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Infusing Macroethical Ideas into a Senior Engineering Course

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Abstract
Engineering ethics education typically focuses on microethical ideas, with some notable exceptions described in the literature. There is a growing call to prepare students to consider macroethical issues of importance to engineering practice – ideas such as social responsibility, sustainability, and social justice. These are typically complex ideas that lack consensus. This paper presents a case study of a course designed to teach students about macroethical issues. This new senior-level Professional Issues in Civil Engineering course was taught for the first time in fall 2015. The course is intended to address the new ABET program specific criteria for civil engineering to "raise the bar" on ethics instruction. The course is also intended to help students understand the importance of sustainable design and the impacts of engineering on society. One of the methods used to teach students about these issues included a structured controversy on a proposed new water resources project in Colorado. There was also an extensive case study analysis of Hurricane Katrina and New Orleans that spanned four weeks of the course, two lengthy written assignments, and in-class discussions. This included a discussion of the social justice issues related to the situation. A vast array of differing student opinions were evident. During in-class discussions, there were clear differences in the extent to which students would engage. Some students seemed interested to discuss these issues, and believed that this was an important part of their education; other students felt this was a waste of their time. This paper will explore student opinions and challenges reaching students who believe that technical expertise alone is sufficient training for engineers.

Background
Engineering students need to be educated about ethics and their future responsibilities as professional engineers. This includes general moral issues of relevance to engineers, the standards and codes to which engineers conform, ethical business practices in which engineers engage, and broader aspects of the influence of engineering and technology on society. Ethics education should therefore encompass both microethical issues and macroethical issues. Microethics has been defined as "ethical decision making by individual engineers and the internal relationships of the engineering profession" while macroethics has been defined as "the profession's collective social responsibility and the role of engineering in societal decisions about technology."[1, pg. 68] The various professional codes of engineering ethics are focused on microethical issues, including designing for public safety, whistle-blowing, conflict of interest, and integrity of data. Macroethics moves into a broader frame of reference, exploring issues such as how the profession addresses complexity, social justice, and sustainable community development. Engineering ethics knowledge is a required outcome for ABET EAC-accredited programs - outcome (f) states "an understanding of professional and ethical responsibility."[2, p. 3] In addition, macroethics could be considered to be included within ABET EAC outcome (h) "understand[ing of] the impact of engineering solutions in a global, economic, environmental, and societal context."[2, p. 3] The relatedness of these two outcomes (f and h) is evident in the proposed revised EAC criterion 3.3: "An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts."[2 pg. 28]

The American Society of Civil Engineers (ASCE) worried that ethics education may be insufficient, noting that an "understanding" could be achieved from a few seminars or lectures.[3] Therefore, the ABET EAC program-specific criteria for civil engineering states "the curriculum must prepare graduates to analyze issues in professional ethics."[2 p. 12] This is intended to bring programs into greater alignment with the Civil Engineering Body of Knowledge (BOK) which states the baccalaureate-level civil engineering graduates should be able to "analyze a situation involving multiple conflicting professional and ethical interests to determine an appropriate course of action."[4 p. 94] A number of groups and individuals have called for increased attention to the ethics education of engineering students[5-11], inclusive of macroethical issues.[8, 12-14]

This paper will explore as a case study a course that was partially designed around the education of students to consider macroethical issues. It is hoped that this example might inspire others to infuse macroethical issues into courses. This contributes to the sparse body of literature around educating students about macroethical issues; a 2008 study noted that education about "macroethical dimensions of engineering… did not appear to be a common practice in the engineering programs we reviewed… few schools had instituted systematic programs to educate for this broad sense of professional responsibility… and engineering ethics is not usually taught with this kind of scope." [13 p. 330]

Case study: Professional Issues Course

The ASCE Body of Knowledge (BOK) presents aspirational vision for the education of civil engineering students.[4] It articulates 24 outcomes and levels of achievement for each, detailing which should be achieved as part of an accredited civil engineering Bachelor's degree. The civil engineering curriculum at the University of Colorado Boulder (CU) was lacking in some of these BOK areas, such as sustainability and historical issues. Further, some members of the curriculum committee felt that robust direct assessment evidence of students' knowledge of current events and contemporary issues (ABET EAC Criteria 3 – J) was lacking. After extensive study and debate by the curriculum committee and faculty, a new two-credit Professional Issues course was added to the curriculum to address these weaknesses.

Course Learning Goals

The Professional Issues course had eight learning goals. Seven of these mapped directly to outcomes articulated in the ASCE BOK. The goals presented to the students in the course syllabus were:

1. Explain the importance of **professional licensure**[2] and the path to become a licensed PE
    a. Describe the knowledge, skills, and attributes required to become a PE, based on the ASCE BOK
    b. Prepare to pass the Fundamentals of Engineering (FE) exam (review topics, develop test taking strategy)
2. Analyze a situation involving multiple conflicting **professional and ethical** interests to determine an appropriate course of action (BOK Outcome 24 [4 p. 112])
3. Identify aspects of **sustainability** in civil engineering projects; and the ethical requirement to strive for sustainable development in civil engineering projects (BOK Outcome 10 [4 p. 107])
4. Explain the impact of historical and **contemporary issues** on the identification, formulation, and solution of engineering problems and explain the impact of engineering solutions on the economy, environment, political landscape, and society (BOK Outcome 11 [4 p. 108])

- Contemporary issues include: America's infrastructure ratings (ASCE Report Card); design for climate change; globalization; resilient infrastructure

5. Explain the key aspects of **project management** (BOK Outcome 13 [4 p. 109])
6. Define & explain **leadership**, the role of a leader, and leadership principles and attitudes (BOK Outcome 20 [4 p. 111])
7. Describe key information related to **public policy related to civil engineering**; Discuss and explain key concepts and processes involved in public policy (BOK Outcome 17 [4 p. 110])
8. Explain key concepts and processes used in **business and public administration** (BOK Outcome 18 [4 p. 110])

Goals 2, 3, and 4 all relate to macroethical issues. The in-class sessions devoted to these topics spanned six weeks in the course (of 15 weeks total). A homework assignment focused on ethics via a case study of New Orleans and Hurricane Katrina was designed to assess goals 2 and 4 (ethics and historical/contemporary issues); it was worth 17% of the course grade. This was followed by a homework assignment on sustainability in the context of rebuilding New Orleans after Hurricane Katrina; this assignment assessed goal 3 and was worth 17% of the course grade. Active participation in the in-class activities and discussions related to goals 2 to 4 were worth an additional 4% of the overall course grade. Thus, macroethical issues encompassed about 38% of the overall grade awarded to the students.

Structured Controversy of Local Issue

Case studies are a commonly used approach for teaching ethics. The first case study explored in the Professional Issues course was a local water supply project which proposed to divert water from a river and build two new reservoirs – the so-called Northern Integrated Supply Project (NISP).[15] The project was locally controversial, involving a 15-year study at a cost of $15 million to produce two extensive Environmental Impact Statements (EIS).[16] The second EIS had been published in the summer prior to the course, and the public comment period had just closed. This project formed the basis for two weeks of in-class discussion. It was assumed that students would be familiar with this project, but a "show of hands" in class found that only 3 of the 19 students had heard about it. This may have diminished the effectiveness of the activity.

Students were first given a general overview of the project via an 8 minute video that had been made to explain the project to the public.[17] Next, a structured controversy[18] was used to help students appreciate the different positions of key stakeholders. Six stakeholder groups were identified: small towns needing water (who supported the project), nature advocates (who opposed the project), the City of Ft. Collins (who opposed the project), the Northern Water agency (who would run the project and supported it), the Army Corps of Engineers (presumably neutral party studying the project, but with a history of support for "big infrastructure" projects related to water), and agricultural water users (could fall on either side of the issue, but largely supportive). Two to three students joined together to play the role of each stakeholder group. The students were given 30-minutes to research the situation and develop their arguments. Then we held a simulated town meeting. Each stakeholder was given a few minutes to articulate its key points for or against the project. Then individuals could respond and "debate" the points raised by the other stakeholders. This process went reasonably well; about two-thirds of the students seemed actively engaged. After the simulation, a portion of the real panel discussion on the issue

that had been sponsored by the League of Women Voters was shown.[17] This allowed the students to hear the opinions of some of the real stakeholders in a similar debate environment.

The class period following the structured controversy exercise used the NISP case study as a basis for discussing ethics and sustainability issues. It was hoped that grounding the discussion of ethics and sustainability in this real-world example might be more compelling then discussing ethical concepts in an abstract manner. The discussion first touched briefly on microethics, although there were minimal issues of this kind. Thus, the bulk of the discussion revolved around macroethical ideas that related to the situation. This included considerations of environmental ethics, anthropocentric vs. non-anthropocentrism, utilitarianism, etc. Two of the students in the class had extensive knowledge of ethical issues, based on full ethics courses they had taken as electives. The majority of the other students seemed generally unfamiliar with these ideas.

Extended Case Study on New Orleans and Katrina

The heart of the macroethics instruction in the course was an extended case study on New Orleans and Hurricane Katrina. Davis[19] cautioned against using New Orleans/Katrina as an ethics case study, due to an incomplete understanding of what happened, who made key decisions, and the exact roles of engineers. Contemporary alternatives such as the San Francisco-Oakland Bay Bridge re-build[20] and the Panama Canal expansion were also considered. But after extensive exploration, it was decided the New Orleans/Katrina situation included a good combination of societal impacts, technical complexity, and ethical issues. Two large forensic studies had been completed to evaluate the cause of the failure.[21,22] There were clear macroethical issues around poverty and race that related to the events. Further, the timing was fortuitous because in the fall 2015 there were lots of news stories on the 10-year anniversary of Katrina. Students were supplied with papers on New Orleans/Katrina via the online course management system. However, it was also expected that seniors would be able to locate relevant information on their own.

Four weeks of the semester were devoted to exploring New Orleans and Hurricane Katrina. The first two weeks were devoted to exploring the ethical dimensions of the situation; the second two weeks focused on sustainability issues. The class explored the levee design and maintenance pre-Katrina, [21] events during the Hurricane and emergency response, [22] and events during recovery and rebuilding.[23] The health and safety concerns associated with the FEMA trailers were considered,[24] along with arguments of federal investments to help New Orleans residents in relation to national needs. Residency, race, and sea level data were presented.[25] The last two weeks of the extended case study focused on sustainability, looking at social, economic, and environmental dimensions related to rebuilding, considering wise investments, risk and uncertainty in design decisions, communicating with the public about risk and uncertainty, and resiliency. Reading the thoughts that people posted on blogs related to New Orleans rebuilding provided insight into the minds of local citizens and their level of trust and confidence in engineering and engineering-dominated organizations such as the Army Corps of Engineers.[26] Different opinions were voiced in class, including why rebuild at all in areas below sea level? However, about half of the students were silent and did not engage in these discussions. The students were perhaps uncomfortable with uncertainty and the lack of clear, correct answers; or uncomfortable sharing their personal opinions when they were uncertain if their peers agreed or

disagreed. Some students voiced open skepticism, wondering why we were even looking at a map of residency disaggregated by race and in reference to sea level in New Orleans.

In-class Discussion: Social Justice

A full class period was devoted to a discussion of social justice and engineering. The students were told to read Riley and Lambrinidou's[27] paper prior to class. The idea was to debate the proposed additional canon's to the engineering code of ethics that would embrace social justice issues. An outside guest professor led the discussion. He reported spending almost an hour discussing primarily the first proposed canon "Engineers' primary goal is to help people in need and to address social problems", and that a majority of the students actively engaged in the discussion. The students first had discussions in small groups, and then the whole class engaged together. When discussing helping people in need, the students were most comfortable discussing scenarios engaged in by the Corps of Engineers during Hurricane Katrina such as pumping all of the flood water out of the city and strategies for relocating the population. They were less comfortable talking about more individualized solutions for helping people as appropriate for engineers such as getting the power back on at the hospital or helping out a specific ethnicity most affected by the flood.

Assessment: Homework Assignment on Ethics

There was a fairly extensive homework assignment on ethics in the context of the New Orleans case study, representing 17% of the overall course grade. Students were supplied with references on the course website (Table 1), with about half designated as "required" (√). For each reference the length of the report was indicated. Some of the references were very long, such as the 582 page congressional report[22]; no students included this citation in their references (although one student clicked on the link). Based on the online course learning tool, the number of students who accessed the references typically exceeded the number of students who cited the source (Table 1); so students may have read more widely than their direct reference list implies. Further, some students failed to cite sources that they clearly had used. For example, only five students included the ASCE Code of Ethics[5] in their reference list, while all but one actually cited specific canons from this code in the assignment (one student used the NSPE code of ethics instead).

Table 1. References consulted based on on-line course learning system and cited references

Resource as listed on Course Management System	Consulted	Cited
ASCE What Went Wrong Why, 92 pg report[21]; pdf (listed first)	13	9
ASCE Lessons of Katrina 2015 Ethics Commentary[28]; link	6	2
Baillie Catalano Eng Society Social Justice – ethics; Ch4 Hurricane Katrina and the flooding of New Orleans[29]; pdf	8	1
Fields Disaster Planning Post Katrina – Wicked Problem,[30] 8 pg; pdf √	11	5
House of Representatives Review[22], 582 pgs; link to website	1	0
Kazmierczak New Orleans Climate Change Resilience,[31] 10 pg; pdf	5	5
McGee Economic Ethical Analysis Katrina Disaster,[32] 12 pg; pdf, √	10	8
Marcello Systemic Ethics Reform in Katrina's Aftermath,[33] 17 pg; pdf, √	10	2
Newberry Katrina Macroethical Issues, [34] 37 pg paper; pdf, √	14	13
New Orleans upgraded levees not enough for next Katrina[35]; link; √	13	9
Seed Letter to ASCE – ethics concerns[23], 42 pg; pdf	9	9

√ = indicated to the students that it was a required reading

The first question on the assignment asked the students to identify three specific incidents where violations of the ASCE Code of Ethics had occurred. The students were asked to cite a specific element within the code and map it to a specific incident before, during, or after Hurricane Katrina in New Orleans, again supported by a specific reference.

The second question on the assignment asked the students to select two different foundational ethical theories and then compare and contrast how events before, during, or after Hurricane Katrina would be handled differently if an individual subscribed to the different ethical theories. The ethical theories discussed most commonly by the 19 students included utilitarian (n=18), duty (n=8), care (n=5), and virtue (n=4). These four theories, as well as rights ethics (n=1), were briefly presented to the students in-class. Only 2 students selected as one of their theories one not presented in-class (contract theory, egoism). Many of the students did not illustrate a complete understanding of how utilitarian ethics are generally translated into extensive benefit:cost analyses.

The third question on the assignment asked the students to select and discuss two macroethical issues related to the Katrina/New Orleans situation. Here the majority of the students focused on the issues discussed in two of the supplied references (Fields[30]; Newberry[34]). The majority of the responses included ideas related to assumptions and risk perception; other macroethical issues from Newberry[34] that were discussed by the students included time, resiliency, organizational interfaces, historical contingency, information, unanticipated failure modes, and faulty assumptions. These ideas include technical elements around engineering design decisions as well as concerns around how we communicate these ideas to the public. Some other macroethical issues that were discussed included disaster response and broader considerations of environmental impacts (citing Fields[30]).

The fourth question on the assignment asked students to select one of the six principles from the social justice essay by Riley and Lambrinidou[27] and discuss how the application of this principle in the case of New Orleans/Katrina would have changed how events unfolded. Although the responses varied, most students did an excellent job on this discussion. The in-class discussion likely helped the students with their responses to this question.

Overall, most students appeared to have devoted thoughtful consideration to the assignment. This was reflected in the strong grades received by the majority of the students: 63% of the students received an A (>90%) and 26% of the students received a B (80-90%); there was only a single student who earned a C (70-80%) and one who received an F (50%). In order to encourage the students to more fully explore these complex issues, they were instructed on four of the six questions that their answers should exceed a full page in length (single-spaced, 12-point font). Thus, while the median length of the assignment was 3550 words, the students who did poorly clearly had not devoted much effort – the C-level assignment was 2500 words and the F-level assignment was only 1200 words. However, verbosity was not required; the top-rated assignment was reasonably concise at 3400 words.

Variety of Student Opinions

Some of the students were very resistant to considering the wider implications of engineering. It was clear that having been immersed in largely technical coursework for the duration of their degree, some perceived this new course as a waste of their time. The first part of the course emphasized the importance of professional licensure and helping students prepare for the Fundamentals of Engineering (FE) exam. While the students were intended to be independently reviewing topics for the FE in preparation for an in-class "practice FE exam" in week 7, the in-class sessions were devoted to the structured controversy/NISP discussions. In week 8 following the in-class multiple-choice exam that simulated the FE, a homework assignment required the students to read the ASCE BOK[4] and reflect on its content. One prompt specifically asked the students: "What did you read in the BOK that surprised you about civil engineering?"

One student indicated his technical bias in his response:

> "I am very surprised that the BOK states that tomorrow's Civil Engineer will acquire broader exposure to the humanities and social science. I find that in my degree here at CU, I have far too many required Social Science and Humanities courses… I have four required Social Science and Humanities courses in addition to two free electives which I suppose I can replace with which ever course I would like to take. I, myself, will take advantage of these free elective spots and take technical courses that actually relate to my focus. I believe that only two Social Science and Humanities courses should be required and the rest of those slots should be filled with Technical Courses related to one's focus. …we need skilled engineers that are diligent and are right for the job, not engineers who kind of learned some stuff here and there in college."

Clearly this student believed that the whole of his college education should focus on technical issues, and seemed to perceive other information as "fluff" that detracts from a technical focus and generally waters down the rigor of the curriculum. This student indicated his worry about engineering students who will enter the workforce and profession lacking necessary technical skills. Others, however, might worry about individuals who enter the engineering profession with *only* technical skills and no appreciation of the broader contexts for how these skills are applied.

In a similar vein, another student wrote: "I was surprised to read the section about the expectations of tomorrow's civil engineers…. ASCE is promoting a richer general education, with increasing exposure to humanities, social science, and natural science, and more technical breadth. Studying philosophy, sociology, foreign language, history, or other social sciences and humanities are great ways to enrich a person's sense of culture or knowledge, but they aren't necessary to be a successful engineer. …these goals cannot be accomplished in four short years of undergraduate education. I understand the need for both well-rounded engineers and specialization, but I think if only one can reasonably be achieved, specialization is the more important goal."

Some other students seemed surprised by this focus, but not hostile to the idea. In the same BOK assignment another student wrote: "When I think of a practicing professional engineer, I think of a technical specialist working as a design or consulting engineer or as a researcher. I do not think of a philosopher, an artist, a civil servant, or a Renaissance man/woman. The outcomes in the

BOK give considerable focus to making the civil engineers of tomorrow well-rounded and broadly educated individuals."

Still other students seemed to welcome learning about broader issues. In the BOK assignment, another student noted:

> "I think the Body of Knowledge is a great resource for learning about the ethical responsibilities of an engineer. While engineering curriculums do well teaching skills and technical knowledge, at least in our curriculum they leave ethics, studies of the humanities, and social sciences to other colleges that do not focuses specifically on engineering as the Body of Knowledge does. Most curriculum leave untouched what ethical situations an engineer might face in the future, and the BOK is a great resource to learn about these circumstances before there are consequences. Not only do I think this is important for civil engineering students in general, but this is a topic that I personally feel I lack a thorough understanding of. The only class that has impressed upon me the important of making strong, personal, moral decisions in the future is my philosophy ethics class, which was not a part of my engineering curriculum."

As this assignment preceded the full case study, I hoped that this student might revise this opinion that no engineering course asked him to consider ethical issues.

By the end of the course, some students appeared to gain an appreciation for the importance of ethical issues and societal impacts. In the final assignment of the semester, which related to public policy, one student wrote:

> "This class has spent a lot of time on ethical issues, which ultimately relates decisions that we may come to interact with and the public. The class has also made my brain think in a different way, a way that respects the public and how much we as engineers, more specifically civil engineers, can impact the society and just how important that unique aspect is. How to be a civil engineer and think of all of these impacts is a huge aspect of being in the profession, one that we need to be aware of. This aspect also shows the importance of science to the public and how we as civil engineers should be involved in this and add to it so that government can see the need/want of society, in the ultimate hope of a more efficient and functional society."

In a similar vein on the same public policy assignment, another student wrote:

> "…how should we incorporate ethical and social concerns into the regulatory infrastructures for innovations such as biotechnology and nanotechnology? The goals and values of decision makers in government vary by city, state, and country. The decision makers in government consider that how science and technology are used to develop and affect public policies in a wide range of domains such as national security, public health, economic competitiveness, and environmental sustainability."

So perhaps over the course of an entire semester, many of the students began to see the importance and worth of macroethical considerations.

Assessment: Students' Evaluations

At the end of the semester, the students completed a confidential campus-level evaluation of the course (so-called Faculty Course Questionnaires or FCQs). These evaluations are standardized across all of the undergraduate courses in the department. The response rate was high; 17 of the 19 students enrolled in the course completed the evaluation. The students overall disliked the

course. The overall course rating averaged 2.5 / 6 (median 2). This is the lowest course rating that the instructor has received over a 19-year teaching career and among the lowest course ratings in the department. The average departmental overall course rating is 4.8. A few students rated the course adequate; four students rated the course at a 4 or 5. Students' expectations were low; the "personal interest before enrolled" average rating was 2.1 / 6 (median 2.0); the lowest seen in the department. The average amount of time that students reported spending on the course (including class) was 7-9 hours per week; that is appropriate to an upper-division engineering course that meets 2 hours per week with an expectation of 2 to 3 hours of outside work per week per credit hour (6 to 8 hours, by that estimate). The median was only 4-6 hours, and this may be why some students did not perform as well as they could have. However, 7-9 hours per week is also the average in the department for 3-credit courses, so some students felt that the workload was too high for a 2-credit course.

In addition to the general "likability" ratings (standard questions campus wide), the evaluations included a series of statements that began "this course improved my ability to / understanding of…." Students responded on a scale of Not Applicable (0) and 1 (lowest) to 6 (highest). The questions included all of the ABET EAC Criterion 3 "A to K" outcomes as well as four questions related to civil engineering program-specific outcomes. The questions most relevant to the Professional Issues course are shown in Table 2.

Table 2. Student Assessment of Outcomes from End-of-Semester Course Evaluations

This course improved my…	Average (6-point scale)	S.D.	Median	Avg Junior & Senior required courses
Understanding of ethics and professional responsibility	4.6	1.7	5	3.3
Understanding of the impact of engineering on society	3.8	1.6	4	3.9
Understanding of business, public policy, and administration fundamentals	4.3	1.7	4.5	2.7
Understanding of the role of the leader and leadership principles and attitudes	3.8	1.5	4	2.7
Understanding of the profession I plan to pursue	2.0	1.9	2	4.2
This course prepared me for my chosen career	2.2	1.9	2	4.3

Despite the low popularity of the course, a number of the targeted learning outcomes were achieved, based on student ratings. Toward assessment for ABET, the departmental goal is to have at least three courses with ratings of four or higher for each A-K outcome. Based on average student ratings, this course met those goals in two areas; using median ratings, the goal was met in two additional areas. Previous data from the department has found that students' ratings of learning outcomes are correlated with the overall course ratings. For example, the "impact of engineering on society" rating had a moderate correlation with "overall course" rating (Pearson correlation of 0.628, 2-tailed sig. 0.001, from IBM SPSS v. 23). Thus, the learning outcome ratings might have been higher if students had found the course more enjoyable. On a related note, it is interesting that the majority of the students appeared to perceive that the four content areas (ethics, societal impact, business, leadership) were not particularly relevant to understanding or preparation for their career. This is disappointing but mirrors the anecdotal

feedback that some students seemed to perceive only technical subjects as having worth in their future as an engineer. It is unclear how and why some students acquire this attitude.

Some write-in comments from the students provide additional insight into their ratings:

- "In general this class was a waste of time." [overall course rating 1]
- "I know engineers need to learn ethics, but I felt the class was unnecessary" [overall course rating 2]
- "Lots of work for a 1 day a week class. Some assignments took 10+ hours" [Student who reported spending 7-9 hrs/week, overall course rating 2]
- "Good class. Covers everything we haven't seen." [overall course rating 4]
- "Learned a lot in this class, but it was graded unnecessarily hard… it should be very easy to get an A…Good course to take though to sum up eng. degree" [Student who reported spending 2-4 hrs/week, overall course rating 5]

The above comments (and additional, similar comments not shown) seem to reflect an attitude that these topics are easy and should not require work. If anything, these attitudes reinforce the need for a course that communicates the importance and complexity of these topics, such that students come to understand that these issues require careful consideration – to the same extent that they are accustomed to devoting to their more technical coursework. However, it seems important to send these messages throughout the curriculum, rather than expecting a single course to accomplish this goal.

Instructor Impressions

One of the difficulties in the course seemed to stem from the diversity of interest and enthusiasms of the students in considering the broader context of engineering. Also, the structure of the course began with an emphasis on professional licensure and preparing the students for the Fundamentals of Engineering exam. This perhaps seemed somewhat "business as usual" as far as an emphasis on solving straightforward problems with right and wrong answers that could be selected among multiple choice options. One student asked – "can't we just spend the rest of the class reviewing for the FE?" which would simply be a repetition of technical information that students should have already learned in other courses but had perhaps forgotten. Thus, it was clear the student had ignored the numerous learning goals for the course that were articulated on the syllabus. The wide potpourri of learning objectives for the course likely detracted from its effectiveness overall. Further, many students were uncomfortable with open-ended problem solving, politics, and broader societal issues.

Another issue to consider was the single-class per week format (meeting for 1 hour and 40 minutes). Some students were interviewing or got sick, and that would lead to missing a significant portion of the course overall. Also, maintaining attention across the long meeting time was a challenge. Further, students could essentially forget about the course for a whole week between meetings. Some students also seem to have an attitude that any course under a typical "full" 3-credit hours must be less valuable and therefore less worthy of respect.

It seemed helpful to supply the students with references, particularly since the course did not have a required textbook. However, for complex situations the number of potential references is overwhelming. The instructor read about fifty references in preparation for the New Orleans case

study. Ten references most relevant to ethics and ten references for sustainability were recommended to the students. The references were intended to reflect a variety of perspectives, but this process was likely unavoidably biased by instructor preferences. The selection of which references to designate as "required" in the course learning system seemed to influential; as shown in Table 1, 10 to 14 students accessed the readings designated as required compared to only 1 to 9 for the other references (with the exception of the reading listed first, but not required, which 13 students consulted). Balancing in-depth reports with shorter, concise documents was also a challenge. Thus, instructors are cautioned to carefully vet materials, and use care when organizing them and presenting them to the students in the course management system.

A further issue to consider will be the ability to scale the course model to a larger number of students. The pilot version of the course in fall 2015 was small – only 19 students. These were largely students who transferred in to civil engineering sometime after the first year, and were therefore following the "new curriculum." The majority of these students also missed the introductory civil engineering course where ideas such as the BOK, the code of ethics, and sustainability had been previously introduced. In future years, the course is required for all civil engineering seniors, so the anticipated size will be 50 to 80 students. Under the full scale model, the majority of the students will have been introduced to macroethics topics in their first year and will be at least considering them in a "book-end" fashion as opposed to seeing these ideas for the first time. At the larger size, the class will likely need to be broken into smaller groups for discussions, but that could prove challenging to facilitate with a single course instructor.

Summary and Conclusions

It is appropriate and important to engage our students in thoughtful considerations of the complex ethical issues around the societal impacts of engineering and technology. Ethical considerations were appropriate as a stand-alone topic in the course, and also seemed to serve as a uniting thread across the semester. There is a section of the FE-exam devoted to ethics. There are ethical considerations inherent in sustainability.[36] Ethics can be an appropriate topic related to leadership.[5,37] The assignment in business issues included a question that asked students to "Discuss the potential ethical issues that might arise as the "business" side of engineering meets the requirement to protect human and environmental health and welfare, professional social responsibility, etc." Some students, without prompting, discussed ethics on the assignment to explore public policy issues. Thus, in the future the course could be presented to the students as having a focus on ethical issues – which could be defined to include the path to professional licensure and related to the other elements in the course.

Ethics through the curriculum approaches are used at some institutions. Infusing ethics and societal impacts issues within core technical courses for the discipline would perhaps be more impactful in demonstrating to students that these are in fact core issues for engineers to understand. Small, frequent discussions of ethics and societal issues might also gradually increase students' confidence and comfort level with these topics. The difficulty is gaining buy-in from a large number of faculty. Some faculty are themselves uncomfortable with these issues. Other faculty are already pressed to teach the breadth and depth of technical topics that they believe are important within the time constraints of their course, so they are unable to accommodate these additional requirements.

Instructors should be aware that some students may be uncomfortable with considering issues that are complex and don't have a single right answer. The rigid nature of most engineering courses tend to select for students who enjoy getting a single right answer; some of these students dislike situations where this is not the case. Discussing issues where disagreements are bound to arise is unfamiliar territory to many students. If students are asked to engage in this type of thinking for the first time in their senior year of college, they may feel that these topics are not "legitimate" for engineering and therefore are likely to be resistant. Instructors should consider how to appeal to these students and convince them of the importance of macroethical issues. For example, is tying macroethical issues to standard technical problems or case studies a good way to make them relevant?

Using complex case studies was largely successful in stimulating the students to consider both ethical issues and sustainability. It seemed important to have the students read at least a short amount on the topics prior to class, in order to have more effective in-class discussions. Asking students to take on particular roles in a debate forum, similar to the structured controversy, also removed issues about students being reluctant to reveal their personal opinions on contentious issues. Also, small group discussions were effective prior to a larger discussion. Instructors are encouraged not to avoid complex and messy real-world events. Choosing timely and locally relevant events may be effective, but instructors should keep in mind that not all students keep up on the news.

The professional issues course seemed to stimulate the majority of the students to think about things that they had not previously considered. Perhaps this will result in different outcomes in the capstone design course the following semester, as students will enter the course possessing a greater appreciation for considering the perspectives of a broader variety of stakeholders. Careful assessment of capstone design reports comparing "before" and "after" the professional issues course was required might reveal evidence of greater considerations of sustainability and societal impacts. In the future, qualitative methods such as interviews might provide additional insights into students' thoughts about macroethical issues.

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