consequentialism and deontology (in the modern period) can be restated in humanitarian terms. To undertake such a critical reassessment of the traditions of ethics in the European and American cultural traditions contributes to an enhanced assessment of the role of humanitarianism, implicitly or explicitly, in the ethical life these traditions, and advance contemporary developments in applied ethics and ethical theory.

Second, with regard to relations between engineering ethics and ethics in general, a working hypothesis is that engineering ethics has taken only selective advantage of the resources available to it in the European and American ethical traditions. To this end we have drawn on contemporary analyses of the strengths and weaknesses of engineering ethics, especially those analyses that point toward the need for professional individualism to be complemented with policy analyses in order to consider not just corporate practices but the implications of globalization.

Third, with regard to humanitarianism in relation to various forms of professional ethics, including engineering ethics in particular, a working hypothesis is that different forms of professional ethics have made selective use of humanitarian resources, arguments, and institutional or political implications. To this end we have compared and contrasted the traditions and practices of humanitarianism and HE in different forms of professional ethics, including but not limited to those in medicine and the military. For instance, in medicine and the military ethics ^[35], there have been important reflections on the obligations and limits of a humanitarian "right to intervene" that can have implications for engineering.

Faculty development

One of the most significant contributions of this project has been on faculty development, allowing members of our research and teaching team to reflect on the literature review and preparing them to incorporate HEE in engineering and interdisciplinary courses. As a result of regular project meetings, the faculty team decided to do an intense, two-day workshop in early May 2006 in which the project investigators would begin to develop a set of HEE criteria and instructional modules. The workshop included dialogue and critique of definitions of humanitarian engineering, the role of technical experts on development, the relationships and tensions among sustainability, cultural appropriateness, and humanitarian practices. To develop and enhance interdisciplinary collaboration, faculty engaged in exercises aimed at understanding each others' perspectives, disciplines, and views of technology. An entire day was devoted to understanding theories and practices of interdisciplinary collaborations at other universities and how these would apply to our own curriculum development (see workshop's agenda in appendix below).

In terms of curricular development, the most significant result of this workshop was the following set of student learning outcomes that have become the drivers of curriculum development, experimentation, and assessment:

1. Students will be able to imagine, understand, and question the humanitarian constraints and ideals of multiple engineering practices
2. Students will be able to effectively develop and present case studies on humanitarian engineering
3. Students will be able to contemplate multiple pathways (grad school, NGO, corporate) of professional practice that might include humanitarian dimensions

Results

Humanitarian engineering ethics criteria

One of the most significant results of the literature review and faculty development has been an emerging set of criteria for humanitarian engineering ethics. Each criterion has been justified by our analysis of the literature and the history of engineering practice in humanitarian activities and was re-written in the form of a question in order to encourage students to reflect critically on and assess technology and/or engineering work. The set of HEE criteria is as follows:

A. Does this engineering work **promote the good of all humans** independent of nationality, religion, class, age, or sex? [Justification: Humanitarianism as an ethical tradition historically rejects the significance of such distinctions.]

B. How might this engineering project be related to the **protection and promotion of human rights**? [Justification: Humanitarianism has been repeatedly linked with the emergence of human rights especially as recognized in such documents as the Universal Declaration of Human Rights (1948).]

C. Is the product, process, or system being engineered any likely to benefit **solving humanitarian crises** such as those typically associated with war or natural disasters? [Justification: Humanitarianism is often exemplified with humanitarian aid during such crises.]

D. Is this engineering work addressed especially to **meet fundamental human needs** (such as food, water, and shelter)? [Justification: Humanitarianism regularly argues the priority of fundamental needs over needs associated with affluence.]

E. Is this engineering work oriented toward providing **benefits for those otherwise underserved by engineering** either in the advanced or the developing regions of the world? [Justification: Humanitarianism typically manifests what is known as the “preferential option for the poor.”]

F. In what ways might the engineering work be **more compatible with not-for-profit enterprises** than for profit making enterprises? How might such engineering and construction work that did seem more compatible with the pursuit of economic profit be either supported by alternative means or recast so as to be compatible with economic motives? [Justification: Humanitarianism has often been practiced in tension with corporate economic interests.]

G. What is the likelihood that this engineering product, process, or system will be **sustainable**? [Justification: Humanitarianism is often thought to be supportive of and appropriately pursued in synthesis with sustainable development.]

H. Does this engineering work **factor in the cultural exigencies of multiple stakeholders**? [Justification: The outcomes of engineering work are only be effective and accepted if they are culturally appropriate, especially in humanitarian crises]

Using this set of criteria as a framework, we have developed an introductory seminar in humanitarian engineering ethics. A version of this seminar was first piloted as a one-credit course in Fall 2006. It is now being offered as a three credit course.

Humanitarian engineering ethics introductory seminar

During Fall 2006, a one-credit team-taught seminar sought to help participating faculty and students develop or refine their conceptions of the core characteristics and ideal outcomes of humanitarian engineering and ethics. Themes addressed included psychoanalytic perspectives on collective violence, the historical and cultural complexities of “development” as an

organizing global framework for progressive action, and problematic legacies of mining ventures in the Americas and beyond. Beyond these core reading and discussion themes, students wrote two short papers. The first focused on exchanges that ensued when they presented themselves as aspiring “humanitarian engineers” to range of interviewers on campus for the major annual CSM “career fair.” The second focused on how specific readings in imaginative literature and cultural anthropology from different world regions could be deployed to sharpen one’s sense of the values and flaws of engineering training, mentalities and practices across time and place.

This one-credit seminar served as experimental grounds for a more comprehensive three-credit HEE seminar where faculty and students will collectively develop and refine a set of humanitarian engineering ethics criteria. Students will then practice critically applying these criteria to specific examples of technology and engineering, some of which they will research and develop into case-studies. Students will also research multiple career paths in humanitarian-related organizations and practices and consider potential careers as humanitarian scientists and engineers. By the completion of this course, students will be able to

1. Understand the basic concepts and history of humanitarianism and humanitarian action
2. Describe how humanitarianism might be related to engineering history, education, and practice
3. Imagine, understand, and question how humanitarian constraints and ideals might engage with multiple engineering practices and standards of professional conduct
4. Research, develop, write and present an effective case study on humanitarian engineering that incorporates ethical dimensions
5. Contemplate multiple pathways (grad school, NGO, corporate) of professional practice that would benefit from humanitarian engineering knowledge and skills

Humanitarian engineering ethics modules

Modularity has been identified as one of the most effective approaches in integrating ethics into the engineering curriculum^[46, 47] and has been favored to introduce responsible conduct to faculty and students in graduate education in science and engineering^[48]. This approach has also been used when incorporating controversial or radical new approaches to professional curricula, as in the teaching about alternative medicine^[49], domestic violence^[50], and humanities^[51] to traditional medical programs. Following the modular approach and our commitment to interdisciplinarity, we are developing HEE modules on Wastewater Engineering, on Energy Engineering and on Humanitarianism in general.

Wastewater Engineering. Our modular approach stemmed from an overarching goal and specific learning objectives. The goal was to help students acquire a richer, more complete appreciation of the complexities inherent in designing, implementing, or working with sanitation treatment systems in the developing world. For the learning objectives, students were to become more familiar with how people in developing countries perceive and treat waste, and what constraints and non-technical issues were associated with sanitation treatment processes in developed and developing countries; non-technical issues could include economic, environmental, social, cultural, political, and ethical.

Rather than tack on the humanitarian engineering ethics content, that content was purposefully integrated into a senior/graduate-level Wastewater Engineering course using a case study approach. In the second full week of a 16-week semester, we began with a pre-test to establish a baseline on student knowledge of technical and non-technical issues associated with sanitation engineering in developed and developing nations. The students were assigned a semester-long design project, on which they worked in teams to design a sanitation solution for a small remote local community; in previous offerings of this course, the design projects focused on large centralized wastewater treatment systems. After later investigating common sanitation practices in the U.S. and in developing nations, students began work on a case study focused on a specific community in a developing nation, a learning process that included visits from guest speakers who had overseen sanitation engineering projects in such communities. In week nine, student teams completed part one of their case study, describing their chosen community and its relevant demographics, current sanitation practices, and the team's ideas for potential sanitation options. In week 11, student teams turned in the second part of their case studies, in which they identified key stakeholders in their chosen communities, conducted a sanitation options assessment, and marshaled evidence to support their recommended sanitation option. In week 12, students re-took the pre-test, and we observed considerable change in their understanding of technical and non-technical sanitation constraints and issues, thus addressing our learning objectives.

Energy Engineering. After the faculty workshop, two faculty members from philosophy and electrical engineering began developing a HEE module for an Energy Engineering course. The rationale for such a module is that energy use requires the interweaving of technical choices among resources, demand, and behavioral alternatives. That is micro-choices (related to the individuals) are constrained by the macro-choices (related to the project of an energy system designed to serve a community).

This module is designed to introduce students to energy technology development as a human process where major consideration is placed on social and economic constraints such as those related to sustainability, social justice, and environmental justice. Students then discover how energy is a key component of humanitarian interventions and various types of community development. Heating, cooking, water delivering and disposal, and most medical equipment, all rely on energy generation and conversion from either fossil fuels, nuclear power, hydropower, and/or small-scale renewable sources such as wind and solar power.

The initial classes in this module cover a historical overview of energy and its interactions with human societies. Students learn how changes in design of energy systems bring about changes in standards of living and lifestyle and vice versa. A group activity of drafting a one-page timeline on the history of energy development aims to promote learning about human-energy interaction. Other group activities allow students to develop design criteria for energy devices and systems used in humanitarian and community development scenarios. These criteria apply the general HEE criteria listed above by providing more specific guidelines directly related to energy. At the end of the module, students write an assessment of a particular energy technology based on the both the general and specific HEE criteria. A roundtable is organized to discuss research findings of each group. This module is being inserted during three hours (one hour per week) in a technical renewable energy engineering course.

Humanitarianism. This is a general three-part module designed to be used in virtually any S&E course. On the assumption that many faculty and students will experience at least a weak attraction to humanitarianism but be unsure about precisely how to proceed, this module adapts much of the material reviewed in the overview section of the present paper into a self-paced learning module and could extend from one to three hours of classroom instruction. For instance, the first hour of the module sets out three objectives:

1. To become aware of humanitarianism as a distinctive historical phenomena and ideology
2. To appreciate some of the major figures in the tradition of humanitarian thought and action
3. To learn the basic history of humanitarianism

It then provides reading assignments and a brief objective personal assessment quiz. Although presently only in hardcopy format, the team member in charge of this module wants to make it available in a web-based format. Faculty can add it to a course syllabus, either as a required component or as a supplement. Then it could easily become a course assignment where students can imagine ways in which their technical learning could be adapted or put to humanitarian use. Rather than teaching ethics as a professional code that places boundary conditions on professional practice, this module would attempt to stimulate idealism among students and encourage the expansion of their ideas about the scope of engineering and the future of their careers.

Assessment

Assessment activities are planned and have been implemented throughout this project. To date, the majority of assessment methods have been formative in nature. As was discussed earlier, a literature review has been completed and based on this review, student learning outcomes have been proposed. These outcomes have been used in curriculum development and thus are aligned teaching and learning goals. As the curriculum is implemented, summative assessments that include pre- and post-content assessments and student surveys will be implemented.

Preliminary formative assessment has taken place in the one-credit pilot seminar and in one HEE module. In the one-credit pilot seminar, students conducted mid-term and final evaluations of the seminar. The quantitative measures of the final evaluation showed that students rated the seminar positively in terms of its teaching methods and content. Qualitative verbal assessments expressed enthusiasm about the seminar's emphasis on cultural and historical forces that should be shaping engineering education, but that were all too often overlooked as extraneous to the S&E curriculum at CSM and elsewhere. Many students hoped that various forms of non-technical inquiry and reflection addressed in the seminar might be presented in a more coordinated fashion in future renditions of coursework focused on humanitarian engineering.

Preliminary formative assessment was also conducted in the HEE module for a Wastewater Engineering course. Preliminary paired comparison of pre- and post-module survey responses showed significantly greater overall number (0.025 level) and more complex responses (0.005 level) post-module, based on the Wilcoxon signed-ranks test. During the almost weekly discussions of the case study, both the regular (technical) course instructor and a non-technical instructor met with students to coach them through the process of writing a case study. Among

many other benefits, students remarked that they drew from the knowledge they gleaned in the process of writing the case study when their teams wrote their final semester design reports. This was evident in their final reports, which, for the first time in the five previous offerings of this course, all included explicit and prominent consideration of non-technical issues such as social, political and environmental constraints.

Conclusion

This paper outlined the literature review and philosophical analysis conducted in different areas related to humanitarianism and its potential contributions to engineering ethics. It has become evident that the field of engineering ethics has much to gain from engaging the questions and problems faced by non-engineering humanitarian practitioners, especially those practicing outside well-defined boundaries where professional responsibility is blurry and ambiguous (e.g., humanitarian camps where there is no clear state or corporate jurisdiction). Most analyses of ethical dimensions of humanitarian intervention have been done for professions other than engineering (e.g., medicine, humanitarian work, military). These ethical dimensions create tensions with existing engineering codes of ethics because humanitarian intervention places responsibility of engineers for human groups that are not traditionally considered in code of ethics such as customers, employers, or customary national publics. Engineering practice in spaces where national sovereignty and corporate responsibility are ambiguous also introduces new challenges to the ethical responsibility of engineers. Further philosophical engagement with humanitarianism will allow the field of engineering ethics to make significant contributions to the emerging curricular and student-based initiatives related to humanitarian practices and to reforming graduate engineering education by providing new pathways for “creative action” to graduate-level engineers who see themselves as scholar-citizens practicing beyond the educational realm. This type of contribution is already evident in the development of HEE criteria being used as a framework for a graduate-level HEE Introductory Seminar and as assessment criteria to evaluate technologies and engineering practices.

This type of engagement requires the collective effort of faculty from different disciplines and areas of practice and a commitment to go beyond well-established disciplinary boundaries to create an interdisciplinary space in which ideas and new forms of practices can be proposed and developed. However, this kind of effort and commitment takes time and experimentation in order to build trust and understanding of faculty’s different perspectives. Our faculty team took more than one year of regular and intense interactions to move from philosophical analysis of the intersection between humanitarianism and engineering ethics, to development of the HEE criteria, to begin curricular experimentation.

The course and modules developed and implemented to date show early signs of success in encouraging engineering students to consider non-technical dimensions of their knowledge and future practices, including potential humanitarian uses of their engineering skills. Future work will focus on thoroughly assessing engineering students’ knowledge of, skills for, and attitudes towards humanitarianism and humanitarian work.

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Appendix

Humanitarian Engineering Ethics IDS Agenda, May 15-16
New Concepts (Monday, May 15, 8 am- 12 noon)
<p>8 am Process writing. <u>Engineers</u>: focus on content of your own module for your own course. List 5 items that you would like to include in your module. Place list aside, add, expand, clarify, or even change throughout the day. <u>LAIS</u>: focus on what you could add to proposed modules. Proposed modules: Energy/Equity; Water treatment/sanitation; Sustainability</p>
<p>8:15 am Humanitarian engineering: some definitions</p>
<p>9 am Humanitarian ethics. Reading: “Ethics beyond borders” by Mathew Hunt</p>
<p>9:45 am Questioning expertise. Reading: Chapter 3 of <u>Pedagogy of the Oppressed</u> by Paulo Freire; Reading: Chapter 5 on “Technology and Expertise” from <u>Whose development?</u>; short films on AIDS education</p>
<p>10:30 am Sustainability in humanitarian engineering.</p>
<p>11: 15 am Cultural barriers. Reading: Chap 7. “Cultural Barriers” from <u>Whose development?</u></p>
<p>12- 12:30 pm Lunch</p>
<p>12:30 pm Construction/deconstruction of technology Goal: To learn how engineers vs. humanist/social scientists solve problems Method: Marcelo and Junko select two specific technologies (alternative energy; water treatment)</p>
<p>12:45 pm Breakout in disciplinary groups Discuss: How are technologies built? What are they for? What are the underlying principles? What does it take to build them? Who are the intended users? <u>Prepare to present to the other group</u></p>
<p>1:30 pm Understanding each other’s concepts: presentations and discussion Engineers: Explain engineering concepts through reverse engineering LAIS: Explain social science/humanities concept using same examples</p>
<p>2:15 pm Forward engineering/technology assessment: Junko/Marcelo briefly present two humanitarian scenarios where technologies could be used</p>
<p>2:30 pm Breakout in disciplinary groups Assess how these technologies will be used in these humanitarian scenarios. <u>Prepare to present.</u></p>
<p>3:15 pm Understanding each other’s ways of using technologies: presentations Engineers: Explain how to use technologies in humanitarian scenarios</p>

LAIS: Explain how to use technologies in humanitarian scenarios

3:45 pm Formative assessment of IDS

Interdisciplinary Team-teaching/Curriculum Development/Planning

Tuesday, May 16

8 am Respond to formative assessment

8:15 am Interdisciplinarity. Reading: chap 1 and 2 from Davis book

Group discussion: what do these concepts mean to me? How could these apply to my teaching?
Why do I agree/disagree with Davis in his rationale for interdisciplinarity?

9:15 am How to build/teach an intro seminar and modules

Reading: chap 3 from Davis book

Readings: Integrating Ethics and Engineering: A Graduate Option; Papers on graduate course on humanities and professional studies and literature in medicine

10:15 am Barriers and opportunities. Read: FIE paper (distributed earlier)

11: 15 – 11:45 pm Lunch

11: 45am – 1:45 pm Module development (in pairs)

Jon moderates on developing modules starting with development of objectives

Once objectives have been set, plan potential activities, content, pedagogies.

Once these are set, plan how to organize/divide work throughout summer

Ready to pilot in Fall 06? Spring 07?

1: 45 - 2:30 pm Presentations to and discussion with the group (15 min each pair)

2:30 – 2:45 pm Break

2:45 – 3:15 pm Discussion on interdisciplinary/team-taught seminar (all)

Audience; outreach to other divisions; main themes

How could we develop this seminar in Fall 2006? Pilot in Spring 2007?

3:15 – 3:45pm Formative assessment of IDS