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Co-Creating the Future: A College of Engineering Micro-Credential on Professional Ethics

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Introduction and Literature Review

Engineering practice is not without risk for the public and one's customers. As Sottile (2023, p. 1) recently argued, "the safety and security of the public rely on the professionalism of engineers." The issue of effective engineering ethics education is important enough that the engineering accreditor ABET prescribes it as a student program outcome (ABET, 2021). This work looks-in on a novel curricular development approach for creating a micro-credential in professional ethics at The Pennsylvania State University (Penn State), a large, public, research-intensive institution location in the northeast United States. The novelty of this approach rests on the curricular development team involving not just an engineering faculty member, but also a current engineering student and an engineer currently practicing in industry.

Case Studies

Sottile (2024) collects a recent review of literature on case study pedagogy on engineering ethics education, highlights of which are presented here. It should be noted that "[c]ase studies are considered to be the most popular method to teach engineering ethics" (Martin, Conlon, & Bowe, p. 47). Harris et al. (1996) decades ago called for more holistic treatments of engineering ethics education, going so far as to make the case for engineering curricula to consider ethical issues as often as possible, both within the formal curriculum but also via extracurricular opportunities. Harris et al. (1996) also noted that ethical cases themselves sometimes originated from industry. Martin, Conlon, and Bowe (2021) drew attention to the fact that selected cases tended to favor individualistic scenarios as opposed to "societal scenarios" (p. 58) considering broader concerns such as power dynamics. Yet case studies present challenges in engineering education practice, not least of which is due to a tendency for their unprincipled use (Dolmans et al., 1997) and challenges with the evaluation of student learning given the need for indirect measurement approaches (Fife-Schaw, 2012).

Curricular Partnerships

Mercer-Mapstone et al. (2017) surveyed the then-extant literature on student partnerships, noting that students' contributions seemed to be minimized on resulting publications and emphasized on outcomes discussions, and further that the existing literature likely underreported challenges encountered with such approaches. Several years later, Bovill (2020) in her own review reporting an observation that "partnership projects [tended to select] small groups of often super-engaged or privileged students" (p. 1023). Bovill (2020) further thought that scope existed for broadening participation to include entire classes instead of just select individual students. On the industrial side, Smith et al. (2018) approached industrial partnerships from the perspective of industrial collective social responsibility (CSR) efforts, concluding that such an approach could "help students develop more holistic perspectives on CSR and the sociotechnical nature of professional engineering practice" (p. 1). Shah and Gillen (2023) have recently pointed out that industrial partnerships were underutilized in the early years of engineering undergraduate programs.

However, a scan of the literature suggests a dearth of attention to the question of faculty-student-industry joint partnerships.

Approach

This work is qualitative in nature. The motivation of qualitative research is "to understand people's beliefs, experiences, attitudes, behavior, and interactions" (Pathak, Jena, & Kalra, 2013, p. 192). Over the course of several months, the authors – an engineering educator (Brad Sottile), a current engineering undergraduate student (Arun Mohan), and a practicing engineer in industry (Frank Barber) – collaborated to develop a micro-credential on professional ethics for Penn State's College of Engineering. The micro-credential is targeted towards engineering students as early as their first year of post-secondary study. The draft micro-credential notably included several historical case studies – notably, the Boeing 737 Max crash, the Space Shuttle *Challenger* explosion, Apple intellectual property misappropriation, the Volkswagen diesel emissions scandal, and the Ford Explorer and Firestone tire tread separation incident – with additional further modern cases inspired by recent engineering industry events. In this work, our qualitative impressions on the micro-credential development process originated via memo-writing (Saldana, 2012), were further validated via internal team member checking (Creswell & Miller, 2020), and are further explored herein.

Results and Discussion

As of the writing of this paper, the professional ethics micro-credential is nearing completion. In this section, we dwell on how the micro-credential creation process itself went. Mindful of Mercer-Mapstone et al.'s (2017) observation that partnership challenges are likely underreported in the literature, we do not shy away from discussing both challenges and advantages. We individually examine our views as participants in the co-creation experience before turning our collective attention back towards anticipated future work.

Student Perspective

The micro-credential creation process has been a thrilling experience for me personally. As a second year student studying industrial engineering, I have learned many intangible skills through this process. I have also learned more deeply about the importance of engineering ethics. I have been able to bring a unique perspective as a student to the micro-credential creation by using as a baseline the typical knowledge of a current undergraduate engineering student and further by reflecting on the benefits to be gained by my peers going forward.

I have learned about historical engineering ethical issues through the research on each of the five case studies. The cases cover a wide range of scenarios and thus have given me a practical understanding of a broad area of engineering ethics. I originally wrote a review paper on software development with Professor Sottile, which was my first experience in scientific/technical writing. Writing about historical engineering ethical issues has furthered my skills in scientific writing and with citation processes in engineering research. I have enjoyed meetings I have had working with Professor Sottile and Mr. Barber, an alumnus working in the

engineering industry. Learning from and discussing my ideas with them has enhanced my perspective and challenged me to think from different angles.

My perspective in this process included voicing what the average undergraduate engineering student might know about engineering ethics. This has allowed me to advocate for certain topics to be emphasized that might not be otherwise covered in our other engineering coursework. Further, thinking from the perspective of a student, I was able to give feedback on whether the examples given by Professor Sottile and Mr. Barber were best suited for furthering students' understanding of engineering ethics.

As a student working with classroom problems, I find that there was typically a unique solution to a given problem or question. I learned in this micro-credential co-creation project that in the real world there is often a tradeoff, that engineers ultimately choose among various options. In some cases, it is not always clear-cut whether the choices can lead to catastrophic outcomes as I learned examining the *Challenger* case study. I have come to realize in a much more real way that the practical engineering world has many shades of gray.

In this process, I have successfully navigated through a couple of challenges. The first challenge is that I need to research the ethical issues at a detailed level, so I understand the engineering phenomenon behind this; writing at that level has required some adjustment for me. Some of the issues such as the *Challenger* case were technically complex, and other cases have covered topics I have not had previous exposure to such as intellectual property law. I have come to understand the ethics cases at a detailed level, but I have needed to work to find a way to explain them in an accessible manner so that future students will be able to understand the micro-credential details.

Industry Perspective

I really enjoyed talking through some of the examples that have occurred in my career with Professor Sottile and Mr. Mohan. It was an interesting flash back in time to when I was getting ready to graduate with my engineering bachelor's degree, but it was also a stark reminder of how unprepared I felt to deal with some of the interpersonal and ethical issues that exist in industry. It was also interesting to see how the questions morphed throughout the process and how the expected decisions and outcomes were analyzed by Mr. Mohan. Through the course of the project, we touched on many more topics than I originally thought that we would, bringing into focus just how interconnected the spheres are between intellectual property, product quality, interpersonal interaction, and professional integrity.

The time commitment was a challenge for me personally due to a variety of emergent personal and professional commitments. In future projects, having scribe support would be helpful to reduce the number of contact hours needed for the industry representative. One idea would be to pair a student with an engineer that is working in industry, have the student do one or a few working sessions to discuss a single case and a resulting decision tree, and to then present a summary of the instance and the solution to their peers. This would allow a faculty member to gather case studies, would make it easier to find industry contributors due to the decreased time

commitment, and would give engineering students a deeper understanding of at least one example.

After spending a considerable amount of time looking around considering examples and models, it occurred to me that it may be extremely difficult to reach a true or idealized "industry partnership." To give examples and cases of ethical issues that would be pertinent to coursework would require an organization to admit and specifically cite examples of downfalls in their leadership or culture. In essence, they would be on a public stage that most companies try to avoid at all costs, particularly in view of competition from competitors who can more readily shield their shortcomings from public view. In view of that, diffusing industrial participation across multiple participants may be worthy of consideration.

Giving examples of real-life situations is not always the easiest task, especially because the intangible interpersonal dynamics of a workplace are often infeasible to fully capture. Unfortunately, no matter how many case studies are written, it is my fear that students will always be operating in a "black box" and missing context. How we include contextual details without overwhelming one's primary audience is something I see as a surmountable but difficult task worthy of continuing future attention.

From my perspective, teaching ethics while using real-world anecdotes gives credibility to the discussion, but such an approach needs to be addressed carefully. Preparing students for the "real world" and giving them a false sense of how often major ethical issues occur presents a fine line to navigate. For the most part, engineering ethics are relatively clear cut unless multiple external factors happen to coincide – a perfect storm, if you will. While it is extremely important to condense the material so that it can be covered in a reasonable amount of time, the information might represent a few major instances in an otherwise reputable career spanning one or fifty years. Teaching ethical decision-making and the honest practice of engineering is important, but college faculty should also want to simultaneously avoid hyper-stimulating students' ethical concepts.

Faculty Perspective

Curricular development is frequently a lonely activity for post-secondary engineering faculty. Faculty teach, students learn, administrators administrate – life within the academy takes on a certain familiar cadence over time. One enjoyable part of this project was the opportunity to transcend familiar professional boundaries and to creatively engage with one's stakeholders. The distributed workflow presented some challenges, as Mr. Barber noted in his commentary, and one thing to keep in mind is that students like Mr. Mohan likewise often have multiple competing demands on their time. A co-creation model requires patience, good humor, and sufficient "drawer time" to allow the product to germinate into an integrated whole.

When adopting co-creation curricular development models, engineering faculty need to be prepared to check their biases and assumptions at the door. In my case, for example, intellectual property considerations usually take a backseat relative to academic integrity issues more traditionally thought about in the ivory tower. As recent work (Sottile et al., 2024) demonstrates, a certain intellectual humility is necessary for effective engineering education, as perception and

knowledge gaps exist to hamper one's efforts. Co-creation models offer one pathway towards systemically addressing those gaps, though one must remain mindful that they are not necessarily less work than "traditional" curricular development, particularly in view of the communication and coordination costs involved.

Looking Forward and Directions for Future Research

With the instant project, future work will involve finalizing the implementation of the professional ethics micro-credential and trialing it with students to assess its efficacy. In suitable future projects, further exploration of co-creation approaches should be explored to identify if more amenable approaches are available. An early hypothesis, however, is that co-creation model partialities are likely to vary widely with individual projects and participants' personalities and preferences.

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