2026 ASEE ANNUAL CONFERENCE June 21–24, 2026 | Charlotte Convention Center, NC
Host Sponsor UNC Charlotte

Paper ID #51433

Teaching Responsibility in Context: Interdisciplinary Collaboration in Embedding Ethics in Bioengineering

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Title:
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Abstract:
Building on robust literature at the intersection of engineering ethics, Science and Technology Studies (STS), history of science, and bioengineering pedagogy, this paper explores an interdisciplinary collaboration to embed ethics content within a sophomore bioengineering laboratory course (Johnson, et. al., 2022; Johnson and Wetmore, 2008; Herkert, 2005; Kline 2001; Lynch and Kline, 2000; Mody, 2019; Miller, et. al., 2020, Bucholz, et. al., 2024, Neeley, et. al., 2019). The interdisciplinary team consisted of a bioengineer, a historian of science with STS training, a bioengineering doctoral candidate, and a lawyer enrolled as a Master of Laws (LL.M.) graduate student in the Law School. The collaboration resulted in a series of embedded ethics modules which were part of a larger department-wide effort to include the ethical and societal contexts of engineering practice in the undergraduate bioengineering curriculum at a large private research university. This paper will focus on the interdisciplinary collaborative approach to curriculum design and on applying STS and history of science scholarship to illuminate ethical dimensions of bioengineering practice. The paper will contribute to broader discussions about contextualizing engineering practice in engineering education and how interdisciplinary teaching teams can function together to prepare engineers for leadership in responsible innovation.

Introduction

While engineering programs have traditionally been focused on technical training, there has been a growing recognition among engineering faculty and academic leadership that societal considerations are integral to engineering practice, and thus engineering education. Curricular innovations in engineering schools have addressed the need to prepare students for responsible innovation and leadership and to identify and address ethical challenges. The ethics curricula in this paper grew from school and department level commitments to embed ethics within the bioengineering curriculum. Additionally, ABET outcomes (“ABET”, 2026) have reflected and upheld this consideration, further motivating the integration of societal considerations into core engineering courses.

Engineering ethics curricula vary widely, as do the disciplinary training and perspectives of those who teach them. Course instructors may have training in an engineering discipline or legal studies, philosophy, the history of science, and science and technology studies (STS), among other fields. There is a robust and growing literature exploring how STS and history can be employed for engineering ethics education (Johnson, et. al., 2022; Johnson and Wetmore, 2008; Herkert, 2005; Kline 2001; Lynch and Kline, 2000; Mody, 2019; Neeley, et. al., 2019; Conlon and Zandvoort, 2011). The pedagogical approaches also represent a wide range of methods, including, for example, standalone ethics courses and embedded modules within technical courses (Hess, 2023; Hess, 2018; NAS, 2016; NAS, 2017). With consideration for the embedded ethics approach, there is a growing body of literature that offers examples of institutional efforts, shares specific lesson plans and curricula, and considers assessments of student learning (Chan, 2023; Grosz, 2019; Miller, et. al., 2020). This paper seeks to add to the robust secondary literature that addresses a large range of ways to introduce engineering students to multidisciplinary perspectives on engineering ethics and the societal context of engineering practice by illuminating an interdisciplinary collaboration to embed ethics content within a core technical bioengineering course.

There are robust literatures that analyze many types of interdisciplinarity collaborations (Bucholz, et. al., 2024; Zandvoort, et. al., 2008), as well as how interdisciplinary curricula may be employed to contextualize engineering practice as a way to teach engineering ethics. We hope our discussion will speak to both themes. Building on valuable scholarship that highlights *why* these collaborations are valuable, as well as examples of *what* is included in the curricula and discussions of student assessments, we'd like to focus on *how* interdisciplinary collaborations may work in this pedagogical context. We will detail our interdisciplinary and collaborative process, as well as reflect on why we found this approach to be effective for engineering ethics education. This narrative is not meant to be prescriptive, but rather to open up broader discussions on the intricacies of interdisciplinary collaboration between engineers and scholars from fields such as Science and Technology Studies (STS), history of science, technology, and medicine, and legal studies. We hope those looking to do similar work at other institutions may gain insight from our practical experience and reflections on successes and challenges. Critically, our experience illuminates the nuances of interdisciplinary approaches to curriculum design, particularly the iterative process of ideation, the extensive learning among instructors, and the funneling of many potential lesson plans to a focused selection of pedagogical interventions.

Interdisciplinary Collaboration

Institutional Context

At the University of Pennsylvania's School of Engineering and Applied Science, the historian of science coauthor participated on a school-level committee to study and make recommendations for ethics and writing instruction for undergraduate engineering students. The final recommendations of the committee work were twofold and recommended that all engineering undergraduate students continue to take an ethics course that adheres to a set of specific requirements as well as to expand ethics content within core technical courses. The standalone ethics course provides foundational knowledge while the embedded ethics content would offer more in-depth, discipline specific content and emphasize to students that societal considerations are part of engineering practice. With the goal of embedding ethics within the Bioengineering (BE) undergraduate curriculum, an Engineering Ethics Initiative (EEI) led by the historian of science and staffed with graduate student Engineering Ethics Fellows was established with school and departmental support. The challenge for the EEI and the BE Department was to implement a four-year embedded ethics curriculum within the undergraduate program. Key considerations and goals included: incorporating multidisciplinary scholarship that complemented the technical content of the courses, equipping students with the skills and knowledge to become responsible leaders in innovation and engineering practice, and to build the ethics curriculum cumulatively over the four year program. Among the core courses to partner with the EEI was a bioengineering sophomore laboratory course, a newly developed, required course taught by the bioengineer coauthor. This paper will discuss the approach the interdisciplinary team, composed of the EEI and BE course instructor, took to develop a specific module for this course.

Team Description

The instructional team included the BE lab course instructor and the EEI team, consisting of the EEI Leader and two Engineering Ethics Fellows. The BE course instructor holds a BS in Mechanical Engineering and a PhD in Bioengineering. Her doctoral research centered on the application of mechanical engineering principles to soft-tissue biomechanics, with emphasis on constitutive behavior and multiscale structure–function relationships. She currently serves as teaching faculty in bioengineering, where she delivers a range of undergraduate and graduate coursework spanning both laboratory-based and lecture-based formats. The EEI Leader holds a

BS in Mass Communications, an MS in Science Studies, and a PhD in History and Sociology of Science with training in Science and Technology Studies. In addition to leading the EEI, she currently teaches a large lecture course that fulfills the engineering ethics requirement for many students from six different engineering disciplines. The Engineering Ethics Fellows included a doctoral candidate from Bioengineering and a lawyer enrolled in a Master of Laws (LL.M.) program in the Law School, a postgraduate legal degree, with prior legal expertise in technology regulations. Importantly, the EEI's work with different courses entails varying levels of resources. For example, the EEI's collaboration with the first-year introductory course involves four modules, including synchronous in-class discussions facilitated by the EEI (Shields, 2023). Alternatively, for the sophomore and junior lab sequence, the EEI's engagement entailed high touch development of the modules and grading for the first year of the ethics assignments, but then pivoted to an as-needed resource offering assistance with curricular updates. The latter arrangement was deemed more sustainable for scalable implementation of ethics throughout the curriculum.

Course Technical Content

The EEI sought to partner with at least one course in each year of the undergraduate BE program. Within the sophomore bioengineering curriculum, the spring laboratory course was selected as the site for the ethics intervention because its laboratory-based structure provides a more natural and robust integration point for societal and contextual considerations than a fundamental engineering content course such as biomechanics. While a course like biomechanics is organized similarly to an introductory physics class, where technical principles are emphasized and real-world applications are presented primarily as secondary illustrations, the stand-alone lab course is inherently application-driven. Its curricular design requires students to engage with evolving experimental modules throughout the semester, each of which is grounded in authentic biomedical engineering contexts. This structure creates frequent and meaningful opportunities to highlight societal implications, ethical dimensions, and real-world relevance alongside technical practice. Consequently, the BE instructor found the dynamic, context-rich environment of the lab course to be a more suitable platform for embedding ethics instruction than the comparatively abstract, theory-focused format of biomechanics and similar engineering-fundamentals courses.

The technical content for the course was developed prior to the integration of the sociotechnical content. The course is a required, stand-alone laboratory course for sophomore bioengineers as part of their larger curriculum. The semester-long course is broken into four modules covering tensile testing of chicken skin, bone cement, building a prototype smartwatch, and creating a low-cost spectrophotometer to meet design specifications. Each module includes three sections, each lasting 1-2 weeks, covering 1) skill-building, 2) application of that skill, and 3) either hypothesis testing or an engineering design challenge depending on the module. Ethics content was embedded into three of the modules. For the purposes of this paper, the second module will be used as a case study for illustration and discussion of the interdisciplinary collaboration.

The second module topic centers around the biomaterial bone cement. Specifically, part 1 of the module consists of a basic circuits tutorial culminating in the creation and calibration of a digital thermometer using a thermistor. The second part of the module asks students to use their digital thermometer to determine the temperature profiles over time, as well as the time to hardening, of four different formulations of bone cement. Students are asked to determine criteria for maximum temperature and hardening time for clinical use, and then are expected to use their experimental results to determine if any of the four tested formulations would meet their criteria. Finally, the third part of the module presents students with a real-world scenario in which students are asked by their boss to investigate hypothetical reports from the field that when bone cements are used in situations of increased ambient temperatures, the maximum temperature and hardening time are different than what is reported by the company (what the students would have found in part 2). They are asked to investigate the influence of increased ambient temperature on the three properties of peak temperature, hardening time, and doughing time. The third parameter of doughing time was added to introduce students to engineering standards testing, specifically ASTM F451 - 21 Standard Specification for Acrylic Bone Cement (ASTM International, 2021). For the final report, students are asked to write a memo to their boss summarizing their findings and re-issuing a recommended bone cement formulation for use in climates with elevated temperatures. Overall this module incorporates the technical elements of circuits, creating a digital thermometer, using their device to collect data, and engineering standards testing, embedded in the context of a real-world scenario.

Interdisciplinary Collaborative Process

The EEI team began the collaboration with the bioengineering course instructor the semester prior to the launch of the new course. As the bioengineering course instructor finished each module's technical lesson plans, the EEI team would read the course materials carefully and brainstorm possible ethics themes. Much interdisciplinary learning happened among the internal EEI team meetings, as well as with the bioengineering course instructor. For example, the BE doctoral candidate would give mini tutorials on the technical content for the historian of science and LL.M. student. Similarly, the historian of science and LL.M. student would also share materials and readings from their disciplines as frameworks for considering the societal and regulatory contexts of the relevant technical material. The EEI team would then meet with the BE course instructor for further deliberations and brainstorming. In collaboration with the BE course instructor, the EEI team would finalize the key themes that resonated with the specific technical content of each module, building upon the ethics themes the students had been exposed to in their introductory course in their first-year, as well as being mindful of additional ethics modules being considered for their junior and senior years. For the bone cement module, key themes that emerged from these deliberations included: considerations for end-users and unanticipated uses of technologies in different contexts, the dynamic regulatory environments for emerging technologies, and interdisciplinary collaborations between engineers and clinical care providers.

Once these potential themes were solidified with the bioengineering course instructor, the EEI team proceeded to develop a lesson plan inclusive of a menu of options for learning objectives, assigned readings, and homework assignments. The generation of these materials reflected the value of interdisciplinary collaboration, with significant contributions from all three disciplinary frameworks: the technical, regulatory, and historical/sociological. Based on the potential themes discussed with the BE instructor, the EEI team proposed a set of learning objectives, indicated in Table 1, which guided their process in generating the lesson plan options.

Table 1: Proposed Learning Objectives
1: Students should demonstrate an understanding that technologies designed by engineers may not always be used as strictly intended and there is a responsibility among engineers to understand their users, context of use, unanticipated consequences, and user error
2: Students should demonstrate an understanding that engineers must consider a technology's end user and that such considerations will impact design decisions as well as guidelines and standards for proper use

3: Students will study the regulatory environment around medical implants, both materials and devices

To support these learning objectives, each member of the EEI team furnished potential lesson plan ideas and reading materials for the students, drawing on their own disciplinary expertise. The BE doctoral candidate, for example, offered ideas on how to embed training on the design process more broadly, with considerations for unintended consequences, user error and contexts of use, including considerations throughout the design, prototyping, testing, and marketing stages such as protocols for safety and risk assessments. These materials addressed human factors engineering, balancing end user error and technical requirements, strategies to resolve conflict between engineers and other stakeholders, and the value of user experience studies in medical device design (Abts, 2017; Andrews, 2020; Bitkina, 2020). The LL.M. student offered materials on the regulatory environment for implantable devices and materials, emphasizing a distinction between policies and law, as well as primary sources from the FDA (Newmarker, 2017; FDA, 2026). And finally, the historian of science suggested literature from the sociology of technology that offered frameworks for considerations of the dynamic role of end users in innovation and unanticipated consequences of technology (Oudshoorn and Pinch, 2003; Rose and Blume, 2003).

The detailed menu of options generated by the EEI is included in Table 2. Once these materials were completed, the bioengineering course instructor reviewed all of the materials and selected what would work well in the course and where and how to embed it within the technical material. The material that the BE course instructor ultimately incorporated into the course is indicated in bold in Table 2.

Table 2: Engineering Ethics Initiative Proposed Lesson Plan and Materials for Module 2. **Assigned Items Selected by the Bioengineering Course Instructor are Bolded.**
Module 2 Part 1 Readings ● **Excerpts from *How Users Matter* edited volume by MIT Press (Oudshoorn and Pinch, 2003; Rose and Blume, 2003)** ● Excerpts from Bitkina, et. al., “Usability and user experience of medical devices: An overview of the current state, analysis methodologies, and future challenges,” International Journal of Industrial Ergonomics 76 (2020). https://doi.org/10.1016/j.ergon.2020.102932
Module 2 Part 1 Homework ● **What is meant by the authors when they write: “There is no one correct use for a technology.”** ● **The authors describe “how users consume, modify, domesticate, design, reconfigure, and resist technologies.” Reflect on your own use of common day technologies in your life, ranging from household technologies to electronics. Can you identify a technology that people have modified, domesticated or reconfigured in a way that the original innovators of the technology perhaps did not intend?**
Module 2 Part 3 Readings ● **Abts, N. “Navigating The Ethics of Product Validation,” Med Device Online, 2017.**

- Andrews, R., et. al., “Collaboration for clinical innovation: a nursing and engineering alliance for better patient care,” *Journal of Research in Nursing 2020*, Vol. 25(3) 291-304. DOI: 10.1177/1744987120918263
- Newmarker, C., 2017. *Biomaterials: Is there a better way for FDA to regulate them?* Podcast. https://www.medicaldesignandoutsourcing.com/biomaterials-better-way-fda-regulate
- FDA primary sources, including websites on premarket notification, premarket approval, and product classification (FDA, 2026)

Module 2 Part 3 Suggested Homework

- Individual Response: The article outlined several dilemmas involving human factors. Considering the scenario presented in module 2 week 3 [bone cement improperly used in OR], analyze the conflicts between the stakeholders in this case. Also, please make suggestions on how to resolve the conflicts you identified.
- **Group Response: The article outlined several dilemmas involving human factors. Considering the scenario presented in module 2 week 3 [bone cement improperly used in OR], analyze the conflicts between the stakeholders in this case. As you draft the memo to your boss, include suggestions on how to resolve the issue by citing this article.**
- Individual: Examine one of the case studies presented by the authors. Who was the intended user the nurses and engineers designed the device for? How did considerations of the intended user impact the design of the medical device?
- Individual: Consider the material from the HBR article. What concepts about effective teamwork are relevant to the case studies presented in the *Journal of Research in Nursing* article?
- Group Response: Reflect upon how a collaborative approach to engineering research and design could impact the final product, device or material. As you draft the memo to your boss, include suggestions on how to resolve the issue by citing this article.
- After listening to the podcast, do you agree with the author’s critique? If yes, (i) elaborate on the fields that could benefit from innovative biomaterials (with examples), and (ii) discuss, based on the experience and discussions conducted in class, whether or not development of bone cement could benefit from such regulatory reform. If not, (i) explain to what extent you consider the current system is capable of addressing the author’s concerns toward innovation (with examples), and (ii) discuss based on the experience [and discussions conducted in class], whether or not development of bone cement could benefit from such regulatory reform.
- Discuss in up 300 words (i) what is the classification of bone cement pursuant to the FDA database, (ii) if you agree with this classification and why, and (iii) if, based on the experiment [and discussions in class], you consider the classification system adopted by the FDA is sufficient to address the dangers and protect the users of bone cement.

When choosing what material to move forward with, the BE instructor considered which topics were most likely to resonate with the engineering students. The career paths of BE students at our institute are varied and include Biotech/Medtech, basic science research, medical school, and healthcare consulting to name a few. Since the ethics content would ultimately be incorporated across three modules in the course, the instructor tried to touch upon a variety of topics. Additionally, the length of the proposed reading and homework assignment often dictated which of the proposed materials were used - because the technical content remained the main focus for the course and was not being reduced, balancing exposure to ethics content with the reality of how much was feasible to ask students to complete for a given module, was always on the forefront of the instructor's mind.

A brief description of the assigned materials for Module 2 that were generated by the collaborative process follows to give the reader a sense of the richness and depth that emerged from cross-disciplinary collaboration, content that could not have been produced within a single disciplinary perspective. Note the material was inserted into Parts 1 and 3 of Module 2.

Module 2: Part 1
The end users material was embedded within Part 1 of the module. The students completed building a digital thermometer in Part 1, which offered an opportunity for students to consider the consequences of their technology. The foundational reading for the ethics module was excerpts from Oudshoorn and Pinch's edited volume *How Users Matter: The Co-Construction of Users and Technology,* including the editor's introduction as well as Rose and Blume's chapter, "Citizens as users of technology" (Oudshoorn and Pinch, 2003; Rose and Blume, 2003). These readings were suggested by the EEI team as they demonstrate for the students the value of an STS framework for thinking about engineering design. In Oudshoorn and Pinch's introduction, they write that the contributors to the volume "follow the research path of studying technologies in their 'context of use' - the society and the web of other artifacts within which technologies are always embedded." They analyze not just the technologies, but also the users of the technologies, asking, "What general lessons are to be drawn from a renewed focus on users in today's technologically mediated societies?" They also cite Ruth Schwartz Cowan's work, emphasizing the social construction of technology approach and situating users as active participants of technological change. Students also read Rose and Blume's chapter in which an analysis of designing for intended users in mind, and norms of distributions of bodies within a population, are discussed. Rose and Blume also frame users as active agents and emphasize the importance of designing for human variability and for allowing for configurations among different actors in varied contexts. Since the students are reading this STS material as they are being trained to design a digital thermometer, they can immediately see its application. The homework question further situates the STS content in relation to the technical skills they are developing, while also challenging them to generalize the lesson to technological innovation more broadly.

This material was chosen by the BE instructor from the EEI team's list of options since it highlights the importance of considering unintended, but still plausible, uses of engineering designs, a concept that bioengineers must understand regardless of what type of technology they are developing. Additionally, this material ties directly to ABET student outcome 4 ("ABET", 2026) where students must recognize a professional responsibility to consider the impact of their design in a societal context. In contrast, the EEI also proposed a reading from the *International Journal of Industrial Ergonomics* article but it was not chosen by the BE instructor due to its format as a scientific journal article (Bitkina, 2020). At the sophomore level, many students in the BE program are not accustomed to reading scientific literature and often find it difficult to understand. Because the topic of unintended users was already outside the technical realm that most BE students expect from an engineering course, the BE instructor thought the story-telling nature of the *How Users Matter* edited volume by MIT Press would be a more approachable format for the students to learn about the topic.

Module 2: Part 3
To conclude the module, the EEI proposed several different frameworks, including readings and homeworks on: human factors engineering, interdisciplinary collaboration between engineers and clinical care teams, and the historical and contemporary regulatory context for biomaterials.

The BE doctoral candidate suggested a reading about product validation which emphasized the value of human factors consultants early in the design process, emphasizing that their interventions often produce more equitable and safer designs that ultimately lead to more economical and societal beneficial products (Abts, 2017). The BE doctoral candidate also suggested a reading on multidisciplinary collaboration between engineers and nursing teams, which emphasized how such collaborations could help foster safe and effective medical innovations (Andrews, et. al., 2020). As the final option, the LL.M. student compiled materials that illuminated the history of US regulations for biomaterials, including both a podcast that analyzed the FDA regulatory environment, as well as primary sources from the FDA on its approach to device regulations (Newmarker, 2017; FDA, 2026).

The EEI team felt that any of these approaches could offer valuable insights on developing biomaterials from clinical care settings, recognizing it would not be feasible to include all of the material within the time and logistical constraints of the course. The BE instructor ultimately selected the human factors material to embed within Part 3 of the module. For the homework for Part 3, the students receive a note from their boss that reports have come in that physicians in the operating room are not following the specific instructions for mixing bone cement and are actually exposing the formula to freezing temperatures prior to warming the materials. This challenges the students to consider a real world example of how a technology may be used differently in different contexts and the responsibility of engineers to design for certain margins of error. This homework challenges the students to not only resolve the immediate concern, but more importantly to think broadly and deeply about mitigating such risks in the future.

When choosing between the readings and homework options developed by the EEI team, the BE course instructor considered what options best integrated with the existing technical content, course assignments, and course goals. For example, the group assignment was chosen instead of the individual since this portion of the technical content was already performed in groups, including the technical postlab report. Recalling that other BE courses would also be integrating ethics content, in consultation with the EEI team, regulatory content would be covered in a later module within the course as well as in a junior lab course. The content for Module 1 Part 3 was also chosen with the assignment for Part 1 in mind, content that already covered “intended users”. In alignment with the objective of engaging with a broad range of BE students’ prospective career paths, the proposed content was selected to focus on product validation and human factors engineering, areas that were identified as both broadly applicable and likely underrepresented in students’ prior academic exposure, and therefore well suited to provide meaningful educational benefit. Finally, the article “Navigating the Ethics of Product Validation” directly aligns with ABET student outcome 2 (“ABET”, 2026), which emphasizes the development of engineering solutions that meet specified needs, by providing students with the opportunity to engage with the complex reality that stakeholder needs frequently conflict and that it is the responsibility of the engineer to evaluate and balance these competing considerations.

Interdisciplinary collaboration beyond course creation

Upon the first offering of the course, the EEI remained involved in grading the student homework to calibrate the grading rubric and determine if the homework questions were appropriately challenging the students and addressing the intended learning outcomes. In subsequent offerings of the course, the BE course instructor and TA staff managed the grading for the ethics components of the homework assignments. The EEI remained, however, a resource available to the BE course instructor for any future consultations or curricular updates.

Author Reflections

Reflections from the BE Course Instructor

In reflecting on our collaboration, this project marked my first sustained experience working alongside a non-engineering colleague. This interdisciplinary arrangement surfaced both notable benefits and productive challenges. Among the benefits, the diversity of intellectual background shaped the development of the module in ways I could not have anticipated alone. My collaborators routinely identified dimensions of the material, especially in the ethical, societal, and cultural space, that fell outside my technical training as an engineer, and their external perspectives helped expand the scope of what we ultimately presented to students, particularly in moments when the technical content did not exhibit clear or intuitive ethical implications to me. Yet this same interdisciplinarity revealed challenges, most notably that engineers and STS or ethics scholars do not always share a common vocabulary, and we often described the same phenomenon using different terms. This required ongoing clarification and calibration within our team. Additionally, because of the way the collaboration was structured, I was physically present in the classroom while the broader ethics team was not, which meant that I was the immediate recipient of student confusion, real-time questions, and unanticipated interpretations. These moments required in-the-moment adjustments to the assignment dissemination, with opportunities to bring those observations back to the interdisciplinary team only after class. For example, we had written a prompt asking students to reflect on the unintended uses of a “technology,” only to discover that a formal definition of “technology” was not readily shared by students, and I needed to pause and articulate one mid-lesson. These dynamics are not raised as deficits but rather to illuminate the lived texture of interdisciplinary instructional design, particularly when iterative refinement occurs simultaneously across classroom practice and team-based deliberation.

Another aspect of the collaboration involved ongoing discussions about what type of ethical content is appropriate for a primarily technical course. The broader ethics team often draws on material typically taught in ethics-focused courses, including foundational concepts such as normative ethical theories, while I was simultaneously navigating the constraints and expectations of a technical lab environment. We spent considerable time deliberating questions such as whether discussions of formal ethical frameworks should be introduced in a course whose primary goals concern experimental design and engineering practice, or whether such content should be reserved for ethics-specific courses elsewhere in the curriculum. These conversations required us to continually return to the intended student learning outcomes, particularly our commitment to integrating ethical and societal context into the existing technical content of the course. In practice, this meant striking a balance between enriching the curriculum with meaningful ethical engagement and ensuring that the depth and type of material remained appropriate for the course’s technical focus. Overall, the content that emerged from this process was not something I could have developed independently, and it ultimately enriched the course in unanticipated and deeply valuable ways.

Reflections from the Historian of Science/EEI Leader

In reflecting upon the interdisciplinary collaboration of embedding ethics within a sophomore bioengineering laboratory course, a few themes come to mind. First, the collaboration was an opportunity for interdisciplinary learning for not just the students, but also for the instructors. While the lesson plan demonstrates the implementation of STS and human factors engineering to complement the technical course material, much of the learning for the instructional team happened outside of the lesson plan. Through team meetings, shared readings, and tutorials, the EEI team and course instructor participated in learning from each other and each others’ disciplines. This allowed me, for example, to gain a better sense of what technical material the students learn and how that material is delivered. Similarly, I also gained knowledge in how the regulatory space around medical devices has evolved over time and where potential gaps in regulation persist. This is distinct from other interdisciplinary co-teaching models in which instructors may divide the course and each teach different sections. Rather, there was training for all instructors in the various knowledge domains.

Second, this experience highlighted the benefits and challenges of developing ethics material to be embedded within a technical course as opposed to a standalone engineering ethics course. The strengths of this approach are many. By allowing for in-depth and discipline-specific content to be taught alongside technical skills, the students develop the skills to understand and navigate the societal context of engineering practice within their discipline. Furthermore, it normalizes such societal contexts as part and parcel of engineering practice, rather than an afterthought or different domain. These benefits far outweigh any challenges we faced. Those challenges however are important considerations for other teaching teams to consider. For example, the interdisciplinary, iterative and collaborative process can be labor intensive and requires the support from school and department leadership and commitment from individual course instructors. Also, there are demanding time and workload constraints in engineering programs, thus any ethics instructional materials must be carefully curated to address specific learning objectives and fit within the bounds of the course.

Conclusion

One of the most valuable experiences we found in our interdisciplinary collaboration is what we referred to as the “screwdriver moment.” In discussing how engineers must anticipate and design for unintended uses of their technologies, the BE instructor shared the example that screwdrivers must be designed to not only manipulate screws, but also be constructed with the structural integrity to withstand the pressures exerted to pry open a can of paint. From an STS perspective, this example resonates with the literature that highlights how technologies are continually shaped by their end users in diverse contexts, where technical function is intertwined with social practices and ethical implications. These approaches to anticipating and designing for unintended use complement and reinforce each other. This was a breakthrough moment in our collaboration in which we realized both disciplines very much have shared considerations, but provide differing - yet complementary - frameworks for studying and analyzing these phenomena. By offering our students the readings, vocabulary and frameworks from multiple disciplines that illustrate similar core principles, in this case the unintended uses of technologies, it allows them to have a deeper, more holistic understanding of the entire sociotechnical context of engineering practice. While all of the disciplines represented in this collaboration, including bioengineering, STS, history of science, and legal studies, all have value in isolation, we strongly believe that the pedagogical outcomes produced together far exceed what any one of us could have produced individually. Through sustained collaboration among the BE instructor and the EEI team, the module was shaped so that material from STS was taught in tandem with technical material and insights from human factors engineering. This resulted in a highly contextualized learning experience in which the students considered the ethical and societal considerations as fundamental to engineering practice. This translational and multidisciplinary work, which bridged disciplinary theories and vocabularies with technical training, was only made possible through interdisciplinary collaboration.

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