120th ASEE Annual Conference & Exposition
FRANKLY, WE DO GIVE A D*MN
June 23-26, 2013

Paper ID #6396

Global Portrayals of Engineering Ethics Education: A Systematic Literature Review

Justin L Hess, Purdue University, West Lafayette

Justin L Hess is a Ph.D. student at Purdue University's School of Engineering Education. His research focuses on the role of individual values in engineering decision making, such as the role of empathy in stakeholder perspective taking, motivating student interest in sustainability, and deconstructing dominant worldviews within engineering. He currently is a research and teaching assistant for an NSF-funded project which uses reflexive principlism as an ethical framework for engineers to reason through moral issues, and explores the effectiveness of using a pedagogical framework of scaffolded, integrated, reflexive analysis to deliver the material. He was the 2012-2013 Engineering Education Graduate Student Association President, the Director of Technology and Events for Engineers for a Sustainable World (ESW) during 2012-2013, and will be the Education Director for ESW during 2013-2014. He is an acting assistant editor for Engineering Studies editor the J-PEER.

Global Applications of Engineering Ethics Education: A Systematic Literature Review

Introduction

Engineering education plays a crucial role in leading students to develop the competencies needed to succeed in a global world .[1] Engineering educators now seek to help students foster a "global perspective" in order to thrive in the global environment[2], yet their focus has a tendency to be on the economic incentives of so doing.[3,4] Dewey stated long ago, "If ever we are to be governed by intelligence, not by things and by words, science (and engineering, I add) must have something to say about *what* we do, and not merely about *how* we may do it most easily and economically".[5] Ethics education is one arena for such discourse.

The contemporary landscape

Today, professional ethics has become a central subject within engineering education in the United States, due in part to an increased focus on professional responsibilities of engineers[6], risks associated with rapid technological development[7], and ABET[8] mandated student outcome of "an understanding of professional and ethical responsibility". The National Academy of Engineers similarly suggests students need to "possess a working framework upon which **high ethical standards** and a strong sense of **professionalism** can be developed".[9] As a core habit of mind, these students must be attentive to ethical considerations, they must realize "the impacts of engineering on people and the environment", and they must be considerate of "unintended consequences of a technology".[10] ABET frames such a responsibility in a global context with the following stated outcome; "the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context".[8]

Internationally, engineering ethics education is also gaining importance.[1] However, its emergence has varied according to the identity of engineers within differing national contexts and according to cultural values, professional codes, and standards of the respective nation.[11] In many countries, such as the U.S., Spain, and the Netherlands, ethics is now "a required part of the curriculum".[12] Accreditation boards are arising globally[13], often playing some role in the impetus of ethics curriculum inclusion. For example, the Japan Accreditation Board for Engineering Education (JABEE) seeks to ensure Japanese engineering students gain an understanding of their professional "responsibility to the public".[14]

Global considerations

What Patil and Codner call for is the development of a "global accreditation model" to "produce better graduate outcomes and also promote mutual recognition and global mobility of engineering education".[15] However, the direct transferability of an ethical model from one context to another is always challenging, given differing values, cultures, and worldviews. Professional codes of ethics are not universal, as they are influenced by political, social, and aesthetic factors.[16] Harris Jr. suggested engineers need ethical *guidelines* to "act ethically" in an international environment, as professional codes as written in the United States are commonly non-transferrable outside of a U.S. context.[17] Weil provides some recommendations toward the development of international or even transnational codes, one recommendation being the addition of conditional statements that take into account local factors.[18] She posits this will also lead to conceptualization of standards as "rough boundaries for practice" rather than rigid rules.

The formulation of international codes may be contingent upon the doctrine of cultural relativism which acknowledges the subjective nature of worldviews. At the core of relativism may be discovered a universal precept; the global need for ethical standards regarding a "sense of what is expected and what is out of line".[19] No matter the national context, there likely exists an acceptable social and cultural norm *within* that context. Therefore, an effective international code that takes into account limitless *necessary* albeit *relative* factors through a complex system of conditional statements may in fact be possible.

Research questions

The development of conditional statements leading towards the development of international codes is beyond the scope of this paper, although this work may be viewed as a step in that direction. This study examines the applications of engineering ethics education worldwide, guided by the following research question, "In what ways is engineering ethics being incorporated into the engineering curriculum globally?" Secondary research questions include, "In what context are these ethics courses situated?" and "What content, assessment, pedagogy, and ethical theories (if any) are implemented by instructors?"

Overview of this study

This study begins with a general literature review exploring the goals of engineering ethics education and methods of incorporating ethics into engineering curriculum. The theoretical framework grounds my assumptions as I perform a systematic literature review of applications of engineering ethics education. This paper ends with results of the literature review, elaboration of three applications from different host nations, a discussion on global reflections and curriculum considerations for engineering ethics educators, and closing remarks.

Admittedly, my ideologies are U.S.-centric, but I make the attempt of the qualitative researcher at approaching my research questions with an open-mind, unguided by potential bias towards U.S. models of engineering ethics education.

Literature Review

Embedding ethics into engineering education

Harris Jr, Davis, Pritchard, and Rabins suggested engineering ethics has varying learning goals, including "to stimulate the ethical imagination of students", to "recognize ethical issues", "to help students analyze key ethical concepts and principles that are relevant to the particular profession or practice", "to help students deal with ethical disagreement, ambiguity, and vagueness", and "to encourage students to take ethical responsibility seriously".[20] Newberry breaks these goals into three broader categories, "emotional engagement, intellectual engagement, and particular knowledge".[21] Haws is more specific, as he posits engineering ethics should help students develop "enactive mastery, as they encounter moral dilemma and work through ethical deliberations" while being provided "vicarious experience, encountering the moral dilemma of others with whom they identify; and expert testimony, following those whose expertise they accept".[22]

Like the varying learning goals, the means through which ethics are included into engineering education are diverse, ranging from general ethics courses in domains outside of engineering, to integration into engineering courses themselves.[23,24] For the most part, when led by engineering instructors the focus has been professional codes and/or case studies.[25] There are many proponents of these methods[20,26] despite "little empirical research on whether the use of cases is the most effective teaching method in promoting ethical understanding for engineering students".[27] Critics of these "individualistic approaches" suggest the focus is too narrow[28,29] and that codes restrict attention to micro-ethics issues, when the focus should instead be on macro-ethics, or societal issues.[30] Devon & De Poel believe both the "social ethics approach and individual ethics approach do not exclude each other.[31] However, individual ethics without social ethics is powerless".[31] Haws goes one step further, suggesting that students should develop a meta-ethic by applying ethical principles within a social context through "the negotiation of moral values".[32]

Potential barriers of effectiveness

Haws is suggesting that some inclusion of ethical theory is necessary for the development of a moral framework to solve future ethical dilemmas.[32] He found in an earlier study that ethical theory was rarely included in engineering ethics education.[25] Unlike Haws, Abaté argues that engineering ethics should *not* and even *cannot* be taught if understood as "training engineers to be moral individuals".[26] Abaté's suggestion is that morality is imbedded deep into one's being, and that a stand-alone course will be insufficient to alter such ethos. Abaté submits that with an alteration of the stated goal and a realization of pedagogical approaches that meet the stated goal the endeavor may be more pursuant. Cruz and Frey recognize Abeté's view as that of a "popular view of moral development" which presupposes moral development "is over by the time children reach their early teens".[33] In opposition, Cruz and Frey suggest the popular view is in fact wrong, and that moral reasoning may be developed later in life.

Newberry, although not focusing solely on moral reasoning, agrees that engineering ethics runs the risk of only being "superficially effective", with barriers of effectiveness being a "lack of emotional engagement with the material on part of the students, which in turn is mainly influenced by the pull of the technical center of gravity of the curriculum, and by the lack of expertise and role modeling by the faculty".[21] Barry and Ohland back up these suggestions, showing that engineering ethics is commonly *in*-effective.[34] They found that exposure to ethics content does *not* necessarily lead to development of engineering education outcomes. They suggest that rather than focusing on *quantity* or exposure, instructors should focus on the *quality* of implemented instructional strategies.

Theoretical Framework

Yadav and Barry have pointed to a lacking engineering ethics education research foundation based on empirical work.[27] My position is that this research foundation must be based on some course design model. This study follows the operational framework offered by, Streveler, Smith, and Pilotte's where "alignment of content (or curriculum), assessment, and delivery (or pedagogy or instructional strategy) to design learning modules, courses, and programs is pivotal to advancing the state of the art of practice in engineering education".[35] Engineering educators must not only disseminate results, but actively assess their teaching strategies. In order to do this, educators must not only set learning goals, but also determine "acceptable evidence to decide whether or not, or to what extent, students have met the learning goals".[35]

I do <u>not</u> elect a priori any "correct" method of engineering ethics education. In an international context, there is limited research regarding such assertions. I <u>do</u> recognize Haws proposition that dogma, rules, and/or codes alone are insufficient for development of a moral framework, as are micro-ethics, which are more individually oriented.[32] I <u>do</u> believe a focus on either macro-ethics[30] or meta-ethics[32] will more likely to lead "students from lower to higher stages of moral development". However, I do not posit that the development of a moral framework is the end goal of engineering ethics education for all instructors, as Harris Jr. and others do not even include such a goal when listing 6 common learning goals of engineering education.[20]

Given the above assertions, this study explicitly focuses on stated learning goals and assessment strategies measuring attainment of those learning goals. Simply exposing students to engineering ethics content is insufficient to meet desired outcomes.[34] While I do not presuppose "the key point in fostering the student's ethical learning abilities is more *how* than *what*"[24], I do believe researchers must be transparent regarding how *and* what in order to develop the needed engineering ethics education research foundation.

Methodology

Literature Criteria

In this study a systematic literature review analyzing sources from 4 journals; three engineering education research journals and one engineering ethics journal. Within found articles, through exploration of the abstracts, literature describing actual implementations of engineering ethics pedagogy was retained, while purely theoretical sources or those lacking specific applications developed learning intervention were removed. Only literature published in the past 10 years (2003-2012) was analyzed.

Data Collection

Journal of Engineering Education (JEE): I explored literature from JEE which used the term "ethic" (and truncated keywords) in the title. I received 19 sources ranging from 1993-2011 and retained 5 which met the criteria for this study. Each of the 5 articles collected found within JEE were based on applications set in the United State[3640]

International Journal of Engineering Education (IJEE): Within IJEE I manually searched for the term "ethic" in the titles of publications dating back to 2003, and I found 11 articles (mostly from a special issue in 2005). Of these 11, 4 were pertained to some course implementation. These sources represented applications within 3 different countries, including Japan[41], Sri Lanka[42], and the United States[43,44].

European Journal of Engineering Education (EJEE): Here I sought literature using the string "ethic" and truncated keywords in the title, finding 8 articles. Of these articles, 6 met the above criteria and spanned 5 different countries; Australia[45], Denmark[46], Netherlands[47,48], Spain[24], and Taiwan[3].

Science and Engineering Ethics: In Science and Engineering Ethics I searched for sources explicitly using "engineer" and truncated keywords in the title, finding 110 academic journals. As a whole, articles within Science and Engineering Ethics spanned pedagogies or philosophies of engineering ethics education in Spain, Puerto Rico, India, Japan, Germany, and Malaysia. After examining the abstracts from each of these sources, I found 17 articles describing specific applications in contexts including India[49], Spain[50,51], Puerto Rico[33], and the United States[5264].

Coding scheme development

The coding scheme used in this study was a product of both deductive and inductive development. Table 1 shows the 11 items included in the database upon completion. These items provided the means for comparative analysis. The majority of these categories are matters of fact, such as whether the course was required, course duration, stated learning goals, whether or not these goals had been met, content, assessment, and the research strategies used.

Table 1: Coding Scheme

What **professorate** is teaching the course?
Towards what **engineering discipline** is the class intended
Who is the targeted **audience**?
Is the course **required** for these students?
What is the **duration** of the course?
What is the stated **learning goal(s)**?
If there is a stated learning goal, **was it met**?
What type of **content** is included in the course?
What sorts of **pedagogy** are employed?
How does the **instructor** assess student learning?
What **research strategies** are used to measure transferability?
What **ethical theory(ies)** must students consider?

Deductive coding was used when I brought pre-conceived notions of items to be included in categories. For example, I used Haws (2001) findings for pedagogical nomenclature, including the following items initially; (1) Professional engineer's codes of ethics, (2) Humanist readings, (3) Theoretical grounding, (4) Ethical heuristics (*I combined ethical heuristics and theoretical grounding into a category called 'ethical theory' due to a lacking coherent means of differentiating between two*), (5) Case studies, and (6) Service learning. Likewise, I initially distinguished between three types of ethical theory following the lead of Lloyd and Busby, "(1) consequential, (2) deontological or non-consequential, and (3) virtue-based".[65]

Inductive codes are those developed through analysis of the literature. Pedagogical items developed inductively included role-playing, problem based learning, ethics across the curriculum (*this included components of nearly all other pedagogies; only ethics across the curriculum was coded in these instances*), and debate (*when used explicitly in the paper)*. Ethical theories developed inductively included human rights, Eckenberger's moral development action theory, and a "multiple" categorization. When ethical theories were not referenced explicitly, I did not code them. There were inferences to theories even when the author(s) failed to explore such philosophies in their course.

Results

<u>*Literature Distribution*</u>

In total, 32 sources were collected from the 4 journals, representing 10 different nationalities. Of these cases, 13 were comparatively analyzed. Given the comparative intent of this study, a maximum of 2 cases from any nationality were included in the analysis. Table 2 shows the distribution of sources by nation, the number of papers analyzed from the respective nation, and the journals that published the case.

Table 2: Distribution of literature by nation

Country	Papers Collected	Papers Analyzed	Journal(s) of Analyzed Case(s)
Australia	1	1	EJEE
Denmark	1	1	EJEE
India	1	1	Sci & Engr Ethics
Japan	1	1	IJEE
New Zealand	2	2	EJEE
Puerto Rico	1	1	Sci & Engr Ethics
Spain	3	2	Sci & Engr Ethics
Sri Lanka	1	1	IJEE
Taiwan	1	1	EJEE
United States	20	2	Sci & Engr Ethics, JEE
Total	**32**	**13**	

Database Analysis

Any meaningful way of comparing the cases according to nationality was limited by the diffusion of other variables. For example, the audience ranged from high school students, undergraduate engineering students, undergraduate non-engineering students, graduate students, to engineering faculty. The durations included 2 hours, 1 day, 1 semester, 2 years, and a student's entire undergraduate career. Of the 13 cases analyzed, 9 had a general orientation, not relating explicitly to a given engineering discipline. 3/13 cases were designed towards civil and environmental engineering students, and 1/13 was aimed towards civil, environmental, and mechanical engineering students. The professorate leading the course was more variable. Engineering instructors had backgrounds or were teaching in biomedical, civil, environmental, mechanical, electrical and/or computer engineering. Liberal instructors included professorate from English, education, and philosophy. Table 3 shows this disparity, and shows that nearly half of the cases were taught in interdisciplinary teams.

Table 3: Professorate of intervention

Engineering only	6
Engineering & Business	1
Engineering & Liberal	3
Liberal only	2
Science and Philosophy	1

Table 4 shows the pedagogies implemented in the ethics courses. In nearly every instance multiple strategies were employed by the authors. It should be stressed the "ethics across the curriculum" models, used twice, seemed to include nearly every other pedagogy. The only instance where case studies were not used was when service learning was implemented.

Table 4: Pedagogical Strategies

Ethics Across the Curriculum	2
Case Studies	10
Codes	4
Debate	4
Ethical Theory	5
Humanist	1
Role Playing	4
Service Learning	1

In 7/13 instances, authors did not reference ethical theories explicitly. While never referencing deontological, teleological (under which I combine utilitarianism), or virtue ethics in isolation, 4/13 authors worked towards the inclusion of multiple ethical frameworks in their course. Human rights served as a "religiously neutral" ethical theory in the Sri Lankan context[42] and Eckenberger's action theory was used as a guide to help individuals develop *their own* moral framework in the Taiwan case study[3].

I have mapped out the learning goals from the 13 studies in Table 5. Please note that the wording of the stated goals has been slightly modified from the original text. Also note that the authors tended to present learning goals in the text without explicitly referring to the goals as such. I have done my best to capture the essence of the authors' intent. Authors tended to neglect asserting whether stated learning goals were met. Only in a few cases did authors thoroughly describe how an educator would know if students had met a stated learning goal. A few learning goals were stated in such a way that no matter what, they would be met.

Table 5: Learning goals or objective from literature

Author(s)	**Country**	**Objectives**
Ansari et al.	India	To understand and resolve environmental problems in and around the city of Hyderabad, India
Bero, Kuhlman	USA	To solve ethical problems through an ethical decision making process that parallels the engineering design process
Boni, Berjano	Spain	To develop moral awareness; To prepare students for future working life by helping them acquire skills that allow them to carry out their professions with autonomy and responsibility
Børsen	Denmark	To develop the ability to recognise, analyse, and understand background/context of controversies; To distinguish between normal and post-normal science; To develop the capacity to formulate explicitly and use one's ethical orientation system
Bowden	Australia	To develop the skills and confidence to tackle those ethical issues that engineering students would encounter on graduation; To develop moral reasoning
Chang, Wang	Taiwan	To enhance students' ethical awareness through cultivating their knowledge of ethical theory using Eckenberger's moral theory framework
Cruz, Frey	Puerto Rico	To identify ethical issues; To develop case studies that dramatize these issues; To develop exercises making use of these cases tailored towards mainstream engineering classes
Fleischmann	USA	To develop the habits of the mind that will enable students to practice engineering in an ethical manner; To create a culture in which the responsible and ethical practice of our profession is taught from the very beginning of our program
Gil-Martín et al.	Spain	To increase the ethical and moral education of the students through internal reflection and a free election
Hoole, Hoole	Sri Lanka	To use human rights as a religiously neutral basis for teaching engineering ethics
Iino	Japan	To learn who engineers are and the world context of engineering work
Wareham, Elefsiniotis, Elms	New Zealand	To participate in a general discussion of ethical theories, using these to explain the behaviour of participants, during a 2-hour workshop
Zandvoort, van Hasselt, Bonnet	New Zealand	To recognize and analyze ethical aspects and problems related to technology and the professional practices of engineers; To provide insight into the relevant backgrounds, relating to those ethical aspects and problems; To impart the knowledge and skills required to enable one to reason on these issues in a consistent and reliable manner and to enter into solution-oriented debate with others on these same issues

Example Applications

Here I explain three cases in detail to provide some context for the discussion.

Case 1: By Bowden.[45] This first case comes from the University of Sydney. The course described is in its 4th year of operations as of 2010. The paper regards the development of an engineering ethics course per the learning objective, "[T]o provide engineers with the skills and confidence to tackle those ethical issues that they would encounter on graduation". Bowden uses 25 case studies to develop a list of 15 ethical issues most relevant in engineering. After distributing these issues to engineering managers and rank ordering the items, 13 issued remained prominent, the first 5 being (1) negligence, (2) inadequate design checking, (3) bid shopping, (4) inadequate workplace safety, and (5) environmental issues. The author also had managers develop a list of skills needed to overcome these ethical issues. The first 5 of these 14 skills were (1) communication capabilities, ethical commitment and skills, (3) Willingness to acquire new knowledge, (4) Ability to work within a team, and (5) Decision making. The assumption seems to be that by developing these skills engineers will also learn to overcome the identified ethical issues.

Bowden later describes the pedagogy used to develop the needed skills. The course is broken into 5 sections. The first is case problem teaching, which provides students real-life context, challenges students to come to some resolution, strengthens "inter-personal communication skills" and capabilities in reasoning through the moral issues in the profession". The second section includes ethical theory and decision making. Using a "version of utilitarianism", the author has students apply and reflect on the application of four principles to engineering problems: (1) do no harm, (2) ensure justice, (3) act with virtue, (4) respect individuals and their freedom. Third, the author incorporates public interest disclosures, with an explicit focus on "how to blow the whistle without incurring retribution for the employee". Fourth, the author implements codes of ethics, with the aim that students develop their own code. Lastly, the author presents students with professional society norms, pulling from the "Code of the Institute of Engineers Australia".

Bowden concludes suggesting this course "provides a sound basis for strengthening moral reasoning and for widening professional ethical practices". Bowden does not explain assessment pieces of the course in any detail, nor does he suggest whether the inexplicitly stated learning objectives were met.

Case 2: By Ansari, Jafari, Mirzana, Imtiaz, & Lukacs.[49] This second case comes from Muffakham Jah, a small-private college in Hyderabad, India. Students in this case are civil and mechanical engineering students. The pedagogy has a service learning orientation as the students are asked to solve real-world environmental problems. The "course" takes the form of extracurricular involvement rather than credit hours. The authors describe 2 projects students work on: (1) the Maqta uplift project where students identify a solution to overcome problems such as "contaminated bore wells, poor sanitation… open sewers, broken hand pumps, and inadequate drinking water supply" in a low-income area, (2) the Natural House project which has students model the "cooling and heating systems of a house".

In this paper there is almost no reference to ethics explicitly. The authors seem to suggest that ethical competencies will be developed insofar as students develop environmental and social sensitivities, or the development of a disposition towards socio-responsive engineering. For example, the authors hope that students realize their "social obligations towards the underprivileged stakeholders of society". The work lacked a formal assessment piece. As a measure or reliability, the authors write individual journal entries attesting to the merit of this approach. The authors leave readers with perhaps their only explicit reference to ethics via their "Hippocratic Oath" proposal. A caption of this oath reads as follows:

> I recognize and appreciate that the profession I am embarking on is a privilege that carries special responsibilities. I recognize and appreciate that the design, creation and use of technology has far-reaching consequences for the natural environment and human society and that as an engineer I must exercise care and consideration to avoid causing harm to either. I recognize and appreciate that the purity and quality of the earth's environmental systems comprising air, water and land are in danger of serious damage and I pledge to protect them when I can.

Case 3: By Fleischmann.[56] This final case is based within the United States, at Grand Valley University. Fleischman shows the school has attempted to weave "an 'ethics theme' throughout the curriculum". This pedagogy was labeled "ethics across the curriculum" following the lead of Cruz and Frey.[33] Here I discuss the sequence of pedagogies implemented across the curriculum in a somewhat linear process.

First, at Grand Valley, students begin their engineering education with an introduction to the Honor Code. During this introduction students evaluate a case study using a laminated card featuring "rules of thumb". The case study has students consider what they would do if they were tempted to copy and share electronic data. By presenting the case at the beginning of the students' career, educators "show students how such behavior violates every one of the rules of thumb".

Second, students are required to participate in the co-op program, what Fleischmann considers "a golden opportunity to teach ethics in the context of professionalism". While working students have assignments, part of which is always a book report regarding professionalism and ethics. "At the end of the semester we hold a mandatory meeting where the main activity is small group discussions of the case study (presented in the assigned book reading) with faculty members acting as discussion facilitators".

Third, students take a required course on ethics offered by the philosophy department. By taking this course, Fleischmann suggest students will learn to apply ethical reasoning to engineering situations. He cautions, "It is difficult to quantify this but it is definitely an intangible benefit of our approach".

Lastly, students are "initiated" into the profession of engineering during The Iron Ring Ceremony. "The ceremony involves the administration of an oath and placing a stainless steel ring on the pinky of one's working hand. The ceremony reinforces the notion of servitude and ethical responsibility stressed throughout the students undergraduate careers.

Like the previous two pieces, this work lacks any formal assessment piece. The author suggests this holistic approach leads to the development of "habits of mind", although she does not provide any empirical data to back up this claim.

Discussion

Global Reflections

Iino wrote, "Engineers innovate and innovation carries new risks".[41] One might think engineering ethics has emerged globally due to engineers' increased ability to manipulate the physical environment, frequently in ways catastrophic. Yet, nearly all of the approaches described in this paper aimed to foster competence at a local level, as a review of the learning goals in Table 5 shows. There seems to be a lacking framework to implement, teach, and assess ethics learning both at the local and global level. While I have not developed such a global framework, next I will recommend a few areas to remain cautious by referencing the 13 cases included in this study's comparative analysis.

First, any effectively "global" approach to engineering ethics education cannot strictly rely on a given country's set of rules. Remaining cognizant of Haws suggestion "we need to lead our students beyond dogmas, ethical heuristics, and the inductive milieu of engineering case studies—to an understanding of diverse ethical theories and the meta-ethics that allows us to establish and reference meaningful ethical values",[22] it seems a focus on reasoning rather than codes would seem to shift focus from "correct" answers to cognitive reasoning.

Second, we should remain cautious of the integration of ethical theories at the interplay of religion. In Gil-Martín and other's study half of the students were proponents of the inclusion of the Judeo-Christian religion in an ethics course, whereas 29% thought the course should not contain any religious elements.[51] In Sri Lanka such discourse is not open for debate, as Hoole and Hoole stressed cultural and religious neutrality were a must for their ethics course. They explain, "[W]e as teachers in a state university are duty bound to advance in a religiously neutral vision of ethics".[42] Weil suggested "human rights" may provide a universal basis for ethics education.[18] In this Sri Lanka case study, human rights actually became the adopted "ethical framework", as the authors believe it to be neutral in regards to religious ideology. [42]

Third, course content is inevitably a byproduct of local factors. In Ansari and other's case studies, local environmental issues provided the context for ethical learning about *environmental responsibility* [49] whereas in Iino's case studies local nuclear issues and provided the context for *general* ethics learning.[41] Whereas Bowden (2008) includes "whistle-blowing" in his curriculum, Asian values tend to militate against so doing.[41,42]

Fourth, language barriers may pose problems when attempting to transfer content and pedagogy out of region. In a New Zealand case, language was a central issue, as Zandvoort and other's explain:

> [Delft University of Technology] made English the compulsory language for all MSc programmes. This poses challenges for our course. The teachers need to be able to express, explain etc. many concepts and typical 'ethics jargon', and the students need to be capable of receiving and understanding what is presented […]DUT requires its international students to have a certain minimum command of English. In spite of this, our experience has been that many international students lack sufficient command of English to allow for the intensity and speed of conversations… [47]

<u>*Curriculum Considerations*</u>

The number of courses required in engineering ethics may not have changed dramatically since times past.[66,67] Cruz and Frey posit this may be because requiring a course on engineering ethics raises the demand that met by a supply of engineering educator's time.[33] What they recommend is an "ethics across the curriculum" model where educators implement pedagogy within existing courses. This is like Fleischmann's model described in Case 3, where students are continually exposed to ethics.[56] In this model, numerous intervention strategies and curriculum aspects must be considered.

First, more ethics education means more of time demanded from engineering faculty. One potential solution to this increase in demand is involving professors outside of engineering. Case 1 described earlier shows an example of how this may be accomplished. Bowden, an instructor outside of engineering, lead the development and implementation of an engineering ethics course. As the case suggests, students may benefit from sounder exposure to ethical theory. Similarly, in Case 3, students were required to take a philosophy course on ethics. Wareham and others, however, criticize this pedagogical inclusion, with the assertion that it decontextualizes ethical theory from engineering. They write,

> Anecdotal evidence suggests that an ethics course taught by outside faculty reflects that faculty's ethos; and therefore experiences similar problems to technical subjects that are taught by non-engineers […] Another danger of teaching ethics as a stand-alone course is that students perceive it as such (i.e. as something outside of engineering to be 'gotten over') rather than as an integrated part of an engineer's education.[48]

Second, Herkert suggested more than 10 years ago that effectively teaching engineering ethics education "begins with self-education (of engineering faculty) through reading, use of online resources, discussions with colleagues and, where available, faculty development seminars" and that faculty must become "comfortable with discussing ethical issues and the social implications of technology in their courses".[67] Cruz and Frey suggest that empowering engineering faculty is essential to meet such an objective. The literature review in this study suggests we are moving in that direction, but even if engineering educators begin to "self-educate", a significant lack of empirical work exists.[33]

Third, engineering ethics education lacks a coherent research framework grounded in empirical work. A wide domain of scholarly literature which is primarily theoretical exists, compared to a relatively miniscule amount which is application based. Of roughly 200 papers sieved through for this study, I uncovered 32 which involved ethics instruction. Even within these, cases were heavily theoretical.

Fourth, instructors must assess student learning, they must be transparent regarding how they made such assessment, and they must share their results. Educators must explicitly state learning objectives, and then use proper assessment to measure whether students meet stated learning objectives. For example, if the goal is moral reasoning, existing tests may be used to decide how students gain moral reasoning skills.

Conclusion

Lucena and others suggested competencies should be defined and situated internationally.[1] That still leaves the question, "Should ethics be a core competency?" left open for debate. This study has found a limited amount of "international" work regarding ethics education as a whole. Furthermore, there is a lack in empirical work to serve as a guide for educators new to the ethics domain even if ethics were to become central to engineering educators globally. Thus far, this study failed to deduce some logical sequence of events for effective ethics education like the following: *Given this duration of exposure, under this setting, with this learning goal, using this assessment strategy, this intervention should be successful.* Educators must back their assertions regarding the effectiveness of their pedagogy and/or content with solid evidence. While global transferability will always remain questionable, such grounding in empirical work will at least pave the way towards a solid research foundation.

Limitations

This study has sought literature explicitly using the term ethics. Admittedly, this purports the Western centricity of the study. Literature outside of the U.S. may use terms similar to ethics, although neglect using the term due to factors of which I am unaware.

Future Work

This study has only examined a small sub-set of engineering ethics education literature. To broaden its implications, the remaining 19 sources found here will be analyzed. Additionally, a second perspective will be included to increase the reliability of these findings.

Acknowledgements

This writing does not represent the views of the following individuals who have provided insight and support to me while conducting this project. Thank you to Dr. Nadine Dolby for your helpful critique and insight in developing this research topic as part of a course on Globalization and Education. Thank you to my full engineering ethics research team for your encouragement; Dr. Andrew Brightman, Dr. Carla Zoltowski, Dr. Jonathan Beever, Dr. Matthew Krane, and Dr. Lorraine Kisselburgh. Thank you especially to Jonathan for critiquing my philosophical arguments herein. Thank you to my advisor Dr. Johannes Strobel for your continual support as I etch out my research foci as I work towards my dissertation.

References

1. Lucena, J., Downey, G., Jesiek, B., and Elber, S. (2008). Competencies Beyond Countries: The Re-Organization of Engineering Education in the United States, Europe, and Latin America. *Journal of Engineering Education*, *97*(4), 433-47.

2. Borri, C., Guberti, E., and Melsa, J. (2007). International Dimension in Engineering Education. *European Journal of Engineering Education*, *32*(6), 627-37.

3. Chang, P.-F., and Wang, D.-C. (2011). Cultivating Engineering Ethics and Critical Thinking: A Systematic and Cross-Cultural Education Approach Using Problem-Based Learning. *European Journal of Engineering Education*, *36*(4), 377-90.

4. Farrell, R., and Papagiannis, G. (2002). Education, Globalization and Sustainable Futures: Struggles over Educational Aims and Purposes in a Period of Environmental and Ecological Challenge.

5. Dewey, J. (1910). Science as Subject-Matter and as Method. *Science*, *31*(787), 121-27.

6. Fleddermann, C. B. (2008). *Engineering Ethics* (3rd ed.). Upper Saddle River, New Jersey: Pearson Prentice Hall.

7. Spier, R., and Bird, S. J. (2007). Science and Engineering Ethics at Springer. *Science & Engineering Ethics*, *13*, 1-3.

8. ABET. (2012). Criteria for Accrediting Engineering Programs, 2012-2013. Retrieved from www.abet.org/engineering-criteria-2012-2013/

9. National Academy of Engineering. (2004). *The Engineer of 2020: Visions of Engineering in the New Century*. Washington DC: National Academies Press.
10. National Academy of Engineering. (2009). *Engineering in K-12 Education: Understanding the Status and Improving the Prosects*. Washington, DC: National Academies Press.
11. Downey, G. L., Lucena, J. C., and Mitcham, C. (2007). Engineering Ethics and Identity: Emerging Initiatives in Comparative Perspective. *Science and Engineering Ethics, 13*(4), 463-87.
12. Kleijnen, J. (2011). Ethical Issues in Engineering Models: An Operations Researcher's Reflections. *Science & Engineering Ethics, 17*(3), 539-52.
13. Honjo, Y., and Tanigaki, M. (2008). Jabee's Role and Future Challenges. *26*. Retrieved from
14. Ohashi, H. (2004). *Establishing Engineering Profession in Japan: Accreditation, Professional Qualification and Cpd*. Paper presented at the 3rd ASEE International Colloquium on Engineering Education, Beijing.
15. Patil, A., and Codner, G. (2007). Accreditation of Engineering Education: Review, Observations and Proposal for Global Accreditation. *European Journal of Engineering Education, 32*(6), 639-51.
16. Aerts, D., et al. (1994). Worldviews: From Fragmentation to Integration. *Worldviews: from fragmentation to integration*.
17. Harris Jr, C. E. (2004). Internationalizing Professional Codes in Engineering. *Science & Engineering Ethics, 10*(3), 503-21.
18. Weil, V. M. (1998). Professional Standards: Can They Shape Practice in an International Context? *Science and Engineering Ethics, 4*(3), 303-14.
19. Blackburn, S. (2003). *Ethics: A Very Short Introduction: A Very Short Introduction* (Vol. 80): Oxford University Press.
20. Harris Jr, C. E., Davis, M., Pritchard, M. S., and Rabins, M. J. (1996). Engineering Ethics: What? Why? How? And When? *Journal of Engineering Education, 85*, 93-96.
21. Newberry, B. (2004). The Dilemma of Ethics in Engineering Education. *Science and Engineering Ethics, 10*(2), 343-51.
22. Haws, D. R. (2006). Engineering the Just War: Examination of an Approach to Teaching Engineering Ethics. *Science & Engineering Ethics, 12*(2), 365-72.
23. Magun-Jackson, S. (2004). A Psychological Model That Integrates Ethics in Engineering Education. *Science & Engineering Ethics, 10*(2), 219-24.
24. Boni, A., and Berjano, E. J. (2009). Ethical Learning in Higher Education: The Experience of the Technical University of Valencia. *European Journal of Engineering Education, 34*(2), 205-13.
25. Haws, D. R. (2001). Ethics Instruction in Engineering Education: A (Mini) Meta-Analysis. *Journal of Engineering Education, 90*(2), 223-29.
26. Abaté, C. (2011). Should Engineering Ethics Be Taught? *Science & Engineering Ethics, 17*(3), 583-96.
27. Yadav, A., and Barry, B. E. (2009). Using Case-Based Instruction to Increase Ethical Understanding in Engineering: What Do We Know? What Do We Need? *International Journal of Engineering Education, 25*(1), 138-43.
28. Conlon, E., and Zandvoort, H. (2011). Broadening Ethics Teaching in Engineering: Beyond the Individualistic Approach. *Science & Engineering Ethics, 17*(2), 217-32.

29. Davis, M. (2006). Engineering Ethics, Individuals, and Organizations. *Science & Engineering Ethics, 12*(2), 223-31.
30. Bucciarelli, L. L. (2008). Ethics and Engineering Education. *European Journal of Engineering Education, 33*(2), 141-49.
31. Devon, R., and De Poel, I. V. (2004). Design Ethics: The Social Ethics Paradigm. *International Journal of Engineering Education, 20*(3), 461-69.
32. Haws, D. R. (2004). The Importance of Meta-Ethics in Engineering Education. *Science & Engineering Ethics, 10*(2), 204-10.
33. Cruz, J. A., and Frey, W. J. (2003). An Effective Strategy for Integrating Ethics across the Curriculum in Engineering: An Abet 2000 Challenge. *Science & Engineering Ethics, 9*(4), 543-68.
34. Barry, B. E., and Ohland, M. W. (2012). Abet Criterion 3.F: How Much Curriculum Content Is Enough? *Science and Engineering Ethics*, *18*(2), 369-92.
35. Streveler, R. A., Smith, K. A., and Pilotte, M. (2012). Aligning Course Content, Assessment, and Delivery: Creating a Context for Outcome-Based Education. *K. Mohd Yusof, S. Mohammad, N. Ahmad Azli, M. Noor Hassan, A. Kosnin and S. K, Syed Yusof (Eds.), Outcome-Based Education and Engineering Curriculum: Evaluation, Assessment and Accreditation. Hershey, Pennsylvania: IGI Global*.
36. Jonassen, D. H., and Cho, Y. H. (2011). Fostering Argumentation While Solving Engineering Ethics Problems. *Journal of Engineering Education-Washington, 100*(4), 680.
37. Jonassen, D. H., et al. (2009). Engaging and Supporting Problem Solving in Engineering Ethics. *Journal of Engineering Education, 98*(3), 235-54.
38. Drake, M. J., Griffin, P. M., Kirkman, R., and Swann, J. L. (2005). Engineering Ethical Curricula: Assessment and Comparison of Two Approaches. *Journal of Engineering Education, 94*(2), 223-31.
39. Rayne, K., et al. (2006). The Development of Adaptive Expertise in Biomedical Engineering Ethics. *Journal of Engineering Education*, *95*(2), 165.
40. Loui, M. C. (2005). Ethics and the Development of Professional Identities of Engineering Students. *Journal of Engineering Education, 94*(4), 383-90.
41. Iino, H. (2005). Introductory and Engineering Ethics Education for Engineering Students in Japan. *International Journal of Engineering Education*, *21*(3), 378-83.
42. Hoole, S. R. H., and Hoole, D. (2005). Asian Values and the Human Rights Basis of Professional Ethics. *International Journal of Engineering Education, 21*(3), 402-14.
43. Lamkin-Kennard, K. A., Lerner, A. L., and King, M. R. (2007). Teaching Biomedical Engineering Ethics in the Context of Statistics. *International Journal of Engineering Education*, *23*(1), 184-91.
44. Erdosne Toth, E., and Kasi Jackson, J. (2012). Pedagogical Challenges for Nanotechnology Education: Getting Science and Engineering Students to Examine Societal and Ethical Issues. *International Journal of Engineering Education, 28*(5), 1056-67.
45. Bowden, P. (2010). Teaching Ethics to Engineers - a Research-Based Perspective. *European Journal of Engineering Education*, *35*(5), 563-72.
46. Børsen, T. (2008). Developing Ethics Competencies among Science Students at the University of Copenhagen. *European Journal of Engineering Education*, *33*(2), 179-86.

47. Zandvoort, H., van Hasselt, G. J., and Bonnet, J. A. B. A. F. (2008). A Joint Venture Model for Teaching Required Courses in 'Ethics and Engineering' to Engineering Students. *European Journal of Engineering Education*, *33*(2), 187-95.

48. Wareham, D. G., Elefsiniotis, T. P., and Elms, D. G. (2006). Introducing Ethics Using Structured Controversies. *European Journal of Engineering Education, 31*(6), 651-60.

49. Ansari, A., Jafari, A., Mirzana, I. M., Imtiaz, Z., and Lukacs, H. (2003). Environmental Education and Socioresponsive Engineering. *Science & Engineering Ethics, 9*(3), 397-408.

50. Lozano, J. F., Palau-Salvador, G., Gozálvez, V., and Boni, A. (2006). The Use of Moral Dilemmas for Teaching Agricultural Engineers. *Science & Engineering Ethics, 12*(2), 327-34.

51. Gil-Martín, L. M., Hernández-Montes, E., and Segura-Naya, A. (2010). A New Experience: The Course of Ethics in Engineering in the Department of Civil Engineering, University of Granada. *Science and Engineering Ethics, 16*(2), 409-13.

52. Benzley, S. E. (2006). The Small Helm Project: An Academic Activity Addressing International Corruption for Undergraduate Civil Engineering and Construction Management Students. *Science & Engineering Ethics*, *12*(2), 355-63.

53. Bero, B., and Kuhlman, A. (2011). Teaching Ethics to Engineers: Ethical Decision Making Parallels the Engineering Design Process. *Science & Engineering Ethics, 17*(3), 597-605.

54. Davis, M. (2005). Introduction to a Symposium Integrating Ethics into Engineering and Science Courses. *Science & Engineering Ethics, 11*(4), 631-34.

55. Davis, M., and Feinerman, A. (2012). Assessing Graduate Student Progress in Engineering Ethics. *Science and Engineering Ethics*, *18*(2), 351-67.

56. Fleischmann, S. T. (2004). Essential Ethics – Embedding Ethics into an Engineering Curriculum. *Science and Engineering Ethics, 10*(2), 369-81.

57. Graber, G. C., and Pionke, C. D. (2006). A Team-Taught Interdisciplinary Approach to Engineering Ethics. *Science & Engineering Ethics, 12*(2), 313-20.

58. Hashemian, G., and Loui, M. C. (2010). Can Instruction in Engineering Ethics Change Students' Feelings About Professional Responsibility? *Science & Engineering Ethics, 16*(1), 201-15.

59. Monk, J. (2009). Ethics, Engineers and Drama. *Science & Engineering Ethics*, *15*(1), 111-23.

60. Newberry, B., Austin, K., Lawson, W., Gorsuch, G., and Darwin, T. (2011). Acclimating International Graduate Students to Professional Engineering Ethics. *Science & Engineering Ethics, 17*(1), 171-94.

61. Prince, R. H. (2006). Teaching Engineering Ethics Using Role-Playing in a Culturally Diverse Student Group. *Science & Engineering Ethics*, *12*(2), 321-26.

62. Sauser Jr, W. I. (2004). Teaching Business Ethics to Professional Engineers*. *Science & Engineering Ethics, 10*(2), 337-42.

63. Chung, C. A., and Alfred, M. (2009). Design, Development, and Evaluation of an Interactive Simulator for Engineering Ethics Education (Seee). *Science & Engineering Ethics, 15*(2), 189-99.

64. Moore, C., Hart, H., Randall, D. A., and Nichols, S. P. (2006). Prime: Integrating Professional Responsibility into the Engineering Curriculum. *Science & Engineering Ethics*, *12*(2), 273-89.

65. Lloyd, P., and Busby, J. (2003). "Things That Went Well -- No Serious Injuries or Deaths": Ethical Reasoning in a Normal Engineering Design Process. *Science & Engineering Ethics*, *9*(4), 503-16.
66. Rabins, M. J. (1998). Teaching Engineering Ethics to Undergraduates: Why? What? How? *Science and Engineering Ethics, 4*(3), 291-302.
67. Herkert, J. R. (2000). Engineering Ethics Education in the USA: Content, Pedagogy and Curriculum. *European Journal of Engineering Education, 25*(4), 303-13.