International Journal of Engineering Education Vol. 42, No. 1, pp. 160–169, 2026
Printed in Great Britain
0949-149X/91 $3.00+0.00

Perceptions of Undergraduate Engineering Students of Two Approaches to Teaching Engineering Ethics: A Case Study*

WESLEY LAWSON and GIDEON SMITH
Department of Electrical and Computer Engineering, University of Maryland, College Park, MD 20742, USA. E-mail: lawson@umd.edu

In this paper, we present and evaluate student impressions of two distinct versions of an undergraduate professional ethics course taught in the Electrical and Computer Engineering (ECE) Department at the University of Maryland. One version has been taught by senior electrical engineering professors and follows a "traditional" approach to professional engineering ethics. The other version teaches the course through a Sociotechnical Systems (STS) lens and relies on the use of STS postures (STSP). In an attempt to understand which approach was more effective at transmitting the required knowledge, skills, and abilities (KSAs) to the students, a survey given to students who have taken either version of the course probed students' opinions about the importance of the course overall and about several key concepts. The survey also queried the students' self-efficacy as to whether they had the tools necessary to resolve different situations ethically. The traditional cohort had 64 respondents while the STSP cohort had 31 respondents. Both cohorts recognized the importance of risk analysis and professional codes of ethics, but generally, students in the "traditional" class felt more positive about the focus of the course and about their ability to resolve situations ethically.

Keywords: engineering; professional ethics; higher education

1. Introduction

Ensuring that electrical engineering students in the United States have the needed training in professional ethics has been left to an accreditation process since 1936 (and in many other countries since 2007). A significant paradigm shift happened with the EC2000 requirements, after which colleges were required to demonstrate that their students had mastered the required student learning objectives (SLOs) [1]. The SLO for professional ethics was stated simply as: *Engineering programs must demonstrate that their graduates have an understanding of professional and ethical responsibility* [1]. In the past few years, this requirement has been expanded and now states that students must demonstrate *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 context*s. [2]

While the current ABET requirement for professional ethics education is clearly more detailed than the previous version, there is still a lot of latitude for an institution to decide *what* should be taught. In addition to developing the required content of a professional ethics course, we propose consideration of the following three principles, borrowed and altered from Joy Buolamwini [3]:

(1) *Why* we teach engineering ethics matters.
(2) *Who* teaches engineering ethics matters.
(3) *How* we teach engineering ethics matters.

There are several reasons for the "why" beyond that it is a requirement for accredited engineering programs. The evolution of technology and society has been intertwined since before the beginning of recorded history [4], and so the need to protect the safety, health, and welfare of the public with evolving technology is imperative. The current SLO on professional ethics clearly spells out the need for macro-ethical considerations in technological development. But the current IEEE code of ethics also discusses the need for micro-ethical training related to the day-to-day interactions of an engineer. In addition to obvious examples, the need for risk analysis is implicit in the first canon when engineers are required to disclose factors that "might" endanger the public. The need to understand the standard of care and various technical standards is embedded in the canon regarding maintaining technical competence. One study looked at the "why" for engineering ethics courses by looking at 26 research articles on the subject and found that 65% of the articles cited ABET requirements as a motivator while only 46% cited potential societal benefits [5].

Three professions come to mind when considering "who" should teach engineering ethics. The first profession is clearly engineers themselves, as senior engineers would likely have considerable personal experience relevant to the course content. However, engineers who were educated before the EC2000 requirements were put into place may well not have had a professional ethics course and might feel that they are not qualified to teach such a course. A second candidate would be ethicists who specialize

* Accepted 8 September 2025.

in the ethics of technology. One successful model came from the National Institute for Engineering Ethics that developed content via a collaboration of engineers and ethicists [6, 7]. A third candidate would be sociologists, particularly ones with a background in science/technology (ST) studies.

There are different schools of thought on "how" to teach engineering ethics to students and there are several reviews of the evolution of engineering ethics education, e.g., [5, 8–10]. One popular book championed a pedagogical strategy through examining case studies, both real and fictional through normative ethics lenses, including professional codes of ethics [11]. We will call this strategy the "traditional" approach. In fact, a systematic review of pedagogical strategies in engineering ethics courses revealed that reviewing codes of ethics and professional standards as the leading pedagogical tool (85%), with case study exposure as a close second (81%), and peer discussion of ethical issues as the third leading pedagogy (77%) [5]. The way in which case studies are discussed can vary, for example, one recent approach emphasizes the role of imagination in ethical discussions [12]. Some of the least utilized strategies in engineering ethics instruction (under 10%) included real-world exposure, community engagement, and game playing [5].

Another recent study examined current challenges and issues related to the implementation of engineering ethics courses and concluded that moving toward a sociotechnical systems orientation in professional engineering ethics courses could address some of these issues [9, 13]. The sociotechnical approach was developed in the middle of the previous century [14] and emphasizes the strong coupling between social and technical systems. Hence a sociotechnical lens will consider how those two systems interact and modify each other and so will focus more on macro-ethics.

At the University of Maryland, we have two versions of the course that agree on the principal content (*what* is taught), but vary significantly on the *why*, *how*, and *who* with respect to teaching professional engineering ethics. The goal of our research was to determine which approach did students feel more effectively transmitted the required KSAs to them. A survey was conducted which asked questions related to each of the main course topics and students responded via a 5-point Likert scale. There were also questions related to course pedagogy and overall course impression. Students were also given three free-response questions at the end of the survey to give further input on their impressions of the course. Our research questions are:

(1) Which approach is more effective at conveying the stated course concepts to the students?
(2) Which approach has a more positive impact on students' self-efficacy with respect to the resolution of professional ethical dilemmas?

In the next section, we discuss the history of the professional ethics course in the Electrical and Computer Engineering Department at the University of Maryland. In the following section, we present the survey questions given to our students and present the results of that survey. In the final two sections, we discuss the significance of those results and draw conclusions.

2. History of Engineering Ethics in the Electrical and Computer Engineering Department

Prior to ABET's EC2000 [1], the Electrical and Computer Engineering (ECE) Department at the University of Maryland introduced engineering ethics via a few lectures that were delivered in capstone design courses. As a result of an ABET review in 2005, the department was required to enhance their professional ethics training, and so a three-credit sophomore course entitled, "ENEE 200: Social and Ethical Dimensions of Engineering Technology" was developed and first taught in 2007. The course mostly followed the text, "Engineering Ethics: Concepts and Cases" [11]. The core topics for the course are listed in Appendix 1 and focus both on micro-ethical issues and macro-ethical issues for engineers. The 4th edition of the textbook [11] was the main resource for all topics except "Technology and Society;" multiple references were used for that part of the course [15, 16].

The course was taught only by an ECE professor for the first five years of the course. In 2013, an instructor with a Ph. D. in science and technology studies (ST) was hired to teach the course. During the next few years, the versions taught by the ECE professor and the ST instructor drifted apart until the focus and pedagogy were significantly different. The modified version now teaches the course from a sociotechnical systems perspective using a teaching style referred to as STS postures (STSP) [17–19]. STS postures incorporate three features to influence macro-ethical thinking of engineering students: (1) understanding how emotions and bodies contribute to knowledge production, (2) providing analytical approaches based on STS theory, and (3) presenting data collection techniques that expose relationships between technology and society [19].

2.1 The Traditional Version of the Course

For the traditional course, lectures were taught by a senior ECE professor, and discussion sections were led by undergraduate teaching fellows (UTFs) who had previously taken the course. The lectures introduced the new content, and the discussion sections focused on the homework, which typically involved examining and evaluating case studies from the textbook and from current events. Three video case studies produced by the National Institute for Engineering Ethics were also presented and discussed [20–22]. The technology and society section of the course has been enhanced to include material on the barriers to, and benefits of, a diverse workforce, and other current topics of interest including bias in technology, the digital divide, sustainable development, privacy and security concerns, etc. In addition to the standard lectures, students are required to watch and evaluate about 20 videos (often TED talks) on modern ST issues. Each semester there are typically thirteen 75-minute discussion sessions. Two are dedicated to group presentations and the remaining focus on each individual homework (one per week). Case studies are often discussed by first breaking up the class into small groups (3–5 people), having them talk about the relevant facts, concepts, conclusions, etc. of the case study, and then sharing the group's ideas with the full class. In addition to verbal communication, sometimes the students express their ideas visually on classroom boards or through electronic means (e.g., responding to polls).

UTFs are given suggestions for what to discuss each session but are given the agency to decide for themselves what the priorities for that week should be. Each week, there is a team meeting to share the experiences of the previous week, talk about what worked well and what didn't work well. The UTFs have developed and shared, on their own, visual aids and other reference materials for each discussion session to help guide the conversation. Assessment activities include 10 quizzes, one on each topic in Appendix 1, and a cumulative final exam. Homework exercises are also graded, albeit often by completion rather than correctness. Often the students have an individual essay to complete on a science and technology topic, and there are typically two group assignments – one related to a case study (e.g., a recent airplane accident) and one related to multinational technology companies. Finally, 20% of the grade comes from a participation grade, which is assigned by the UTFs based on the quality of the contributions of their students during the discussion sections.

2.2 The STSP Version of the Course

In contrast, during the past few years, the STSP version of the class has been taught by several different instructors. This version of the course is now taught throughout the college (as ENES 200) and not just in the ECE Department. The official title course is now "Technology and Consequences: Engineering, Ethics, and Humanity," though both instructors of the traditional and STSP versions profess to teach the topics given in Appendix 1. The instructors in the past year for the STSP course ENEE/ENES 200 have backgrounds in ST studies (Ph.D), History (Ph.D), Education Policy (Ph.D.), English (Ph.D), Dance Studies (Ph.D) and Theater (B.A.).

The focus and pedagogy for the STSP version of the course have been well-described [17–19], and so only a brief summary of the course is included here. Even though there are many instructors with varied backgrounds, discussion sections for all STSP instructors follow the same schedule with the same focus. In fact, the weekly meetings for the UTFs are held together for all STSP sections. The discussion sections are tightly choreographed with all 75 minutes accounted for and divided up into intervals as small as 30 seconds. The discussion sections' pedagogy utilizes a lot of role-playing and other physical movements. In fact, at the end of the first discussion section, the UTFs are instructed to say to their students something akin to: "We'll be singing and dancing together soon enough, but for now, let's end with a cheer to this semester. Grab your imaginary glass, it might be a champagne glass or just a water glass, and we'll cheer for our semester. 3-2-1, Cheers!" In a later week, students are instructed to play "Zip Zap Zop" to "pass" energy to each other [23].

The titles for the STSP discussion sections are given in Appendix 2, except for the first week (Course norms) and last week (Reflections). After the introductory week, the first few weeks deal with the status quo, critiquing the "dominant paradigms" and engineering "cultures" and "mindsets". The message to the students is that dominant paradigms and mindsets can be problematic. For example, they argue that dominant ethical theories (Virtue theory, Deontology, and Consequentialism) have limitations, and so students should look to emotive theories like Feminist Ethics and the Ethics of Care instead.

The STSP version of the course really focuses on issues of diversity, equity, and inclusion (DEI), as can be seen by the titles of several discussion sections. For example, in the first discussion section, students are asked to look at indigenous justice and land acknowledgement statements and then are asked how those topics relate to engineers. Furthermore, students are to examine technological artifacts (like an outdoor bench) to evaluate if they are hostile or inclusive. Students are encouraged to have conversations with artifacts, like benches or cell phones, as part of the enlightenment process. In disability justice, students are asked to follow a disabled person around campus, and in gender values, students are asked to assemble breast pumps or identify gendered artifacts like razors.

While the majority of the topics seem to relate to macro-ethical issues, some micro-ethical situations are discussed in the STSP class. Considerations related to harm are central to the STSP course; for example, three of the four FERE's in their textbook relate to harm [24]. However, concepts and techniques related to mitigating harm, such as risk assessment, standard of care, and reliability, are absent from the discussion planning documents. Conflicts of Interest are discussed, although no operational definition is given. In fact, a recent paper examined 26 engineering textbooks, looking for 41 common ethical themes and found that the STSP course textbook [24] contained 13 of those themes whereas the traditional textbook [11] has 31 of the themes (the most any textbook had was 33 themes) [25].

Assessment for the STSP sections is quite different from the traditional sections. STSP students are told that grades are racist and are instructed to watch a podcast that supports that perspective. There are no quizzes or exams, instead, students sign a contract at the beginning of the semester describing how many papers and other activities they need to produce to get a specified grade.

3. Course Survey and Results

A course survey was developed to assess the students' appreciation for and self-efficacy beliefs regarding most of the ten course topics listed in Appendix 1. In addition to that, the voluntary survey asked questions about diversity, course pedagogy, and overall course assessment. No demographic data was taken, and the survey was anonymous, as not even email addresses were collected. Students were divided into two groups based on whether they had taken the traditional version of the course or the STSP version of the course. The same twenty-three questions were asked of each group, and responses were in the form of a 5-point Likert scale ranging from strongly disagree (–2) to strongly agree (+2), so a score of zero represents a neutral response. Three open-ended questions were asked at the end of the survey:

(1) What was your favorite part of the course?
(2) What was your least favorite part of the course?
(3) Any last comments or feedback you would like to share?

The survey link was sent to about 350–400 students (the exact number is not known due to the potential overlap in invitations). Ninety-eight students responded to the survey, so about 25% of the students, with 64 who had taken the traditional version, 31 who had taken the STSP version, and three who had taken neither class. About 82% of the students had taken the course in the past year, and no student had taken the course more than four years ago.

Only one question was asked regarding the first topic in Appendix 1, and the prompt and the average value of the responses are given in Table 1. Both cohorts agree that codes of ethics are an important framework for engineers. (A response of one corresponds to "agree" and a response of two would be "strongly agree".) The standard deviations are not given for any of the responses, though they varied from about 1.16 to 1.62. The p-value listed is from an unpaired t-test [26]. There is no statistical difference between the two groups, which might be somewhat surprising as the STSP textbook states that overreliance on professional codes of ethics can "hamper" an engineer's ethical development [24].

The two questions regarding ethical concepts and problem resolution are shown in Table 2. The first question asks if students can recognize ethical dilemmas and the second asks if they have the tools to resolve such dilemmas. Students in the traditional version of the course agree that they have both the tools to recognize and resolve ethical dilemmas, with the latter belief 0.2 points below the former. The STSP students were much less confident that they have the tools to recognize ethical dilemmas and were slightly negative on the idea that they could resolve ethical dilemmas. The p-values

Table 1. Professions and Codes of Ethics

Survey Prompt	Traditional Response	STSP Response	p-value
Professional codes of ethics represent an important framework for engineers to consider.	1.20	1.13	0.819

Table 2. Ethical Concepts and Problem Resolution

Survey Prompt	Traditional Response	STSP Response	p–value
This course gave me the tools needed to recognize ethical dilemmas that may occur in my professional career.	1.08	0.42	0.034
This course gave me the tools I would need to resolve ethical dilemmas that may occur in my professional career.	0.89	–0.23	0.0005

Table 3. Technology and Society

Survey Prompt	Traditional Response	STSP Response	p–value
This course helped me understand ways in which technology modifies social interactions.	0.92	0.48	0.151
This course helped me understand ways in which society drives technological change.	0.97	0.42	0.065
This course helped me understand additional factors that must be considered when my professional obligations cross cultural or national boundaries.	0.98	0.45	0.082
This course helped me to think of ways to reduce injustices that result from technological artifacts.	0.88	0.61	0.373
This course helped me to see evidence of bias in some technological artifacts and understand the harm caused by the bias.	0.97	0.60	0.225
This course helped me understand the importance of having a diverse engineering workforce.	0.95	–0.19	0.0003

for both questions were less than 0.05, indicating statistical significance.

One STSP student summed it up this way: "This course doesn't build upon my ethical outlook when it comes to engineering. All of the information presented was either prior knowledge or could be inferred by anyone with rational critical thinking skills."

Questions related to Technology and Society are shown in Table 3. For each of the survey questions, students in the traditional version of the course on average agree with the prompts, and while most of the STSP students' responses, with one exception, did not differ by a statistically significant amount, they were on average one-half point below the traditional student responses. The first two questions relate to the roles that society and technology play in a sociotechnical system, which is purported to be a strong point of the STSP approach. The third question is related to the final topic in Appendix 1 related to international engineering and has a significant presence in the traditional version of the class.

The next two questions in Table 3 are related to bias and injustices related to technological artifacts. This subject is also purported to be a strong point for the STSP version, and those results come the closest to matching the traditional responses.

The final question reveals perhaps the most surprising result of the study. The traditional students agreed that the course helped them understand the need for a diverse engineering workforce, whereas the STSP response was slightly negative. The distribution of responses is shown in Fig. 1. Half of the traditional students strongly agree with the prompt, while half of the STSP students disagree or strongly disagree. It's not clear from the survey why this is the case. Focus group discussions seem to indicate that while both versions discuss the harm that can arise in a non-diverse workforce, the STSP version seems to focus on the blame for the problems, while the traditional version seems to focus on formulating solutions to the problems.

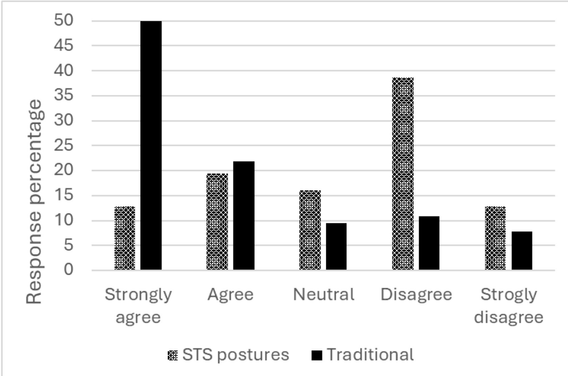

Fig. 1. A comparison of the survey results for the question of understanding the importance of having a diverse engineering workforce.

Risk analysis is addressed in two questions in Table 4. Both cohorts feel that risk analysis is an important skill; though not significant, the STSP response is slightly higher. However, there is a significant difference between the responses regarding whether students can act on risk assessment, with the traditional cohort generally feeling they have the knowledge to evaluate and mitigate risk while the STSP students are barely positive.

The distribution of responses to the two risk questions are shown in Fig. 2 for the traditional

Table 4. Risk analysis

Survey Prompt	Traditional Response	STSP Response	p–value
Risk analysis is an important skill for engineers.	1.36	1.42	0.857
I learned the tools necessary to evaluate and mitigate risk related to a new technology I am working on.	0.77	0.19	0.050

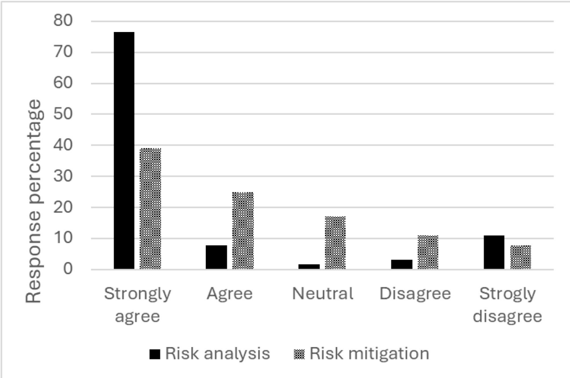

Fig. 2. Response of the traditional students regarding the importance of risk analysis versus the ability to mitigate risk.

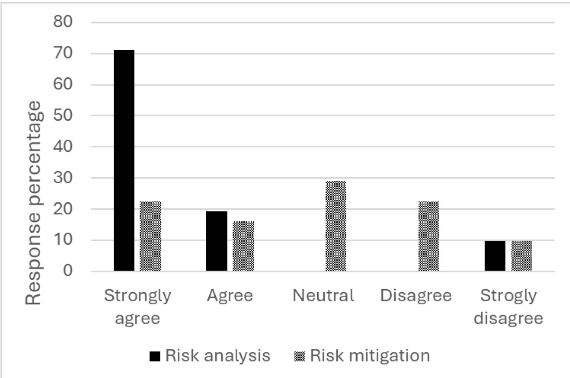

Fig. 3. Response of the STSP students regarding the importance of risk analysis versus the ability to mitigate risk.

students and in Fig. 3 for the STSP students. Figs. 1–3 demonstrate a common theme in all the survey response questions – regardless of the question, there is always a 5–10% strongly disagree response – indicative of a fraction of each cohort that are generally unhappy with the course they took.

Still, over 70% of all students strongly agree that risk analysis is an important skill. When it comes to self-efficacy, over 60% of traditional students at least agree they learned the necessary tools, while less than 40% of the STSP students believe in their evaluation and mitigation skills. The number of STSP students who at least disagree with that statement is nearly double the number of traditional students who at least disagree.

Regarding engineers in institutions, the survey asked three questions, as shown in Table 5. The traditional students, on average, agreed that their course helped them understand the concepts of whistle-blowing and professional conflicts of interest, and while less strong of a response, that they know how to act on conflicts of interest. The STSP student responses were weaker, with significant differences on both conflict of interest questions, including a slight negative response on reporting conflicts of interest and avoiding the appearance of improper behavior.

Table 6 shows the results for the two questions on engineers and the environment. The first question looks at the short-term impact that technology can have on the environment, and the second question asks about the role technology plays in achieving sustainable development. On average, the traditional students agreed with both positive prompts. The STSP students had a weaker response to the environmental impact question and a significantly weaker response to the sustainable development question.

Three questions were asked about course pedagogy, and the results are summarized in Table 7. Since both textbooks emphasize the importance of case studies, the first question asked about the impact of those case studies on the students' understanding of their ethical responsibilities. The traditional students, on average, felt that those case

Table 5. Ethics and institutions

Survey Prompt	Traditional Response	STSP Response	p–value
The course helped me understand the circumstances for which whistle-blowing is necessary and the protections and potential consequences that can result.	1.03	0.55	0.118
This course helped me to identify conflicts of interest in my professional career.	1.09	0.42	0.031
This course taught me how to report conflicts of interest in my professional career and what steps are needed to avoid the appearance of improper behavior.	0.70	–0.13	0.007

Table 6. Environmental Engineering

Survey Prompt	Traditional Response	STSP Response	p–value
The course discussed the impact that technology has and can have on the environment.	0.94	0.52	0.179
The course discussed the role technology can play in achieving sustainable development with respect to the environment, the economy, and sociopolitical factors.	0.92	0.29	0.039

Table 7. Course Pedagogy

Survey prompt	Traditional Response	STSP Response	p–value
The case studies presented in the class were important for helping me to understand my ethical responsibilities as a professional.	1.11	0.52	0.078
The content presented in the lectures was important for helping me to understand my ethical responsibilities as a professional.	1.02	0.23	0.015
The content presented in the discussion sections was important for helping me to understand my ethical responsibilities as a professional.	1.00	–0.16	0.001

Table 8. Overall course assessment

Survey prompt	Traditional Response	STSP Response	p–value
ENEE/ENES 200 is an important course for engineers.	1.00	0.84	0.620
The knowledge, skills, and abilities I learned in ENEE/ENES 200 will help me be a better engineer.	0.92	0.39	0.095
I felt I learned a lot in ENEE/ENES 200.	0.81	–0.10	0.005
If this course were not a required course, I would still recommend it to other engineering students.	0.64	–0.10	0.028

studies were an important part, while the STSP students' response was half as positive. The last two questions involved the content of the lectures and the content of the discussion sections. The traditional cohort agreed that both parts of the course were important for their ethical training. The STSP group had a slight positive response to the lecture content and a slight negative response regarding the discussion content. Both differences between the two cohorts were significant.

The most frequent negative responses from the STSP cohort were about the discussion sections. One student said discussion sections had "weird activities with no point other than being artistic." Multiple students didn't like the acting/improv exercises in the discussion sections. Even a fan of the STSP approach said, "Overall, I love this class. I think a lot of things can improve specifically within the discussion sections."

Table 8 shows the responses for four questions on the overall course assessment. Both cohorts felt that the course was an important course for engineers, but after that, the responses diverged. The traditional students generally felt that they learned the knowledge, skills, and abilities they would need to be a better engineer, but the STSP response was less than half positive. One student's comment might give insight regarding the difference between the two STSP responses. The student said, "I think ethics is an important part of engineering, but the way this class is taught makes it almost impossible to learn these important lessons." When asked if students felt they learned "a lot" in the course, the traditional students still agreed (though slightly weaker), while the STSP response was barely negative.

The final survey question was to ascertain the value of the course by asking if they would recommend it even if the course were not required. The traditional cohort response was the weakest of all responses, though still somewhat positive at 0.64. The STSP cohort response was again slightly negative, with a significant reduction over the traditional response.

4. Discussion

Several conclusions can be drawn by looking at the responses to the open-ended questions. Clearly, both versions of the professional ethics class had their supporters and detractors. For both cohorts, their favorite part of the course was discussing case studies. The second most favorite part for the traditional students appears to be the group projects; for the STSP cohort, the final project came in second place. An STSP student mentioned that they liked the discussion activities, saying, "My favorite part of the course by far was the hands-on ideology used in teaching, having students physically see the results of certain ethical implementations or lack thereof." Another STSP student mentioned that they liked the contract grading.

Grading in the traditional version brought the largest number of complaints. One student for the traditional version stated, "Abolish the exam for this course, it's an ethics course, we don't learn ethics by studying for an exam and answering questions that can be argued between different parties. For a course that preaches about diversity, I don't understand why certain voices were considered wrong on the exam." Other students agreed that the grading seemed "arbitrary" or "biased." Another student disagreed, liking "the engaging discussions led by (the professor), the thoughtful advocating for multiple sides of the arguments, and teaching us to engage, empathize, and ultimately understand alternative ideas and ways of thought." For many assessment problems, the judgment (ethical/unethical) brought no points, the assessment grade came from the students' defense of their position. This approach is what the last comment is referring to, although obviously, several students did not agree.

As to the relevance of the course, one student who took the traditional version said, "Some of the standards (the professor) presented were directly used by the company I interned with this past summer. Having background knowledge from 200 translated into a real-world scenario." Another student said: "I believe that ENEE200, when I took it with my professor, to be not only a relevant class, but also a necessary one to develop the character for the engineer of tomorrow."

Some of the students who took the STSP version of the class had a different takeaway. For example, one student stated, "I really tried liking this class and I did for a good amount of the semester. . . . Though I really feel like it should be restructured because it is simply not effective for so many of the students. . . . I remember having to answer exit tickets about what we learned or felt surprised about. And I would sit there for a good minute and think "what DID I learn today?" Another STSP student lamented, "I think engineering ethics is very important for engineers, but the course had little to do with engineering ethics the way it was taught to me."

The survey responses were integrated over a number of variables. First, the background training of the STSP instructors varied widely. Second, the venues for both versions of the course also varied. Both versions have been offered in fall, spring, summer, and winter semesters. Both courses have been offered in person and online. Fall and spring sections typically have 75–90 students, though there are multiple discussion sections with 15–18 students per section. The winter and summer courses typically have 10–30 students. The STSP version always has separate discussion leaders, irrespective of the semester, but the traditional version sometimes has the professor lead the discussion sections in the winter and spring. Attendance in the summer and winter versions, as well as in the discussion sections year-round, is typically nearly 100%, but attendance in the large fall/spring lectures can drop to 60–70%. Even the total number of contact hours varies from one version to another due to holidays and other scheduling issues.

One limitation of the study was that students were not randomly selected, but rather participants volunteered to take the survey, impacting the external validity of the study. As the participants are self-reporting on their acquired knowledge, skills, and abilities, the conclusions are limited to the students' perceptions.

A much larger, longitudinal study would be needed to try to attribute various attitudes and beliefs to these variables, and such a study will be attempted in the future. Nonetheless, the results of this study have demonstrated that most students understand the value of a professional ethics course and the need for ethical guidelines. However, when we look at students' beliefs regarding the knowledge, skills, and abilities that they have acquired by taking the course, there are significant differences in those beliefs. Students who took the traditional version of the course generally feel that they acquired the necessary knowledge to recognize ethical responsibilities in different professional situations and that they have the skills to make informed judgements and take informed actions. They generally understand the impact of technology on society and the environment, both locally and internationally. The students who took the STSP version scored lower on all but one of the 23 survey questions, with almost half of those differences being statistically significant. Finally, despite the STSP version's emphasis on DEI concepts, students who took the traditional version scored over a full point higher on their recognition of the need for a diverse engineering workforce.

While this survey focused on a single engineering department in the United States, the importance of optimal ethics instruction for engineering students is one that transcends engineering disciplines and nations (e.g., Refs. [27–30]). The ethics course at the University of Maryland is now required for most majors within the college. In fact, in the traditional sections in the past year, about 26% of the students were majoring in electrical engineering, about 32% of the students were majoring in computer engineering, about 21% were majoring in other engineering disciplines, and about 21% were from other disciplines (e.g., computer science and other STEM fields). The effort is truly international with ABET reviewing the criteria for student learning, including ethics instruction, in over 40 countries. While the "traditional approach" features the dominant pedagogical tools to date, STS theory appears to be gaining traction, and so a thorough evaluation of the strengths and weaknesses of both approaches, as measured by student evaluation and performance seems warranted.

5. Conclusions

With respect to the stated course concepts, students in both the traditional and STSP versions of the course understood the value of risk analysis and codes of ethics. However, for the remaining course concepts, the students in the traditional course self-reported on average greater understanding of those concepts compared to the students in the STSP course. In addition, students in the traditional course rated their ability to manage conflicts of interest, risk mitigation, and ethical dilemmas in general higher than their STSP counterparts. Both cohorts felt comfortable with their abilities to recognize harm from bias and injustices that can arise from technological development.

Acknowledgements – The authors would like to thank J. Bentley for carefully reading the manuscript and making significant improvements.

References

1. P. Daniels, S. Kerns and K. Watson, Evaluating engineering programs under ABET EC2000 criteria: a perspective from ABET program visitors, *FIE '98. 28th Annual Frontiers in Education Conference. Moving from 'Teacher-Centered' to 'Learner-Centered' Education. Conference Proceedings (Cat. No.98CH36214)*, Tempe, AZ, USA, November 4–7, p. 877, 1998.
2. 2024-2025 criteria for Accrediting Engineering Programs, https://www.abet.org/wp-content/uploads/2023/05/2024-2025_EAC_Criteria.pdf , Accessed 25 March 2025.
3. Joy Buolamwini: How I'm fighting bias in algorithms | TED Talk, https://www.ted.com/talks/joy_buolamwini_how_i_m_fighting_bias_in_algorithms?language=en, Accessed 25 March 2025.
4. D. E. Nye, *Technology Matters: Questions to Live With*, MIT Press, Cambridge, MA, 2007.
5. J. Hess and G. Fore, A Systematic Literature Review of US Engineering Ethics Interventions. *Sci. Eng. Ethics,* **24**(2), pp. 551–583, 2018.
6. C. Harris, M. Davis, M. Pritchard and M. Rabins, Engineering ethics: What? why? how? and when?, *Journal of Engineering Education*, **85**(2), pp. 93–96, 1996.
7. Home, National Institute for Engineering Ethics (NIEE), https://www.niee.org/, Accessed 25 March 2025.
8. C. Mitcham, A historico-ethical perspective on engineering education: from use and convenience to policy engagement. *Engineering Studies*, **1**(1), pp. 35–53, 2009.
9. D. Martin, E. Conlon and B. Bowe, A multi-level review of engineering ethics education: towards a socio-technical orientation of engineering education for ethics. *Sci. Eng. Ethics*, **27**(60), pp. 1–38, 2021.
10. O. Pierrakos, M. Prentice, C. Silverglate, M. Lamb, A. Demaske and R. Smout, Reimagining engineering ethics: from ethics education to character education, *IEEE Frontiers in Education Conference (FIE)*, Covington, KY, USA, October 16–19, pp. 1–9, 2019.
11. M. Pritchard, C. Harris and M. Rabins, *Engineering Ethics: Concepts and Cases*, Wadsworth, Belmont, CA, pp. 1–336, 2008.
12. Y. Jalali, C. Matheis and V. Lohani, Imagination and moral deliberation: a case study of an ethics discussion section, *International Journal of Engineering Education*, **38**(3), pp. 709–718, 2022.
13. G. Walker, Come back sociotechnical systems theory, all is forgiven..., *Civil Engineering and Environmental Systems*, **32**(1–2), pp. 170–179, 2015.
14. E. L. Trist and K. Bamforth, Some social and psychological consequences of the Longwall Method of coal-getting: An examination of the psychological situation and defences of a work group in relation to the social structure and technological content of the work system, *Human Relations*, **4(1)**, pp. 3–38, 1951.
15. W. Bijker, T. Hughes and T. Pinch, eds., *The Social Construction of Technological Systems*, MIT Press, Cambridge, MA, 1990.
16. H. Sladovich, ed., *Engineering as a Social Enterprise*, National Academy Press, Washington, D.C., 1991
17. D. Tomblin and N. Mogul, STS postures: responsible innovation and research in undergraduate STEM education, *Journal of Responsible Innovation*, **7**, pp. 117–127, 2020.
18. D. Tomblin and N. Mogul, STS postures: changing how undergraduate engineering students move through the world, *ASEE Annual Conference & Exposition*, Minneapolis, MN, August 26–29, pp. 1–15, 2022.
19. D. Tomblin, N. Mogul and C. Salley, Countering Passive Engagement: STS Postures and Analyzing Student Agency in Everyday Engineering, *ASEE Annual Conference & Exposition*, Portland, OR, June 23–26, pp. 1–21, 2024.
20. Online Ethics Center: Gilbane Gold Summary and Plan, https://onlineethics.org/cases/engineering-ethics-cases-texas-am/gilbane-gold-summary-and-plan, Accessed 25 March, 2025.
21. J. Smith and S. Nichols, Incident at Morales: an engineering ethics story, *ASEE Annual Conference & Exposition*, Salt Lake City, UT, June 20–23, pp. 9.714.1–9.714.6, 2004.
22. M. Loui, J. Smith, J. Herkert and S. Nichols, Special session – Henry's daughters: a new engineering ethics movie, *40th Annual Frontiers in Education Conference*, Arlington, VA, October 27–30, pp. T4B1–T4B3, 2010.
23. Drama-Based Pedagogy: Zip Zap Zop, https://dbp.theatredance.utexas.edu/teaching-strategies/zip-zap-zop, Accessed 25 March, 2025.
24. R. McGinn, *The Ethical Engineer: Contemporary Concepts and Cases*, Princeton University Press, Princeton, NJ, pp. 1–352, 2018.
25. C. Adams, O. Pierrakos and L. Agasthya, How good is our undergraduate engineering ethics training? a comparative analysis of engineering ethics textbooks, *ASEE Annual Conference & Exposition*, Portland, OR, June 23–26, pp. 1–17, 2024.
26. H. Kim, Statistical notes for clinical researchers: the independent samples *t*-test, *Restor. Dent. Endod.*, **44**(3), 2019.
27. A, Dizani, A. Ghorbani, B. Taebi and I. van de Poel, Understanding engineering ethics in countries: Towards an analytical framework, *Technology in Society*, **77**, pp. 1–10, 2024.
28. M. Brumsen, Ethics in engineering in The Netherlands: the role of professional associations, universities, and law, *International Journal of Engineering Education*, **21**(3), pp. 391–401, 2005.
29. K. Lamkin-Kennard, A. Lerner and M. King, Teaching biomedical engineering ethics in the context of statistics. *International Journal of Engineering Education*, **23**(1), pp. 184–191, 2007.
30. R. Devon and I. van de Poel, Design ethics: the social ethics paradigm, *International Journal of Engineering Education*, **20**(3), pp. 461–469, 2004.

Appendix 1. The current course topics

Professions and codes of ethics
Responsibility in engineering
Ethical concepts, methods, theories, and their application
Problem resolution
Technology and society
Trust and reliability
Risk analysis and liability
Ethics and institutions
Environmental engineering
International engineering

Appendix 2. The discussion topics in the STSP version of the class

Dominant Paradigms in Ethics
Dominant Paradigms in Infrastructure
Engineering Cultures and Historical Lens
Engineering Mindsets
Sociotechnical Imaginaries
Hacking the Human
Default Discrimination
Disability Justice
Gender Values
Who Pays for Innovation
Sensing COIs and Locating Power in Engineering Systems
Communicating Expertise

Wesley Lawson has been at the University of Maryland since 1985 where he is currently a full professor. While his primary research efforts have focused on fast-wave microwave sources and high-power passive components, he has also performed research projects in the areas of medical devices and engineering education.

Gideon Smith has been at the University of Maryland since 2021, working hard to get his degree in electrical engineering with a minor in computer engineering. He will be obtaining his degrees at the end of 2025 where he hopes to make an impact within the field.