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# Which Courses Influence Engineering Students' Views of Social Responsibility?

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**Abstract**

Many professional bodies are calling for engineering education to develop holistic engineers, trained in more than just technical content. Educational expectations include ethics and understanding social context, as well as attitudinal dispositions such as tolerance and thoughtfulness. These skills and dispositions add increased complexity and difficulty to the education of engineers beyond teaching only technical content. Moreover, there may be significant disconnects between what engineering faculty think they are teaching and what students are in fact learning. In looking at student learning versus faculty teaching, student responses to an open ended question about which, if any, courses had been influential to their views of social responsibility were examined. The ways in which engineers see their role in society, their social responsibility, is seen as one way to examine larger student views which may positively or negatively influence many of the professional and attitudinal dispositions which are now goals of engineering education.

The Engineering Professional Responsibility Assessment (EPRA) tool was distributed to undergraduate engineering students across all majors and all academic years at 17 universities in the spring of 2014 to assess student views of social responsibility. In total, 1885 undergraduate students completed the survey. One question on this survey asked if there were any college classes that the student found influential to his/her views of social responsibility. Forty-three percent of the students said that no classes had been influential to their views of social responsibility. If the student answered yes, an open-ended question then asked the student to describe what courses had been influential and in what ways. These 1224 open-ended responses were coded using emergent coding strategies. Inter-rater reliability for the code book was examined. Codes focused on the type of course (engineering course, humanities course, senior design, first-year), the topic of the course (e.g. sustainability, energy, religion, ethics), and teaching pedagogy (e.g. service-learning, case-studies, project-based).

It is concerning that 42% of the engineering students indicated that no courses in their undergraduate studies influenced their views of social responsibility. Of the seniors who completed the survey, 37% indicated that no courses had influenced these views. Of those who were influenced, the most common courses were engineering courses (44%) and humanities courses (44%). Doing design work (11%), projects (9%) and service learning (8%) were the most common educational approaches cited, while case studies were rarely cited by students. Ethics (24%) was the most common topic in student responses, with environment (8%) and sustainability (6%) the next most common. The benefit of this examination is to see where students are being influenced with respect to their social responsibility. Because many of the courses influencing students were outside of engineering, it is unclear how these may influence the ways in which students see their social responsibility as engineers. Further, if the courses are electives, it appears an unreliable method to educate all engineering students about social responsibility.

## Introduction

The drive to train more holistic engineers places an additional degree of complexity on engineering education, forcing educators to reach beyond just technical skills[1]. Additionally, many of the professional skills and attitudinal dispositions that are emphasized by engineering professional societies are difficult to implement in engineering courses and to assess. Examples of these skills come from the accreditation board of ABET's criterion 3; "an understanding of professional and ethical responsibility", "the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context" [2]. The American Society for Civil Engineering's second edition Body of Knowledge also highlights attitudinal dispositions that are central to being an effective engineer, including consideration of others, integrity, respect, and tolerance[3].

This research focused on student attitudes toward personal and professional social responsibility as a way to examine the foundation from which many of these skills and dispositions could be developed. Social responsibility is seen as a value orientation focused on feelings of personal and professional obligation to help others, with special consideration for disadvantaged or marginalized communities[4]. Student views of social responsibility are likely deeply held beliefs which have developed throughout an individual's life, with myriad influences including family, school, personal experiences, travel, and even just watching the news[5]. How social responsibility relates to engineering, however, likely develops for most individuals during their undergraduate education, as they learn more clearly what engineering is and what engineers do. This presents a key opportunity for engineering educators to influence the development of professional social responsibility in their students. One study, however, found that views of professional social responsibly and related dispositions may actually decrease over time, both as students and later as professionals[6].

Previous work has shown that service-learning and active participation in extracurricular engineering service programs, such as Engineers Without Borders, attract students with stronger beliefs of social responsibility[7]. Engagement in service learning also correlated with positive gains in social responsibility attitudes of engineering students. Similar findings have been seen outside of engineering as well, where engagement in service increased student's awareness of the world and of personal values[8], such as social responsibility. Service learning is only one pedagogical approach, however, that may be influencing student's views of social responsibility. This paper explores what other in-class experiences students highlight as being influential to those views.

## Research Questions

This research was guided by the following research questions:

1. What types of courses do engineering students reference as being influential to their views of social responsibility?
2. What course topics do engineering students reference as being influential to their views of social responsibility?
3. What course pedagogical approaches do engineering students reference as being influential to their views of social responsibility?

4. Does the frequency that course types, topics, or pedagogical approaches are cited by engineering students differ by demographic, specifically gender, academic rank, and major?

**Data Collection and Analysis**

The Engineering Professional Responsibility Assessment (EPRA) tool was used to gather the data for this paper[9]. In the 2014 spring term, EPRA was distributed electronically to engineering undergraduate students at 17 ABET accredited universities. At 15 of those universities, students from all engineering majors received the solicitation email. At the other two universities, only students within one department at each received the email. The universities surveyed included eight public universities, three private, non-religious universities, five private, religiously affiliated universities, and one military academy. As incentive for completing the survey, student names were entered into gift card raffles among respondents from each university.

In total, 1885 undergraduate students completed at least 90% of the survey and correctly answered a "check" question. Institutional response rates ranged from 6% to 33%. The response population was 36% female, represented all undergraduate grade levels and 22 different engineering majors such as Aerospace, Biomedical, Chemical, Civil, Computer, Electrical, Environmental, Materials, and Mechanical.

The EPRA tool began with an informed consent statement. Students were asked open-ended questions to define social responsibility and factors that led them to choose their current major. The bulk of the EPRA tool consisted of 50 Likert-items on a 7-point scale with questions directed at student attitudes of social responsibility, rooted in the Professional Social Responsibility Development Model[4]. Results from these Likert items are not discussed in this paper, but may be found in other publications by the authors (e.g. [7, 9]). After the Likert items, students were asked "Are there any college classes that you have found influential to your views of social responsibility?" to which they selected 'yes' or 'no'. If they selected 'yes', they were then prompted to an open-ended question asking the following, "If yes, what courses and in what ways?" Forty-two percent of the students (n=916) checked 'no' and were not prompted to give an open response. Thirty-seven more left the follow-up question blank. In the end, 1224 students wrote in a response to the open-ended question. Response numbers by demographic are shown in Table 1. After the courses question, students were asked an open-ended question to describe events that influenced their views of community service and social responsibility, a series of questions about their volunteer histories, and demographic information. The survey itself and protocols were approved by an Institutional Review Board to ensure that appropriate human subjects research methods were followed.

Student responses to the open-ended questions about influential classes were coded using emergent coding methods[10]. The codes that emerged focused on the type of course (engineering course, humanities course, senior design, first-year), the topic of the course (e.g. sustainability, energy, religion, ethics), and teaching pedagogy (e.g. service-learning, case-studies, project-based). The most common codes are shown in Table 2. A single course could be coded into multiple categories. The student may also have discussed multiple courses. The percentages shown represent the percentage of the students with a write-in response whose response fit the code shown.

Table 1. Response numbers by demographic

| Demographic | Total | Responded that 'no' courses were influential to social responsibility |
|---|---|---|
| All | 1885 | 42% |
| Male | 1180 | 42% |
| Female | 662 | 42% |
| First-year | 258 | 53% |
| Sophomore | 521 | 44% |
| Junior | 536 | 40% |
| Senior | 553 | 37% |
| Mechanical | 602 | 46% |
| Civil/Environmental | 403 | 28% |
| Computer/Software/Electrical | 386 | 47% |
| Chemical/Biological/ChemBio* | 126 | 62% |

* Note that biomedical engineers were omitted from this list because of the significant difference in responses from students in specified biomedical engineering programs. The researchers acknowledge that some schools do not have biomedical programs and that students who study biomedical engineering may in fact officially be in Chemical, Biological, or mixed programs instead.

Inter-rater reliability (IRR) for the codes was determined using Cohen's kappa over a randomly selected sample, using 140 responses and two reviewers[11-13]. Results from the IRR analysis are given in Table 2. Standard rule of thumb of kappa greater than 0.6 was used to identify codes with acceptable reliability[14]. Both 'First-Yr' and 'Project' had lower poor reliability based upon their kappa values. Beyond dual-coding for this subset, the entire group of responses was coded by a single individual. This individual consulted the course catalog from each institution in order to assist in the correct identification of the course characteristics.

**Results and Discussion**

*RQ1: Types of course*

This research was interested in which types of classes the students referenced as being influential to their views of social responsibility. Engineering courses were the most common types of courses cited by students (44%). When students talked about engineering courses, they often talked about a course with respect to the overall course topic, such as sustainability, renewable energy, and product design. Sometimes students would mention a specific topic within a course, such as an ethics module in an introductory course. Engineering courses that could be considered core course, such as Mechanics of Materials or Thermodynamics, as well as elective courses, such as Social Entrepreneurship, were mentioned by students. One example of a student response that related to an engineering course is:

> "I've taken a few classes that have helped with my view on society and positive impacts. Some are ESM (Environmental Sustainability and Management); it helped show the cause and effect of our actions. People hear environment and just think of nature, but helping lower poverty and raise societies education on certain matters have a huge impact on both nature and other people. Another class would

be my Chemical Engineering intro class, we went through a lot of ethics, including about cutting corners and how it can lead to negative outcomes."

Table 2. Most common codes for student responses regarding influential classes to the development of social responsibility

| | Code (% of total responses given) | Definition | Example | IRR - Cohen's Kappa |
|---|---|---|---|---|
| Course Type | Engr Course (45%) | Any engineering courses, required or otherwise, mentioned by a student. | CAD, Fluid mechanics, Thermodynamics, Introduction to Environmental Engineering, Environmental Sociology | 0.67 |
| | HSS Course (42%) | Humanities/Social Science courses | Anthropology, History, Music courses, Psychology, Philosophy, Religion, Politics, Communication, Leadership | 0.69 |
| | First-Yr (9%) | Specifically cite a first-year course, usually an introductory or first-year projects course | "Freshman series we focused on helping other by working with local non-profits" | 0.33 |
| Topic | Ethics (24%) | Referencing ethics as a topic within or title of a course | "Ethics course. Made me think extremely hard about who I am and what kind of person I should be." | 0.93 |
| | Design (12%) | Referencing engineering design or design work within a class | "My design classes where we tackle medical device problems for people in the local area or in 3rd world countries." | 0.63 |
| | Environment (8%) | Discussions of the need or desire to do environmental protection or remediation | "Environmental science. I learned a few of the different environmental problems that are facing our society." | 0.64 |
| | Sustainability (7%) | Also included discussion of renewable resources | "All of my materials engineering courses stress sustainability and social responsibility. We strive to solve the current issues that affect us economically, socially, and environmentally." | 0.79 |
| Pedagogy | Project (9%) | Referencing a curricular or extracurricular project that they worked on | "…Advanced Writing Composition - We had a community service project as part of the course." | 0.51 |
| | Service Learning (7%) | Discussions of volunteering or community project work connected with a specific class | "Engineering 130. We did a service-learning project that showed me new ways to help the community." | 0.64 |

Here the student points to how the Environment Sustainability and Management class helped them to see larger connections between their work as an engineer and global social issues. In talking about the chemical engineering course, they talk about how discussions of ethics played into their views of social responsibility and expectations of them as an engineer.

Some students also talked about influential professors in a given engineering class, how that individual would emphasis the responsibility that engineers have, especially with respect to public safety and integrity in their work. One such example is "Materials Processing: Instructor helped the class as a whole to look outside the engineering field to how our future actions can and will affect the world." Here the student points to the instructor and how they included discussions of the impacts that engineers have on society, beyond the specific topic of the class – materials processing.

Humanities and social science (HSS) courses were also common types of classes mentioned (44%). Common types of classes included philosophy, sociology, business ethics, political science and religion. An example response from this category is:

> "Psychology courses, particularly the Psychology of Gender. This class really opened my eyes to a lot of [global]-issues like discrimination due to disability, gender, and socioeconomic status. My professor in this course encouraged participation in campus events and projects, and related the course work to current events."

Similar to student responses toward engineering courses, this student mentions both the topic of the course, gender, and the instructor's personal encouragement of the students to engage in social activism. Philosophy and religion courses were the most commonly cited types of HSS courses mentioned by students, with religion courses being almost entirely from students at the five religiously affiliated schools.

Other course types that were seen in student responses included senior design (10% of seniors) and first-year introductory and engineering projects courses (10% of total, 22% of first-years). Very few students referenced math or natural science courses as having been influential to their views of social responsibility (2%). A small percentage of students also responded that all of their courses had been influential (2%).

Reflecting on the types of courses that students cite as being influential to their views of social responsibility, the prevalence of responses that reference engineering courses was encouraging. However, 37% of the seniors indicated that no courses had influenced their views of social responsibility; therefore of all seniors only 43% of those who were influenced discussed engineering courses. Both engineering topics and engineering faculty seem to be positively influencing student views. It was also interesting to see how common HSS courses were mentioned, disproportionately so to how many of these types of courses students take versus engineering courses. The nature of many of these courses typically encourages students to reflect on and challenge larger social issues, which students often cited as being influential to

their views. Few students, however, discussed if their HSS course experiences related to views of their social responsibility as engineers. An example of one of the few responses that did make this connection is, "Ethics and Religion courses at (XY University) show engineers that there is a much bigger picture then working for a firm to build massive structures and have a successful career." For this student they were able on their own or perhaps through the course instruction, to connect the issues of ethics and religion from the courses to their role as an engineer.

Responses like this were very uncommon, however. This could point to a missing link with respect to developing a professional sense of social responsibility in engineers that could draw from the existing HSS influences that students reported. One student actually discussed how their humanities class influenced them negatively with respect to their views of engineering, saying:

> "Mostly the humanities, the engineering classes I took made me realize how irrelevant my major (mechanical engineering) is to making a difference in the world. I don't plan on using my major for anything in the future- planning on shifting my career path to the humanities/social sciences."

This response came from a female, senior engineering student who, presumably, finished her degree a month after taking this survey and then left engineering all together. Perhaps if a better link had been created for this student, showing how her mechanical engineering degree could address her desire to make "a difference in the world", then she would have stayed in the profession upon graduation.

*RQ2: Course topics*

In addition to the type of course, students often mentioned the topic of the course that was influential to them. Ethics was the most commonly cited topic (25%). Ethics was evident as the title of the course (Engineering Ethics) or as a subtopic that was covered within a given course. About half of the students who mentioned ethics in their responses also referenced an engineering course, and a third cited an HSS course. About 10% of the students who mentioned ethics also cited a first-year course and 5% percent of the seniors who cited ethics also referenced senior design courses. An example response that included ethics and a first-year engineering course is:

> "In several courses such as Intro to Civil Engineering and Environmental Engineering, we went over several Case-studies involving ethics. We went over why certain decisions were unethical and what was the correct course of action. I think these topics exposed me to common issues and themes that engineer face all the time and must decide carefully."

For this student, it was the discussions of ethical decisions through engineering case studies that influenced their views of social responsibility.

Sustainability, design, the environment, international development and discussions revolving around engineers' ability to have an impact (both positive and negative) on society were other,

less common themes that emerged from the data. An example response that incorporates sustainability is:

> "I studied environmental sustainability and theater of the oppressed. They informed me about the ways in which systems have hidden costs and damaging effects. They showed that things will not improve without active participation in their solutions."

The way in which this student's views of social responsibility were influence was through not only their exposure and greater understanding of sustainability, but also in the need for "active participation in their solutions." Though not supported by this quote, presumably the student saw the need for him personally to become an active participant toward the solution. A key element of social responsibility outlined by the PSRDM is the need to take action in order to develop stronger views of social responsibility. Perhaps this exposure to sustainability and accompanying call to action encouraged this student to do so, thereby potentially strengthening their beliefs of social responsibility.

Many of these topics were interrelated in student responses. A student may talk about how a course taught them about the importance of sustainability considerations in their design process. Students also talked about professors or courses that would emphasize the impact that engineers can have on society, both in positive and negative ways, especially with respect to environmental health or sustainability. Most of the ways in which students talked about these topics in relation to their courses was how the course exposed them to these issues and, when seen within an engineering context, oftentimes this exposure challenged them to see how engineers may contribute to these issues.

*RQ3: Course pedagogies*

The third research question addressed which pedagogical approaches students referenced as influential to their views of social responsibility. References to pedagogical approaches were not very common among the student responses (<9% for any given code). Those approaches that were referenced included projects-based (9%) and service-learning (7%). Case-studies were also mentioned by a few students, as seen in the quote used above relating to ethics, though it was not common (<1%). In relation to project-based learning, most students talked about the need to think of the end-user or of the sustainability implications of their project. An example is,

> "I took a social entrepreneurship course where we created and designed a project that would help a targeted group of people. In doing so, we learned about the difficulties that some people face and realized that there are solutions that we can come up with to help."

Many of the projects mentioned by students were focused on working with marginalized or disabled populations and therefore also counted as service-learning. One student talked about developing an app for local homeless people through a projects course. They talked about how that project helped them to recognize that there are people in his/her own community that could benefit from the skills that he/she was learning as an engineer. This form of project-based service-learning as a way to improve student views of social responsibility supports what had

been shown in previous work[7]. One student, in talking about their service-learning experience said,

> "Engineering Design 1: In this class we worked with a client that had very different needs then our own. Her name is Lena and she is a girl who has had cerebral palsy since she was young. We had to design a vehicle for Lena, and we learned that a large part of social responsibility is listening to people in need because their needs are often overheard or misinterpreted."

Through this student's project-based service learning experience, he gained insight into how engineering can be used to help underserved portions of our society, thereby increasing this students views of professional social responsibility. Service experiences outside of engineering were also mentioned by student, but, similar to the lack of transfer with HSS courses, students rarely discussed how these experiences influenced their views of social responsibility related to engineering.

When referencing either projects or service work, students most often talked about how engaging with clients who came from different backgrounds than themselves was the primary influence to their social responsibility. Oftentimes this meant seeing a problem in a different way, or sometimes engaging with a problem that the engineering students hadn't even considered, like the mobility needs of a girl with cerebral palsy. Guiding students to engage with these diverse communities as engineers seemed to help broaden their perspectives of how engineers can use their skills to help improve society. This, in turn, influenced their views of social responsibility as engineers.

*RQ4: Demographic differences*

The final research question was to examine the course types, topics and pedagogies discussed above to see if there were frequency differentials by demographic group, namely gender, academic rank, and major. Examining first by gender showed that there was no difference between men and women in the percentage that initially said no class had influenced their views of social responsibility, 42% for both, as seen in Table 1. Examining the common codes also showed few differences by gender. The largest difference was with the project code, where 13% of the female respondents mentioned a project while only 5% of the male respondents did so. Additionally, women were more likely to cite engineering courses (40% vs. 38%) and less likely to cite HSS courses (32% vs. 42%). All other codes had frequencies within three percent of each other.

Looking across academic ranks showed more variation in responses than gender. First, looking at who responded that no classes had influenced their views, first-year students were more likely to have not had any influential classes than seniors (53% vs. 37%). This makes sense as first-year students had had fewer courses in college to draw from. Still, 37% of senior respondents said they had had no influential courses with respect to social responsibility, which is concerning

since they presumably had taken or were in a senior capstone course that would likely contain some reflection of an engineer's ethical and professional responsibilities. Further, they should have fulfilled all of the ABET outcomes. Of those students who wrote in a response, the most common codes by academic rank are shown in Table 3. First-year students were more likely to mention HSS courses than the other academic ranks, with seniors being least likely. The percentage of each academic rank to cite engineering courses was similar. Not surprisingly, first-year students were most likely to mention first-year courses, with sophomore students being the next most likely. Junior and senior students were more likely to cite ethics than first-year and sophomore students, again perhaps due to where ethics courses fall in students course schedule.

Table 3. Common response codes by academic rank

| | Percent response for common codes | | | | | | |
|---|---|---|---|---|---|---|---|
| Rank | Engr. Courses | HSS Courses | First-year Courses | Ethics | Design | Project | Service-Learning |
| First-year | 47% | 51% | 22% | 19% | 5% | 12% | 7% |
| Sophomore | 46% | 46% | 13% | 18% | 9% | 9% | 9% |
| Junior | 45% | 47% | 7% | 26% | 15% | 8% | 7% |
| Senior | 43% | 38% | 6% | 30% | 11% | 9% | 8% |

When examined by major it was observed that Civil and Environmental engineering students were least likely to say that no classes had influenced their views of social responsibility (28%). The other majors had more students say that no classes had been influential than Civil and Environmental students, ranging from 46% to 62%. Note that in order to get large enough groups, and to account for the wide variety of degree combinations at the 17 sampled schools, many programs were combined (such as Civil and Environmental, or Computer, Software, and Electrical). A breakdown of responses by major for common codes are shown in Table 4.

Table 4. Common response codes by major

| | Percent response for common codes | | | | | | |
|---|---|---|---|---|---|---|---|
| Major | Engr. Courses | HSS Courses | Sustainability | The Environment | Ethics | Design | Service-Learning |
| Mechanical | 43% | 48% | 4% | 5% | 27% | 13% | 7% |
| Civil/ Environmental | 59% | 31% | 10% | 16% | 24% | 14% | 6% |
| Computer/ Software/ Electrical | 29% | 55% | 3% | 3% | 25% | 5% | 9% |
| Chemical/ Biological/ ChemBio | 38% | 49% | 0% | 2% | 26% | 6% | 6% |

Looking at student responses of course type by major showed that Civil and Environmental students were most likely to cite their engineering courses, followed by Mechanical, Chemical/Biological/ChemBio, and Computer/Software/Electrical. Conversely, Computer/Software/Electrical students were most likely to cite HSS courses, followed by

Chemical/Biological/ChemBio, Mechanical, and finally Civil and Environmental. One possible explanation for this inverse relationship could be that students who have been influenced in their views of social responsibility within engineering, naturally report those classes first. For students who may not have been influenced from classes within their major, they then reach outside of their core engineering classes and discuss HSS courses instead.

Examining topics showed that Civil and Environmental engineering students were most likely to cite sustainability and the environment. All four major groups discussed ethics with the same frequencies. Design considerations were a more common theme for both Mechanical and Civil and Environmental students. There were no differences in responses related to pedagogical approaches among the majors.

**Conclusion**

This paper has examined which classes students say have been influential to their views of personal and/or professional social responsibility. First off, 42% of the engineering students surveyed said that none of their college courses had influenced their views. Thirty-seven percent of senior engineering students said the same. This is concerning given that engineering programs are supposed to be influencing not only student's technical knowledge, but also their professional skills including an understanding of ethical and professional responsibility and an understanding of the impacts of engineering design in diverse contexts. The students perhaps held a variety of differing definitions of social responsibility which impacted how they interpreted the question on influential courses. A wide diversity of definitions was seen in the open-ended response at the start of the survey. However, the Likert survey questions that preceded the course question indicated a number of elements related to social responsibility which would lead the authors to believe that students had at least a general flavor for what social responsibility was to them. Survey laziness or a lack of reflection on ways in which one could experience messages relating to social responsibility may have led students to under-report influential courses compared to what students actually experience.

Engineering students were equally likely to cite engineering or HSS courses in their responses. It is encouraging that students are being positively influenced within their degree programs. However, the percentage of these courses that were required versus elective is less certain. Initially engineering courses were categorized into elective and required courses, but the IRR values were poor so they were combined. Broadly, however, required engineering courses were more commonly cited than perceived elective courses. It was expected that senior design and first-year projects would have been more common since they most often include ethics components to meet ABET requirements. Many students also cited HSS courses as being influential. Because HSS courses are also a critical source for engineering students in the development of their personal and professional social responsibility, this presents an opportunity for engineering faculty to build upon the experiences that students have in non-engineering courses. To truly do so, it would seem that inter-departmental collaboration would be necessary, where engineering faculty work with non-engineering faculty to coordinate the HSS course experiences with engineering courses with respect to developing social responsibility. Further, relying on HSS courses seems to be a problematic strategy. First, some institutions do not restrain HSS courses but rather allow all of these courses to be student-selected electives. The students who could most benefit from courses that relate to social responsibility might shy away

from courses that discuss these concepts. In addition, the diversity and breadth of HSS courses varies significantly between different degree programs; for example, one study found that HSS courses (so called general education courses) comprised between 14 and 53 credits of ABET-accredited civil engineering degree programs[15].

The most common topics seen in student responses included ethics, sustainability, design, the environment, and how engineering impacts society. Few pedagogical approaches were specifically highlighted by students, but projects-based and service-learning approaches were the most common of those. Case-studies were infrequently cited by students as being influential to their views of social responsibility.

Finally, when looking across demographic groups few differences among male and female students were seen. The likelihood of citing HSS courses decreased with academic rank (First-year to senior) while the likelihood of citing an engineering course increased. Ethics was also more commonly cited among juniors and seniors than first-year or sophomore students. Civil and Environmental engineering students were least likely to not have had influential course, and the most likely to cite engineering courses, mention sustainability and the environment, or, with Mechanical engineers, to discuss the impact of engineering design.

If positively influencing student views of social responsibility is a goal for engineering education, than seeing where students currently are being influences can be a crucial step. Currently, nearly half of the engineering students surveyed found no classes as being influential, so there is space for engineering departments to improve. Topically, students seem to be positively influenced by discussions of ethics, as well as sustainability and environmental issues. Students seem responsive to project-based and service learning pedagogies as tools to help their social responsibility development. Encouragingly, students also cited both course topics as well as individuals who, sometimes tangentially, brought issues related to social responsibility into their courses. Finally, there is space for engineering faculty to build upon the positive influences that students are experiencing in courses outside of engineering, so that students can take those messages and relate them more concretely to their professional views of social responsibility.

These results show student perceptions of course influences to social responsibility, but they don't examine how faculty or departments believe that they are influencing such views. At the 17 institutions surveyed, it would be beneficial for departments to see where their students said they were influenced and compare that to where they thought they were affecting student views. Departments could assess if the first-year or capstone projects were influencing the ethical development that they expect. Possible single time interventions on ethical or professional responsibility are not enough to provide lasting impressions on students such that they would highlight that course years later. This could be an impetus to change such approaches to ethics education. More broadly, this work provides a useful approach to assessing other professional skills development, using bottom-up approaches where students are asked about influential experiences as opposed to top-down where faculty report where these skills are taught. Such approaches could be used to assess leadership, communication, teamwork, etc. Recognizing the difference between teaching and learning will be a critical component toward creating educational systems that train holistic engineers of the type called for by the engineering professional societies and academies.

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