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Work in Progress: Personalizing Engineering Ethics through the Individual Stories of Engineers and People Impacted

Angela R Bielefeldt (Professor)

Angela Bielefeldt, Ph.D., P.E., is a professor at the University of Colorado Boulder (CU) in the Department of Civil, Environmental, and Architectural Engineering (CEAE). She is also the Director for the Engineering Plus program, which is in the process of being renamed to Integrated Design Engineering. Bielefeldt also serves as the co-director for the Engineering Education and AI-Augmented Learning Integrated Research Theme (IRT) at CU. She has been a faculty member at CU since 1996, serving in various roles including Faculty Director of the Sustainable By Design Residential Academic Program (2014-2017), Director of the Environmental Engineering program (2006-2010), and ABET Assessment Coordinator for the CEAE Department (2008-2018). Bielefeldt is active in the American Society of Civil Engineers (ASCE), serving on the Civil Engineering Program Criteria Task Committee (2019-2022) and the Body of Knowledge 3 Task Committee (2016-2018). She is the Senior Editor for the International Journal for Service Learning in Engineering (IJSLE) and a Deputy Editor for the ASCE Journal of Civil Engineering Education. Her research focuses on engineering education, including ethics, social responsibility, sustainable engineering, and community engagement. Bielefeldt is also a Fellow of the American Society for Engineering Education.

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Abstract

Engineering ethics is grounded in the responsibility of engineers for human safety and welfare. Traditional approaches that introduce the code of ethics or present case studies often emphasize the collective actions of engineers and their impacts on society broadly. In fact, many of the engineering disaster case studies take a very numerical approach, rather than sharing the stories of individuals who were harmed and naming the engineers responsible. An alternative teaching approach is to bring in the personal stories of both individual engineers and the people who have been impacted by engineering in positive and negative ways. This personal approach may be more effective in activating emotions and aligns with Bratton's (2004) Model of Affective Morality and Scholl et al.'s (2016) core affect model. Further, emotional responses may be heightened by seeing the individuals tell their own stories rather than reading text-based narratives. The collective and individual perspectives embedded within the teaching methods for engineering ethics that the author has integrated in civil/environmental engineering courses for undergraduate students are shared and critiqued. Individual examples from the perspective of engineers include: the personal story of Marc Edwards who fought for communities exposed to lead in drinking water in both Washington DC and Flint Michigan, moral exemplars from the Online Ethics Center (William LeMessurier, Fred Cuny, Inez Austin), and an interview with Jack Gillum (a structural engineer who lost his P.E. license due to the Hyatt-Regency walkway collapse). Individuals from the public who were negatively impacted by engineering and/or engineers have been given a voice via a video from a panel with five members of different communities (Lena Young-Green, Albert P. Naquin, E. Yvonne Lewis, Robert Miranda, Sydney Brown) and interviews with individuals injured in the Hyatt-Regency walkway collapse. Evidence for the impact on students from teaching methods that focused on personal stories in comparison to depersonalized approaches is demonstrated using reflective statements from students and survey results. It is believed that including personal stories when teaching engineering ethics holds promise for impacting the ethical awareness and reasoning abilities of students.

Introduction

The work of engineers has significant impacts on human well-being and the environment. For example, civil engineers design systems for clean drinking water, sanitation, and transportation infrastructure that contributes to healthy living in urban settings. Biomedical engineers develop equipment to assist doctors in diagnosing and treating diseases and illness, as well as assistive technologies for individuals. While engineering has delivered many benefits to humanity, there are examples where some communities and the broader environment have been negatively impacted as a result of engineering. Thus, it is critical that engineers are provided with a solid understanding of ethics, to serve as a foundation for ethical behavior in their work.

Ethics education in engineering is an important and challenging task. There is a lack of consensus on the teaching and assessment approaches best suited for particular settings. One lens that can be applied to engineering ethics teaching practices is to consider the extent to which we

focus on the impacts of engineering on society and the environment as whole in a widely collective sense, or draw attention to specific individuals impacted by our work as engineers. Case studies are commonly applied in engineering ethics education, drawing attention to specific examples of ethical dilemmas. Case studies can provide either personal or more collective views of engineers and/or those impacted by engineers. Individual (personal) versus collective approaches when teaching ethics are more or less likely to evoke emotions. This paper explores these background issues and then provides specific examples of collective versus personally focused teaching approaches that have been used by the author over a 20-year period while integrating ethics education into a course for first-year civil engineering students.

Background: Engineering Ethics

The engineering profession has explicit codes of ethics that outline behavioral expectations. Professional societies for each sub-discipline have their own ethics codes, codes vary by state and country, and codes change over time. The American Society of Civil Engineers (ASCE) has recently been among the most active in updating its ethics code [1,2]. A historical summary of the evolution of the ASCE Code of Ethics includes [3]:

1914 First adopted with 6 articles dictating behavior to be avoided with clients and other engineers
1934 Added article 7 making it unethical to compete unfairly with other engineers
1942 Added article 8 to avoid discrediting the honor of the engineering profession
1950 added Canon of Ethics that recognized for the "first time… that the primary responsibility of engineering is to serve the public good" [3, pg. 6] and article 9 which prevented participation in competitive bidding based solely on price
1962 Change in preamble
1971 Removed article related to competitive bidding (in anticipation of US Department of Justice antitrust lawsuit)
1975/76 Complete overhaul of code, abandoning old code and "adopting the Engineers Council for Professional Development (ECPD) code in its entirety." [3, pg. 7] This placed public welfare first stating in Canon 1, "Engineers shall hold paramount the safety, health and welfare of the public in the performance of their professional duties."
1980 Added an obligation to consider the environment; "I.f Engineers should be committed to improving the environment to enhance the quality of life."
2009 Sustainable Development added
2017 Added Canon 8 which included "treat all persons fairly and encourage equitable participation without regard to gender or gender identity, race, national origin, ethnicity, religion, age, sexual orientation, disability, political affiliation, or family, marital, or economic status" and "Engineers shall consider the diversity of the community, and shall endeavor in good faith to include diverse perspectives, in the planning and performance of their professional services." [2]
2020 Completely changed the code moving from canons to a hierarchical stakeholder model, placing obligations to society (public, humanity) first, the natural and built environment second (e.g., adhere to principles of sustainable development), the profession third, clients and employers fourth, and peers fifth. The environmental considerations were significantly strengthened, moving from should and try to "a. adhere to the principles

> of sustainable development; b. consider and balance societal, environmental, and economic impacts…; c. mitigate adverse societal, environmental, and economic effects; and d. use resources wisely while minimizing resource depletion." [1]

The current ASCE code [1] clearly places microethical obligations to clients, employers, and co-workers well below the more macroethical concerns for societal well-being and environmental protection. However, the broad notion of "the public" has been critiqued for potentially failing to adequately acknowledge harms to sub-groups and 'multiple publics' [4]. Further, engineers may have deficit views of the public that are counter productive [5, 6]. In addition, some sub-disciplines within engineering appear to consider individual issues to a larger degree. For example, in biomedical engineering one can readily envision impacts at the level of a single patient [7].

The professional licensure process in engineering promotes ethics knowledge and ethical behavior among engineers. For example, the first required examination toward professional licensure in the United States, the National Council of Examiners for Engineering and Surveying (NCEES) Fundamentals of Engineering (F.E.) Exam includes questions on ethics for all engineering sub-disciplines. The second NCEES Principles and Practice of Engineering Exam includes safety for all sub-disciplines and environmental/sustainability issues for some (e.g., Agricultural, Architectural, Chemical). Professional engineering (P.E.) licensure occurs at the state level, and some states require a separate examination on ethics (e.g., Texas) and continuing education requirements related to ethics [8]. Individuals can lose their license to practice engineering due to unethical behavior. However, individual P.E. licensure is only common in a few engineering disciplines, such as civil engineering. Some have critiqued this de-professionalization of engineering partially based on the risks posed by the industrial exemption to licensure which may contribute to engineers placing loyalty to their employer over responsibilities to the public [9-11].

Engineering students should be educated about ethics, with the intent for them to carefully consider the impacts of their work. Engineering accreditation requirements in the U.S. and abroad include ethics as a student learning outcome [12, 13]. From 2000 to 2019 the ABET requirements set a fairly low bar for ethics education, requiring only "Criterion 3. Student Outcomes. (f) an understanding of professional and ethical responsibility" [14]. The ASCE argued that this ABET requirement could be met with only a few seminars or lectures [15]. Therefore, the civil engineering program criteria under ABET aimed higher, requiring that the curriculum enabled graduates to "analyze issues in professional ethics". The recently revised ABET criteria [12] have increased the expectations for the ethics educational outcomes of engineering students to "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." Similarly, the International Engineering Alliance (IEA) [13] expects that graduates from Washington Accord programs will have "knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes" (WK9) and "Knowledge of the role of engineering in society… such as the professional responsibility of an engineer to public safety and sustainable development" (WK7).

Teaching Ethics in Engineering

Despite the importance of ethics in the career of engineers and the requirement for ethics education in accredited undergraduate degree programs, engineering continues to struggle with this complex educational requirement. The majority of faculty who teach engineering students believe that the education of undergraduate and graduate students in either ethics and/or the broader impacts of technology in their program are inadequate [16]. Topics included and methods used to teach ethical issues in engineering vary widely [17], but often include codes or rules (85% in [17], 48% in [18]) and case studies (81% in [17], 67% [16]). Service-learning experiences where engineering students work directly with impacted people and communities may be particularly valuable for the ethical development of students [19, 20]. Emotion has been found to be a key element in the success of service-learning [21-23]. There may be a link between the ethics educational outcomes and the emotional components within service-learning.

Engineering ethics can be taught from a largely impersonal perspective. This has been critiqued by Johnson [24, 25] who noted that the dominant philosophical frameworks used "decontextualize engineering". Further, Smith [4, p. 30] states that there is an "advantage of compelling us to consider specific rather than generalizable actors, such as particular citizen groups rather than an amorphous 'public'". Similarly, Lambrinidou and Edwards [26] promoted the perspective that "listening will put a human face on ethical dilemmas and reduce tolerance for conduct that can harm the public" (p. 4). They believed that the most personal approach to recognizing the impacts of engineering are to hear and see individuals telling their stories. Optimally, this would occur in authentic settings, such as during service-learning (SL) / community engagement (CE) activities by students. However, those situations may be difficult to integrate into courses without a SL / CE focus. Alternatively, students could interact with community members over zoom. This was done in the graduate-level ethics course taught by Edwards and Lambrinidou [27]. However, scheduling these interactions at a convenient time for community members may be challenging.

Role of Emotion in Learning and Ethical Development

Emotion has been shown to be important in learning in general [28], and more specifically in ethics education [29]. In summarizing other literature, Goralnik et al. [29] write, "Emotion impacts attention, focus, and memory" (p. 415), and thereby plays a key role in cognitive learning. More specifically, a few individuals have promoted the role of emotion in engineering ethics education [30], with Hess et al. [31] specifically focusing on the role of empathy.

A variety of theories have been promoted to describe the processes behind ethical behavior, ethical decision making, and ethical development. Relevant in the current study are theories that recognize the role of emotion in these processes. Bratton [32] built on the work of other researchers from social neuroscience and management in exploring the role of emotion in recognizing ethical dilemmas, as well as the process of ethical reasoning that leads to behavior. Bratton brought together ideas from Affective Event Theory, Rest's Moral Deliberation, and various frameworks applied to ethical decision making in marketing and organizations to propose a model that accounted for the role of emotion in ethical reasoning (see Figure 1). In

research attempting to validate the model using an experiment with college students, 17 hypotheses were tested, with three yielding statistically significant results and one partially significant finding; however, there were generally insufficient sample sizes to test the hypotheses [32].

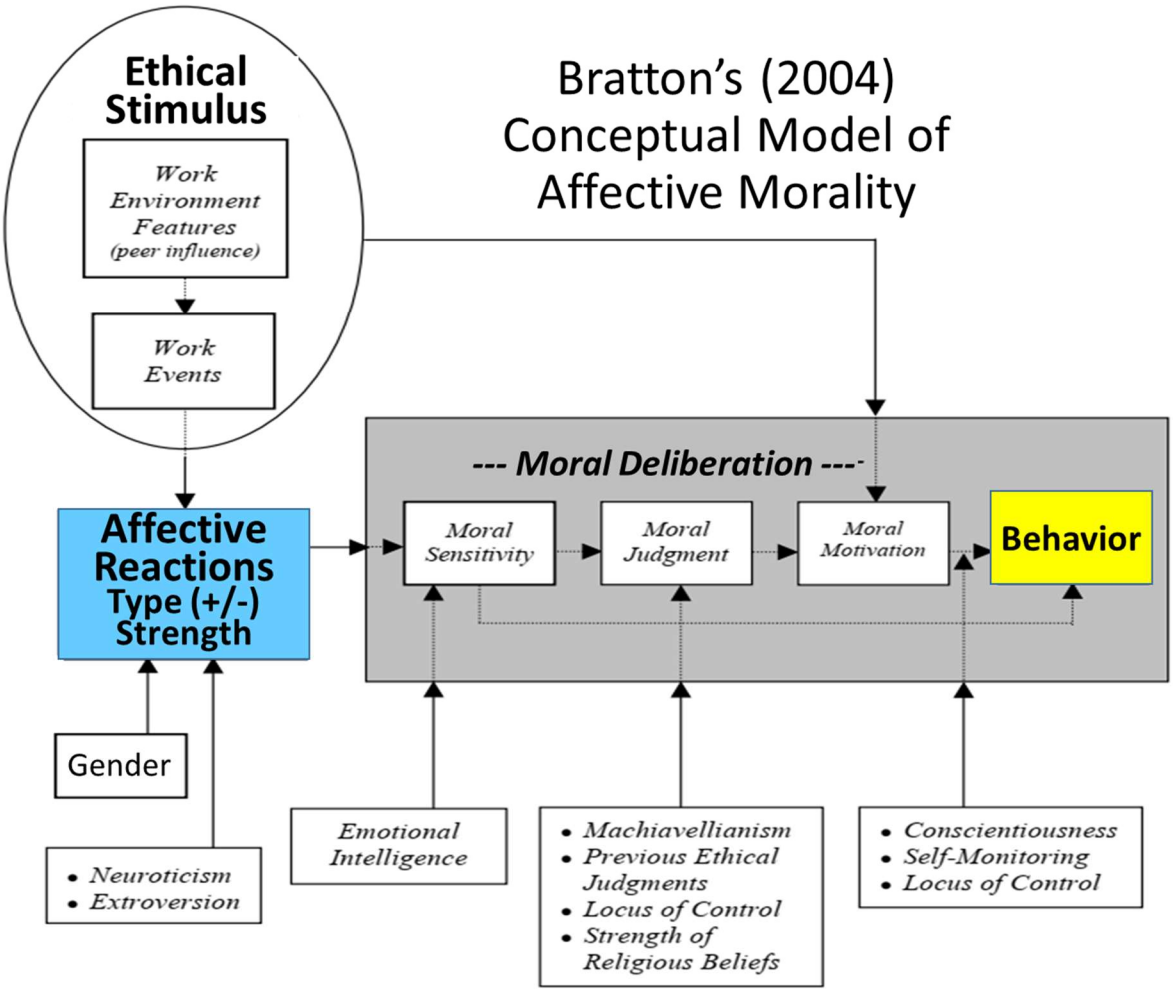

Figure 1. Bratton [32] conceptual model of affective morality (Figure 2.7 in dissertation)

Scholl et al. [33] also explored the role of emotions and affect in motivating ethical behavior, considering both immediate emotions and expected emotions. They proposed a core affect model (based on Seo et al. [34]). This draws further attention to considering both the valence and strength of the emotions, which are also components in Bratton's [32] model.

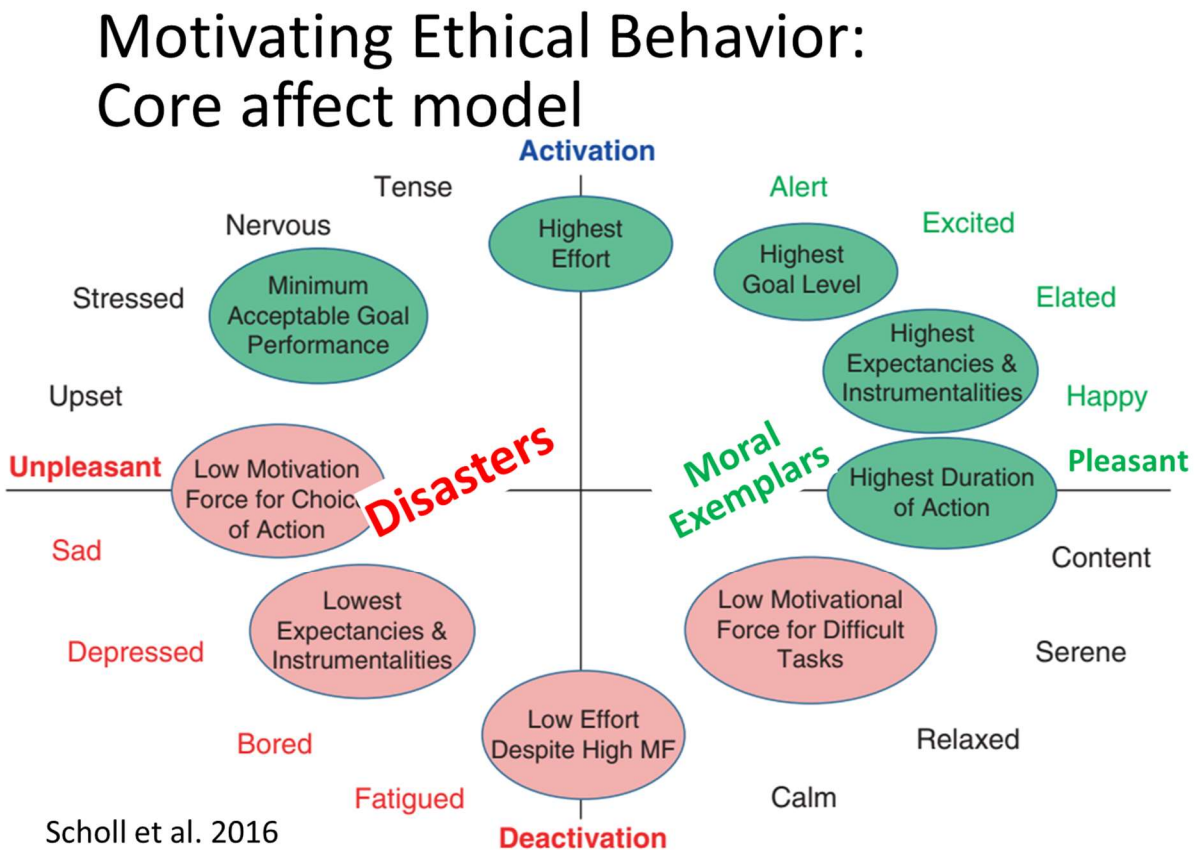

Figure 2. Affect motivating ethical behavior (Adapted from Scholl et al. [33] Figure 3)

Building on the role of emotion in ethical decision making, Korkut and Sinclair [35] offered suggestions for ethics education in psychology with respect to the use of case studies. They discuss attuning students to identifying their own values and emotional reactions regarding the dilemmas in a case study. In addition, case studies themselves might include indications of emotions within the characters For example, the case study example provided noted, “you find yourself irritated and angry and wonder what would be the most ethical way to respond.”

Thinking more deeply about case studies, information from the analysis of emotion in news coverage provides ideas for attributes that could be important, including large numbers of people impacted, proximity (cultural and geographical), and recency [36]. More specifically, Maier et al [37] found that story personification, or putting a ‘human face’ on tragedy was more impactful than just reporting numbers harmed. This aligns with the singularity effect which is the common “preference to help a single identified victim over a group of victims” (p. 1015).

Proposed Framework

This paper uses the following framework to explore engineering ethics teaching practices. The framework considers both the perspective of the engineer and the impacts of engineering. The framework then explores the extent of individual or collective focus of each of those dimensions.

This framework may be particularly relevant to use when examining the case studies that are frequently implemented in engineering education. While all cases have both 'engineer' and 'impact' sides, generally there is a stronger focus on one or the other. In addition, one can consider the presentation media of print versus audio, video, or live. Emotion is perhaps less likely be to associated with reading a text only version of accounts, versus having photographs, video, and/or in-person accounts.

Figure 3. Examples of individual to collective perspectives in engineering ethics education

	Individual → Collective			
Engineer	Personal story of specific engineer in-person or video (e.g., Marc Edwards)	Individual engineer named (e.g., Gilson from Hyatt-Regency Collapse)	Specific company (e.g., Ford Pinto; BP Oil Spill)	The Engineering Profession (e.g., Code of Ethics)
Impacted	Specific impacted individual video (e.g., Lena Young-Green)	Individual impacted person named (e.g., Lois Gibbs from Love Canal)	Specific impacted community (e.g., Flint, Michigan)	Societal impacts, 'the public'

Another consideration is the extent to which engineering ethics is taught from a negative valence (examples of unethical actions) or positive valence (highlighting exemplars of ethical actions). The majority of engineering ethics appears to be taught from a negative valence, at least in the realm of civil engineering. Moving to more positive valence examples, aligned with aspirational ethics [38, 39], could be beneficial.

First-Year Course

The majority of the teaching examples in this paper are drawn from a course designed to serve as an introduction to civil engineering for incoming first-year students. The course has varied from one credit hour with fifteen fifty-minute lectures in the semester (1997-2011, 2017-2021) to two credit hours with thirty fifty-minute lectures in the semester (2012-2016). Enrollment in the course has varied from 35 to 85 students. The majority of the enrolled students were majoring in civil engineering and attending the university for the first time. The course has had five to six learning objectives, which have included ethics (1997-2021) and sustainability (2009-2021). The specific wording of these objectives has varied somewhat over time but in the 1-credit course these two objectives have most recently been stated as:

- describe the ethical behavior expected of civil engineers
- define sustainability and describe its importance to civil engineering

The author also taught a similar 1-credit introduction to environmental engineering course from 2006-2011, with the ethics examples tailored to environmental engineering.

Given the introductory nature of the course, it is aiming for the lower levels of Bloom's taxonomy for both the ethics and sustainability learning outcomes, with the intent of providing a foundation that will be built upon in later courses.

The course has always presented the Code of Ethics from the American Society of Civil Engineers to the students. This code has undergone a number of revisions (as described earlier in this paper), and the students have been presented with the contemporary code and alerted to any recent changes. Frequently students have also been assigned to read a chapter on ethics in an introductory engineering textbook [40]. The chapter contains an introductory case study that is deidentified and refers to "some engineers" from a "variety of engineering firms" where the situation alludes to the potential that contracts were awarded in a biased manner. The authors also describe personal experience with corruption in Ghana. The additional supporting materials on ethics that are presented in the class have varied significantly over time and will be discussed within the framework of collective and individual perspectives below.

Recently, there has been one individual written assignment used to assess each student learning objective. A team bridge design assignment has also explicitly required the consideration of sustainability and ethical issues. In addition, the course has culminated with a final reflective essay; the specific requirements of the essay have varied over time. The course has also included an optional pre and post survey, which typically includes questions to gauge students interest and value of sustainable engineering (2010 to present), social responsibility (2011 to present), and/or ethics (2019 to present). While student participation on the pre-survey is usually high (70-90%), participation in the post survey is much lower (10-50%). Results from these assessments will be included as evidence of the impact of the teaching methods on student learning.

Engineering Impact Examples

It is common in engineering ethics instruction that the impacts of engineering are first considered at a broad scale. This may include global issues such as carbon dioxide and greenhouse gas emissions and human safety related to vehicles (e.g., autonomous vehicles, air bag designs, Ford Pinto). Within particular case studies the impacts on human welfare are specific to a community or situation. Given that an expectation is for protecting human well-being, these case studies are often examples of unethical behavior and negative outcomes from engineering. Generally the human cost of these tragedies is reflected in numbers – such as reporting the number of people killed in New Orleans due to Hurricane Katrina. In some cases this could also include identifying specific sub-groups or communities that were particularly hard hit, such as the racial disparities in the neighborhoods impacted in New Orleans [41]. Students are then cautioned to be careful engineers to avoid these negative impacts, aligned with a preventative ethics approach [38, 39]

The Peace Bridge case study from [42] has been provided to students via a handout and with various levels of in-class discussion (2017-2021). The case is about 1 page of text. Students were reminded of this case in the context of the team bridge design project. The project requires the team to submit a written report, including "Discuss ethical issues pertinent to bridge design. This may include a discussion of "Case 1" in the Riley/Lambrinidou paper about the Peace Bridge. Cite at least 3 parts of the ASCE Code of Ethics to support your answer – reference by sub-part."

The case study 'a plow for Mexican peasant farmers' [43] raises a combination of potential benefits and harms. But this is a generic person considered from a rather distant perspective. The text of this case study has only been orally presented and discussed during the class in a few course iterations.

Videos have also been used to show the positive impacts of engineering. Videos from the ASEE Community Engagement Division video competition often highlight the benefits of student-involved engineering projects with local communities or individuals. Most show community level impacts, although one highlighted a single child provided with an assistive technology device (e.g., *I am Standing*, Loyola Marymount University, which later became a short movie documentary: https://www.imdb.com/title/tt4546874/). More relevant to civil engineering, a video from the Colorado School of Mines Bridges to Prosperity project has often been shown during class (https://www.youtube.com/watch?v=MfQHt3cbuXs). The story of Lois Gibbs at Love Canal was shared in a senior/graduate level hazardous waste management course [44], and would also be relevant in a first-year environmental engineering course. I would recommend watching one of the many video interviews with Lois Gibbs that are available online, e.g., [45].

The Hyatt Regency walkway collapse case study is usually presented in a depersonalized manner in engineering textbooks, just reporting the number of deaths and injuries (114 and 216, respectively). However, there are opportunities to personalize this story. In 2016 I showed a video during class that included archival footage from news reports where people impacted by this disaster were interviewed, including a boy in a hospital bed [46]. There is also a video that interviews both individuals who were at the Hyatt and survived the incident as well as the engineer found partially responsible, Jack Gillum [47]. This personalizes the story, although the situation may seem to be in the very distant past to many current students, thereby reducing its impact.

The stories of community members who have had negative interactions with engineers and engineering projects were brought into the course from 2019 to 2021 using a video from a community panel at the American Society for Engineering Education (ASEE) annual conference [48]. The video was initially integrated by showing students clips during class and then discussing. More recently, students were assigned to watch portions of the video on their own time and answer associated questions in a homework assignment (Figure 4), which is followed by in-class discussion (a flipped class lesson format). In the ethics module the course has focused on the story from Lena Young-Green about the interstate highway cutting through her community in Tampa, Florida. As part of the sustainability module students listened to Chief Albert P. Naquin talking about the Isle de Jean Charles community resettlement due to their land washing away with sea level rise. Additional portions of the video were shown during class, including the experiences and perspectives of E. Yvonne Lewis from Flint, Michigan, Robert Miranda from Milwaukee, Wisconsin, Sydney Brown from Buffalo, NY, and panel moderator Dr. Darshan Karwat from Arizona State University. The presentation from Sydney Brown was included in my senior / graduate level Hazardous and Industrial Waste management course. The stories from Lewis and Miranda would be particularly well suited for integration into environmental engineering courses, given their focus on safe drinking water.

Figure 4. Example prompt in the ethics homework assignment related to the ASEE panel video

Write a short reflection on the relationship between the ASCE Code of Ethics and what the speaker was discussing:

(a) Discuss two or three canons (including specific sub-parts) that you believe relate to the situation described with the interstate highway system and local community in Tampa Florida. Summarize each canon and how it relates. In what ways does the situation appear ethical or unethical in relation to the codes.
(b) It what ways does the code of ethics appear to fall short of considering the benefits/harms to the local community of the speaker? What did you find most compelling from Lean Young-Green?
(c) How does the skill of listening relate to ethical engineering?

Engineer Perspectives and Examples

The National Society of Professional Engineers (NSPE) website includes ethical dilemma case studies from the perspective of engineers which have been "generalized" (names changed) from real cases brought before the board for review [49]. These cases deal with an array of issues, typically with a microethical focus. The write-ups are fairly short and do not include a lot of context. As such, the people from the public being impacted by the engineer's decisions are not clear. Such case studies were used in the class as part of homework assignments from 2000 to 2017, with different cases selected in different years. It is unclear that the students connected these cases with real people or situations, as they seem very hypothetical (e.g., Engineer M…).

In 2016 the class lecture included short examples of individual engineers whose professional engineering license was revoked. Individuals were named and the situation described, as gleaned from online information published by the Texas and Kentucky Licensing Boards [50, 51]. However, these examples are too brief to be considered case studies. Students are unlikely to relate to these individuals as people, without more context. These examples are also all negative valence, and may make students uneasy at the prospect that they could lose their P.E. license.

Moral exemplar cases from the Online Ethics Center (OEC) were included as part of the written ethics homework assignment for a long while (2000-2017; as of 2021, this online moral exemplar collection was named 'engineers and scientists behaving well'). These longer case write-ups include a reasonable level of detail and context. Students were given the option to select William LeMessurier (civil/ structural engineer, 1977), Fred Cuny (humanitarian aid, 1969-1995), and Inez Austin (1990, engineer dealing with chemical hazards); in 2016 Marc Edwards (civil/environmental engineer, 2003) was added as a fourth option [52-55]. Many of these moral exemplar stories now seem quite outdated, in both the timing of the relevant case and the format of the presentation on the OEC website (a few blurry photos). The first-year civil engineering students most commonly selected the LeMessurier case, followed by Fred Cuny. The OEC website includes an embedded video of a 1995 interview with LeMessurier, although it is unclear if students read the case and/or watched the video. These cases reflect different valences (positive to negative continuum) from the perspective of the engineer (LeMessurier, Edwards, Austin, Cuny, respectively) and the public (Cuny, LeMessurier, Austin, Edwards, respectively).

At the most personal level, engineers share a personal story in their own words. This is commonly done by class instructors themselves [56] or guest speakers. However, sometimes an instructor does not have personally compelling stories of ethical dilemmas they encountered in engineering practice. This may be particularly true for faculty who have spent the bulk of their career in academia, where the types of ethical issues encountered may be very different than engineers who work for industry, consulting, or construction firms. If faculty are trying to motivate students with more practical examples, the situations in academia may seem less relevant. In my course, real world ethics examples are often provided by a guest speaker who is a working engineer. In a number of years, a local engineer (Jeff T. Martin, Program Manager at Denver Water) shared experiences surrounding a local dam raising project that blended technical elements, environmental impact considerations, and issues of construction safety and local impacts. An alumna of the program (Rosanna LaPlante, P.E.) also shared a blend of information about types of work and ethical issues. A good substitute to instructors and visitors sharing personal experiences can be to watch videos where engineers describe their experiences. For example, various videos of Professor Marc Edwards discussing the Washington DC and/or Flint MI lead in drinking water crises were shown during class [57-59].

Assessment: Student Survey

A survey instrument has been used in the course that combines elements of engineering ethics (value, interest, and systems thinking from [60]), the Engineering Professional Social Responsibility Assessment (EPRA, [61]), and sustainable engineering attitudes (self-efficacy, value, affect, negative; [62]). These instruments were all developed with first-year civil engineering students among the respondent population. The specific items on the survey have varied over time but consist primarily of Likert-type items. The survey was given at the start and end of the semester in the first-year course for civil engineering students. Students could earn extra credit (less than 1% of their course grade) by taking the survey, with many other alternatives to earn extra credit during the semester. Survey response rates were generally high at the beginning of the semester and low at the end of the semester.

Example assessment results are summarized in Table 1. The 2018 and 2021 data are compared, since the course was similar with the primary exception of using the ASEE community panel video as part of the ethics and sustainability modules (1 credit, same learning objectives, similar individual homework assignments for ethics and sustainability, team bridge project). Thus the 2021 course included a more personal perspective on the potential negative impacts of engineering. Note that while the ethical responsibilities of engineers are inseparable from considering societal context and impacts, the students continue to distinguish these issues (based on their Likert-type responses of importance). Given the low number of student responses, particularly those who completed both the pre and post survey (enabling paired statistical tests to be conducted), the survey findings are inconclusive regarding a beneficial impact from the inclusion of the community panel video. In addition, the literature has shown that self-reports of abilities by students and their perceptions of their learning are often inaccurate [63].

Table 1. Average results from course survey

Item	Pre 2018 (n=52)	Pre 2021 (n=30)	Post 2018 (n=32)	Post 2021 (n=9)	2018 Paired difference (n=23)	2021 Paired difference (n=8)
7-point Likert-type items						
Importance of ethics for professional engineers	6.8	6.6	NA	6.4	NA	-0.2
Importance of societal context	6.1	5.8	NA	5.8	NA	0.4
I believe that is it important to learn about ethics as an engineering student	6.0	6.3	6.1	6.0	0.1	0.1
Preparation, ease, comfort with ethics	5.1	5.0	5.2	5.3	0.2	0.9
5 items on 0-100 scale (11-pt)						
Sustainability confidence	70	54	79	71	5	17

NA = data not available because item not included on the survey

Qualitative Assessment

Because the course is targeting a low level of Bloom's taxonomy, the ethics and sustainability homework assignments are quite basic, and require students to write about 500 words. In addition, the assignments are currently submitted as "pre-lecture" assignments, and therefore the full impact of both the independent activities and the in-class discussion is not evident within the students' written pre-lecture assignments. Prior to 2018 the course used more traditional, longer homework assignments that were due after the in-class lectures. Regardless, these assignments can be used to provide evidence of the impacts of the ethics educational approach. The author used a combination of inductive and deductive coding to identify themes in the responses. The deductive process looked for evidence that students were emotionally engaged or appreciated the personal aspects of engineering ethics, in alignment with the hypothesized benefits of integrating individual perspectives when teaching engineering ethics. The following paragraphs summarize the insights from the 2021 assignments.

Student Ethics Homework Assignments

On the ethics assignment, the first element that stood out was that some students were apparently surprised at the level of importance of ethics to engineering. For example, one student in fall 2021 began his write-up by stating, "Although it seems engineers should not bear too much of the responsibility in terms of ethics, quite the opposite is true." Also, some students commented on the fairly significant changes in the ASCE Code of Ethics over time. One noted,

> One specific thing I noticed… was that societal well-being only seemed to be a small portion of the [2006] code of ethics, while the rest mainly focused on things like avoiding fraud and bribery or doctoring reports, at least from my perspective. However, when reviewing the code of ethics in 2020, "Society" actually had the most sub-parts which was nice to see.

Reading the students' assignments, about six of the 30 students personally connected in an emotional way with the panel. On the ethics assignment, one student in fall 2021 wrote:

> I think Lena Young-Green's most compelling arguments centered around the grief experienced by the community after the division [due to the interstate]. The emotional tragedy of family members struggling to connect as they could no longer easily walk or take street cars several blocks over, or the tarnished air quality would make anyone question the decision to build a highway through an urban community.

Another fall 2021 student wrote, "It was saddening to see someone's quality of life diminished because of poor engineering. She was not emotional, but the audience was able to sense her frustration and how upset she was by everything in her life that had been affected by this interstate highway."

Finally, one student seemed to have a generally negative view of the panel (although also appeared to misinterpret these as engineers on the panel rather than community members): "in regards to what I found most compelling about the Lena Young-Green lecture, I must say that I wasn't particularly captivated by it. Having a panel of lecturers speak about community engagement seems self-defeating; instead of speaking about community engagement, go out and engage the community!" Or perhaps the student is referring to a preference for actively participating in service-learning in communities in order to obtain a first-hand experience of the ethical tensions in engineering work.

Student Sustainability Homework Assignments

Recently the sustainability module in the course has been similar to the ethics module, with an assigned reading from the Royal Academy of Engineering [64] and students assigned to watch Chief Albert Naquin of the Isle de Jean Charles community during the ASEE panel [48]. His story personalizes the impacts of climate change and the impacts of engineering decisions, and he contrasts working with engineers who collaborated with the community and respected their goals with the later situation when the State of Louisiana took over. The situation starkly illustrates both the environmental and societal aspects of sustainability. Most students discussed both of these facets. A number of students also discussed a portion of Chief Naquin's presentation:

> One thing that Chief Albert stated that had an impact on me was the 5 S's. Service, Safety, Sovereignty, Sustainability, and Self-Sufficiency are the points that his tribe lives by. I believe these points are important in the engineering world as well.

Only about five students clearly included emotional elements in their essays. For example, one student's discussion Chief Naquin's story acknowledged Chief Naquin's "frustrations" and "anger" concluding with:

> My biggest takeaway from Chief Albert's presentation was that being an engineer is more than drawing plans and outlining ideas, because your work can have much greater impact outside of mere design of a project. There is also an ethical responsibility to approach your work with sustainability in mind so that humans, the environment and other systems benefit from your work.

Another student commented,

> The most impactful element of Chief Albert's presentation was the love and commitment that he expressed for his tribe and community. He speaks with such poise, but you can tell that it pains him very much to see his tribe continue to suffer and shrink. It's also very disappointing to hear about the way the state is treating the members of the tribe and blocking them from becoming whole again.

Another student referred to his personal emotions in response to the story, which included "heartbreaking", "sad", and "disappointing". The student notes "[the situation] honestly motivates me and shows me an example of the type of engineer that I don't want to become." In addition one student made a very positive comment, "I really enjoyed all of the Chief's presentation."

Students' Final Essays

Another approach to determine potential differences in student learning and attitudes related to engineering ethics on the basis of the instructional strategies employed is to explore the students' final reflection essays from the end of the semester. This gives a sense of students' take-aways from the semester. In 2018 the final essay instructions included, "Demonstrate your understanding the essence of civil engineering, discussing what you learned about civil engineering during the semester. This should include references to specific guest speakers, reading assignments, etc." In 2018 students were also asked to make a "concept map of sustainable engineering and discuss why sustainability is important in civil engineering." In 2021 this second set of instructions were modified to "discuss why ethics and sustainability are important to civil engineering". In both cases, the prompts were open-ended. Thus, if a student chose to discuss particular elements these were assumed to have had a genuine impact.

Among the fall 2021 essays of the 30 students who completed the assignment, 11 directly discussed elements from the community panel videos, primarily Lena Young-Green and less often the Isle de Jean Charles situation. For example, four excerpts from students who discussed the panel are shared below:

> [Student 1] I really appreciated the focus on ethics and societal impacts in this class because I was really expecting to learn mostly about the technical/structural aspects. … I think all of our classes, discussions and assignments about balancing prioritizing economic, environment and societal impacts were far more important as far as demonstrating the impactful choices that civil engineers make in their profession. To some extent, I feel like an increasing amount of jobs, even in the engineering field, will be done by computers in the following years. …. What cannot be replaced (at least at this point in time, we'll see where AI goes) is the human factor that goes into making ethical decisions about how that project will affect people and the environment. The assignment about Lena Young-Green and the Tampa Interstate really highlighted the importance of prioritizing people and how this profession has failed to do that in the past, resulting in degradation of human health and huge ramifications for the social cohesiveness of that community. I'd previously considered that a new interstate in an urban area would negatively impact the surrounding population,

but hearing the trauma and suffering first hand from a community member makes a very emotionally compelling case that civil engineers do have an incredible impact on society and should have a closer relationship with (essentially) their clients.

[Student 2] When I think of the word 'civil', I think of 'for the people' and associate civil engineers with being public servants …. I think that makes it all the more infuriating when we talked about instances like the Tampa Interstate System or the Isle de Jean Charles where civilians are unable to improve their living situation or had it degraded because civil engineers dropped the ball. The profession is far more important than just sitting in an office doing calculations or drawing plans, because if used correctly, your impact on society can be incredibly positive.

[Student 3] …engineers need to be trustworthy. They must always have ethics and sustainability in mind. Ethics is being able to look outside of biases and being honest. You should be able to work with others and develop something that serves the community by serving the community in the best way possible, you can make something sustainable. To be sustainable is not just being environmentally friendly, but also socially and economically sustainable. If the people don't have the money to build the design you have made, then it's no good to them. Listening to Lena Young, her struggles, and her passion for her community for justice is important. As an engineer she is who you are creating for, and it's important to listen. I want to be an engineer that takes everyone's word into consideration. I don't want to create for the richest or the elite, I want to build to serve the public. I want to evaluate their problems and dedicate my time to building something that will be sustainable in the community for decades.

[Student 4] Civil engineers are responsible for the design, construction and maintenance of massive infrastructure projects. These projects can cost billions of dollars, directly impact the lives of millions of people, and have massive environmental impacts. It is of the utmost importance that civil engineers conduct themselves ethically …. Civil engineering projects last for decades and may be created during a time where the civil engineers used different ethics and followed different laws. A great example of this comes from the Tampa Bay interstate highway system that we discussed in Homework 6. The ethics used to construct this multi-billion dollar project did not align with the ethics laid out by the American Society of Civil Engineers today, and the project had lots of negative consequences for people in the local community because of it ... Many people in the immediate proximity of the project developed chronic respiratory diseases such as asthma. … The main reason I want to become a civil engineer is because I want to be able to contribute to my community.

These student essays provide some evidence that the ethics and sustainability modules helped achieve the modest learning goals for the course with respect to these outcomes. The evidence for the impact of taking a more individual rather than collective approach to engineering ethics education are unclear. The sense from the instructor who has taught this topic to first-year civil engineering students for 25 years is that the personal / individual perspectives are more meaningful. But there are not yet rigorous measurements which validate this assertion.

Limitations and Future Work

This paper presents perspectives on different methods to teach students about engineering ethics, aligned with the traditions of the Scholarship of Teaching and Learning. Improved assessment methods would provide a better understanding of student learning, such as asking the students to write short reflections on their perceptions of engineering ethics at the beginning of the semester and at the end of the course [65]. The process of reflection could both facilitate student learning and be used to assess student learning. A rubric could be used to assess these reflections. At the end of the semester students could also be explicitly asked what course activities were impactful to their understanding of engineering ethics and why. If one were interested in rigorously assessing student learning at a level appropriate for research, validated instruments such as the Engineering Ethical Reasoning Instrument [66] could be used. However, it is important to match the outcomes targeted with an appropriate assessment instrument.

One goal for integrating personal stories into engineering ethics education is to achieve affective outcomes related to students' valuing ethical behavior in the practice of engineering [67] and a belief that the ethical responsibilities of engineers include a nuanced commitment to the welfare of people (including those from traditionally marginalized groups). Further, it was hoped that students would develop an appreciation for engineering ethics as a goal that transcends avoiding unethical behavior and aspires to benefit people and the environment. These outcomes don't lend themselves to evaluation by existing quantitative assessment instruments. However, appropriately designed reflective prompts could both spur and reveal affective changes.

Conclusion

Individual (personal) versus collective perspectives provides one lens through which the case studies that are used to teach engineering ethics can be examined. Over a 25 year period of integrating engineering ethics topics into engineering courses, the author has increasingly shifted from largely collective approaches to a greater emphasis on personal perspectives. This includes individual stories from both engineers and those impacted by engineering. In addition, both positive and negative situations are included in an attempt to balance the valence of student emotions aligned with aspirational and preventative motivations. There is anecdotal evidence that personal stories help students develop their understanding of engineering ethics. However, the incremental evolution of the ethics educational strategies used in the course over time and weaknesses in the evaluation methods prevents making conclusive comparisons.

Resources are freely available online including videos where engineers and impacted members of the public talk about their experiences. These videos provide compelling information to help engineering students understand the real ethical and moral dilemmas that they may encounter in the engineering profession and the perspectives of those who rely on engineers to do their best. In a broader sense, these personal stories can integrate emotion and perhaps spur empathy, elements that are generally lacking in engineering education [68]. Similar to McPhail [69] when exploring accounting and business ethics, one can question whether engineering "has become dangerously dehumanized and that one of the most important objectives for any [ ] ethics education must be to develop an empathy with 'the other'." This re-humanizing might help engineers "use their emotions in order to develop morally responsible technologies" ([68], p.

103). The author believes that these personal stories within engineering ethics case studies are a good complement to other approaches to engineering ethics education (e.g., introducing students to the codes of ethics from professional societies). Those teaching engineering ethics are also encouraged to attend to both cognitive and affective outcomes when designing their instructional strategies. Engineering ethics education should not only steer students away from unethical behavior but also inspire students with the potential for the great good that they can achieve through their work as engineers.

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