Faculty Integration of Social Justice Issues into Courses and Co-Curricular Activities for Engineering Students

Dr. Angela R Bielefeldt, University of Colorado Boulder

Angela Bielefeldt is a professor at the University of Colorado Boulder in the Department of Civil, Environmental, and Architectural Engineering (CEAE) and Director for the Engineering Plus program. She has served as the Associate Chair for Undergraduate Education in the CEAE Department, as well as the ABET assessment coordinator. Professor Bielefeldt was also the faculty director of the Sustainable By Design Residential Academic Program, a living-learning community where students learned about and practice sustainability. Bielefeldt is also a Fellow of the American Society for Engineering Education and a licensed P.E. Professor Bielefeldt’s research interests in engineering education include service-learning, sustainable engineering, social responsibility, ethics, and diversity.
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Abstract

Recent attention has been drawn to historical inequalities in society that persist in some form today. Social justice concerns marginalization in the form of social disadvantage which may be in terms of income, services, and/or participation. If engineers are to work effectively with and for marginalized communities both locally and abroad, they should be sensitized to social justice issues and have sophisticated ethical reasoning skills. This research explored the perspectives and practices related to social justice issues among engineering educators who integrate ethics and societal impact issues (ESI) into their courses. A survey found that among 1268 instructors who embed ESI in their courses, 27% include social justice and/or poverty topics. The majority of individuals who taught social justice and/or poverty believed that the ESI education of undergraduate and graduate students in their program was not sufficient. Based on interviews, faculty descriptions of how they taught social justice issues in a variety of course types and co-curricular settings are provided. This includes pedagogies that are common for ESI broadly such as reflection, discussion, and case studies. These results provide ideas to help engineering faculty integrate social justice topics into their teaching.

Background

Engineering education should prepare students to practice as ethical professionals. The ABET Engineering Accreditation Commission student outcomes require that students upon graduation have “an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.” [1] While social justice (SJ) is not explicitly mentioned, these concerns certainly fall under this criterion. The SJ principles of equity, access, participation, and rights are relevant to both engineered works and the engineering education process itself. The 2017 update to the American Society of Civil Engineers (ASCE) Code of Ethics added a requirement for engineers to “treat all persons fairly and encourage equitable participation.” [2] While there have been strong proponents for the integration of SJ into engineering education, e.g. [3-11], it is unclear whether or not these efforts are common. In addition, given the national spotlight on racism in 2020 [12-13], a number of engineering faculty may be newly motivated to integrate SJ issues into their teaching. This paper provides ideas for individuals newer to considering SJ integration into their teaching.

Most engineering ethics textbooks fail to address SJ issues in a substantive way. In Unger’s 2017 book [14] the terms social justice, racism, and poverty are not found. A passing nod is given to these issues in a short description of the Panama Canal project, i.e. “there is much to criticize about the way that the workers, particularly the black Caribbean laborers, were treated.” (p. x). McGinn’s 2018 The Ethical Engineer [15] does not explicitly use the term social justice but does discuss Rawl’s Theory of Justice: “for the unequal distribution of a benefit or a burden among members of a group to be distributively just… it must make the greatest positive or least negative difference to the currently worst off.” (p. 32). A footnote elaborates, “Rawl’s Difference Principle invites one to become aware of the elements of one’s current privileged situation… and
to adopt a policy that is not shaped by that privilege, but, rather, driven by recipients’ degree of genuine need.” While the majority of the 18 cases in the book are traditional (e.g. Ford Pinto, Google Street View), one discusses ‘innovations for rural Kenyan farmers’ which addresses poverty, a quintessential SJ issue. However, the social-structural elements and a SJ lens is not particularly evident in how the case is presented. The older 2004 Martin and Schinzinger text [16] includes the term social justice twice. For example, a discussion around affirmative action citing issues of compensatory justice notes “sexism and racism still permeate our society today, and to counterbalance their insidious impact reverse preferential treatment is warranted.” The potential negative effects of affirmative action are described including “encouraging racism by generating intense resentment among white males and their families, encouraging traditional stereotypes that minorities and women cannot make it on their own without special help” (p. 171). An older 1998 textbook by Vesilind and Gunn [17] discussed issues of justice and racism, but did use the term SJ explicitly. Other new engineering ethics textbooks with little to no discussion of SJ issues include Peterson [18] and Harris et al. [19]. Thus, it is unclear that SJ is a mainstream topic in engineering ethics education.

Entire books have been written about teaching for social justice in higher education (e.g. [20]), but it is unclear to what extent the practices in engineering education align with these approaches. For example, Adams and Bell [20] describe traditional lecture methods as inadequate and advocate for active, participatory pedagogies that challenge students to reflect on their own experiences. They encourage educators to acknowledge their unique identities and experiences that they bring to their teaching, in addition to being intentional about learning objectives and taking a facilitation mindset. They present a helpful framework for considering SJ, a so-called ‘three dimensional matrix of oppression’, which includes (1) conscious and unconscious, (2) attitudes and behaviors, and (3) the spheres of individual, institutional, and social-cultural. Concrete teaching activities and handouts are provided on a website that accompanies the book. These resources may be particularly helpful to engineering educators without a formal background in SJ issues.

More specific to engineering, 3 of the 25 exemplars of engineering ethics education identified by the National Academy of Engineering included social justice to some extent [21]. Other excellent resources include [3-11,22,23]. There is evidence of increasing integration of social justice issues into engineering education. Using the ASEE Annual Conference proceedings as an example [24], the number of papers identified that included the term “social justice” increased steadily from 49 in 2015 (2.7% of the papers) to 117 in 2019 (6.6% of the papers), with a drop to 82 in 2020 (4.6% of the papers, perhaps due in part to the ~20 SJ papers presented at the ASEE CoNECD conference in 2018 and 2019). The divisions publishing the most papers that included SJ were Liberal Education / Engineering & Society (n=91; 30%), Educational Research & Methods (n=53; 7%), Engineering Ethics (n=45; 26%), Community Engagement (n=30; 19%), and Minorities in Engineering (n=29; 14%). In the majority of the conference papers, SJ was not the focus but rather mentioned in passing; social justice appeared in the title of only 21 ASEE annual conference papers from 2006-2020.

Previous research identified demographic differences among the types of faculty that integrate SJ into their teaching [25, 26]. For example, there were large disciplinary differences among the percentage of faculty who integrated SJ issues into their courses, ranging from a high of 61% of
faculty teaching HSS courses for engineering students down to 9% in mechanical engineering and none of the faculty teaching aerospace engineering students [26]. While interesting, these results failed to provide information on the common ways that faculty integrated SJ issues into their teaching practices.

**Research Questions**

The questions explored in this study are:

- How common are social justice issues among the ethical and societal issues (ESI) topics taught by engineering educators?
- Do those who teach social justice have similar perceptions about the sufficiency of engineering ethics instruction in their programs as engineering educators who teach ESI but not SJ?
- Are engineering educators who teach social justice similar to engineering educators who teach other ethics and/or societal issues in terms of the types of ESI topics, course types where they integrate ESI, teaching methods associated with ESI, and assessment methods for ESI?
- What are faculty perspectives on how they integrate social justice topics into different types of courses and co-curricular settings?

The results provide examples for those teaching ESI on modifications to their practices that can integrate SJ.

**Methods**

This research was a post-hoc study embedded within a larger project that explored how faculty integrate ESI into their teaching for engineering students. SJ was included among the ESI topics of interest, although not the sole focus of the larger study [25, 26]. This paper takes an in-depth look at the SJ findings, primarily examining the qualitative results with context provided by the quantitative results. The study was reviewed by an Institutional Review Board for Human Subjects Research, and deemed exempt with minimal risk level (Protocol #15-0326).

Two surveys were developed to broadly assess the ESI teaching practices of faculty who educate engineering students in the courses they teach and/or co-curricular activities they advise. One survey focused primarily on educators courses, followed by brief questions on co-curricular activities that they advised / mentored (e.g. professional societies, research). The other survey focused initially on co-curricular activities advised or mentored by the faculty member, followed by teaching practices in their courses. Both surveys asked which, if any, among 18 ESI topics were taught in courses, including SJ and relatedly engineering and poverty. The co-curricular survey asked individuals to identify the integration of the 18 ESI topics in co-curricular activities that they advised. The survey also included additional items and an open-ended question, concluding with demographic items.

Email invitations to take the two surveys were distributed primarily to engineering educators and the advisors of co-curricular groups in the U.S. in spring 2016 (via ASEE list serves, etc.) [25]. Invitations to take the course survey were also emailed to educators at institutions in other Anglo and Western European countries in summer 2018 [27]. The data set was limited to responses
from individuals who indicated that they taught one or more ESI topics in courses and also indicated the teaching methods for ESI that they used in one or more courses. The data set represents 796 respondents to the survey with detailed information on co-curricular settings in 2016, 325 respondents to the course-focused survey in 2016, and 147 responses from the 2018 global survey. Collectively, these 1268 individuals represent 364 different U.S. institutions and 100 international universities. More details on the survey development and dissemination have been previously published [25-27]. Readers should keep in mind the time frame when the survey data were collected, with respect to the increasing prevalence of SJ in engineering education (e.g. ASEE Annual Conference papers) and the revised ABET criteria.

A sub-set of 37 faculty were interviewed about their ESI teaching practices. These individuals were selected to represent potentially exemplary integration of ESI into their courses or co-curricular activities that they advised. The methods for selecting faculty for interviews and the interview methods have been previously described [28, 29]. The interviews were audio recorded and verbatim transcripts generated, assisted by Trint software. Pseudonyms were assigned using a random name generator. The interviews focused on the setting where the individual believed their ESI instruction was the most effective. In two cases the individuals discussed larger programs that included multiple courses, and one individual discussed an array of different courses. None of the interview questions asked explicitly about SJ. Thus, although on the survey 24 of the interviewees indicated that SJ and/or poverty issues were included in courses they taught and/or co-curricular activities they advised, only fifteen explicitly discussed SJ, racism, or poverty during their interview (including two instructors who did not indicate SJ on the survey). This research methodology means that SJ would only be discussed if it was significant in the context of ESI education in the mind of the faculty member. The basic characteristics of the individuals who discussed SJ in their interview and their institutions are provided in Table 1. Note that five among the fifteen did not have degrees in engineering or computing, but they primarily taught courses for engineering and/or computing students. The interviews provide concrete examples of SJ integration into engineering courses and co-curricular activities. Within this manuscript, the quotes from instructors have been lightly edited to remove hesitation and filler words to improve readability while accurately representing the words of the speaker (i.e. clean verbatim).

Table 1. Interviews with faculty where SJ issues were discussed

<table>
<thead>
<tr>
<th>Pseudonym</th>
<th>Program / Background</th>
<th>Demographics</th>
<th>Institution / Carnegie Basic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adair</td>
<td>Chemical Eng</td>
<td>Female</td>
<td>Public Master’s</td>
</tr>
<tr>
<td>Deibel</td>
<td>Electrical Eng</td>
<td>Male, Intl</td>
<td>Intl Private Doctoral</td>
</tr>
<tr>
<td>Holt</td>
<td>Civil and Environmental Eng</td>
<td>Female</td>
<td>Public R1</td>
</tr>
<tr>
<td>Jardine</td>
<td>Civil and Environmental Eng</td>
<td>Female</td>
<td>Public Master’s</td>
</tr>
<tr>
<td>Kay</td>
<td>Electrical Eng</td>
<td>Male</td>
<td>Private religious Doctoral</td>
</tr>
<tr>
<td>Kinsley</td>
<td>Eng Education, Civil / Env Eng</td>
<td>Female</td>
<td>Public R1</td>
</tr>
<tr>
<td>Meagle</td>
<td>Materials Eng</td>
<td>Female</td>
<td>Private religious, R2</td>
</tr>
<tr>
<td>Odell</td>
<td>Anthropology</td>
<td>Male</td>
<td>Public Tech R2</td>
</tr>
<tr>
<td>Pryor</td>
<td>Linguistics</td>
<td>Female</td>
<td>Public R1</td>
</tr>
<tr>
<td>Randall</td>
<td>Psychology</td>
<td>Male</td>
<td>Private religious Bac.</td>
</tr>
<tr>
<td>Shepard</td>
<td>Chemical Eng</td>
<td>Male</td>
<td>Public R2</td>
</tr>
<tr>
<td>Simms</td>
<td>Electrical Eng</td>
<td>Male, Intl</td>
<td>Private R2 / Public R1</td>
</tr>
<tr>
<td>Sumner</td>
<td>Education / English</td>
<td>Male</td>
<td>Public Tech R2</td>
</tr>
<tr>
<td>Tyler</td>
<td>Civil Eng</td>
<td>Male</td>
<td>Private Master’s</td>
</tr>
<tr>
<td>Walton</td>
<td>Ethics, Genetics</td>
<td>Male</td>
<td>Private Religious Doctoral</td>
</tr>
</tbody>
</table>
Results and Discussion

Teaching About Social Justice and/or Poverty

Among the 37 ESI instructors interviewed, two were passionate proponents of integrating SJ issues into engineering education and advocated an across-the-curriculum approach. Integrating SJ across the curriculum is perhaps the best approach to impact student’s knowledge, attitudes, and critical thinking [30-32]. Kinsley stated, “the more opportunities that you have to remind students of why it's important and why you're doing it, the better.” Kinsley also advocated for instructors to try SJ integration within a particular course a few times, iterating each time to find what works and doesn’t work best for specific settings (which will be unique for each program). The other strong SJ advocate, Sumner, was involved with a program integrating SJ into a number of courses. He noted:

Why social justice? You know, why not talk about ethics or broader social implications? The reason that we've moved to a social justice framework is because it provides engineering students with very clear guidelines and also tools for looking at engineering problem solving and problem defining. And specifically it gives them a focus on social-structural conditions and what's the root cause of inequality. That does not come through in any other course.

An additional 13 of the interviewees discussed SJ more briefly. As themes within SJ, 10 explicitly discussed issues related to power and 6 discussed privilege.

Among the survey respondents who taught courses that included any ESI topics, 27% (n=338) included SJ and/or poverty (SJP). This is similar to the 26% of papers published by the Engineering Ethics division at the ASEE Annual Conference that included the term social justice between 2015 to 2020 (n=45 among 171 [24]). The individuals who taught SJP in their courses represented 174 U.S. institutions and 42 international universities (47% of the institutions represented in the full data set). Among 155 individuals who taught SJP in their courses and responded to the co-curricular survey, 90 (58%) also taught SJP in one or more co-curricular activities that they advised. In addition, 145 individuals who did not teach SJP in one of their courses taught SJP in a co-curricular setting. This implies that a number of individuals feel that SJP topics are applicable in some but not all of the settings where they teach (i.e. co-curricular settings but not their courses). Based on the ESI topics that were taught, the respondents were grouped into SJP educators (those who taught SJP in any setting) and nonSJP educators (those who taught ESI topics, but did not include SJP among those topics).

Perceptions that Students’ ESI Education is Insufficient

The majority of faculty who taught ESI topics felt that engineering students’ ESI education was insufficient. A larger percentage of SJP educators characterized the students’ education about ESI in their undergraduate and graduate programs as insufficient, in comparison to nonSJP educators (Table 2). Even fewer of the instructors who taught both social justice and poverty issues in their courses (n=110) felt that ESI education was sufficient, with 65% indicating that it was not enough.
Table 2. Opinions on whether engineering/computing students in their program receive sufficient education on the societal impacts of technology and ethical issues¹

<table>
<thead>
<tr>
<th>Response</th>
<th>Undergraduate students</th>
<th>Graduate students</th>
<th>Chi test p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes, but too much; time could be better spent on other topics</td>
<td>0.5% SJP educators (n=429)</td>
<td>1.3% nonSJP educators (n=677)</td>
<td>0.3% SJP educators (n=335)</td>
</tr>
<tr>
<td>Yes, a sufficient amount</td>
<td>24.2% SJP educators (n=429)</td>
<td>32.8% nonSJP educators (n=677)</td>
<td>13.4% SJP educators (n=335)</td>
</tr>
<tr>
<td>A sufficient amount of ethics, but insufficient on the broader impacts of technology</td>
<td>16.8% SJP educators (n=429)</td>
<td>17.3% nonSJP educators (n=677)</td>
<td>7.2% SJP educators (n=335)</td>
</tr>
<tr>
<td>A sufficient amount on the broader impacts of technology, but not enough ethics</td>
<td>12.8% SJP educators (n=429)</td>
<td>13.3% nonSJP educators (n=677)</td>
<td>11.3% SJP educators (n=335)</td>
</tr>
<tr>
<td>No, not enough</td>
<td>45.7% SJP educators (n=429)</td>
<td>35.3% nonSJP educators (n=677)</td>
<td>67.8% SJP educators (n=335)</td>
</tr>
</tbody>
</table>

¹Excludes individuals who indicated ‘unsure, not enough information to judge’ (undergraduates) or ‘Not applicable / unsure’ (graduate students; some programs do not offer graduate degrees)

It is unclear whether faculty believed that students’ ESI education was insufficient due to a lack of breadth (type of ESI topics, such as SJP) and/or lack of depth in cognitive and/or affective domains (such as reaching analysis or higher level of Bloom’s taxonomy). It is unlikely that there is broad consensus on what a sufficient level of ESI education for engineering students would entail.

Some of the survey-takers and faculty who were interviewed advocated for greater integration of SJP into engineering education. For example, a write-in comment on the survey stated “I think most of our students get a reasonable exposure to ethics related to professional code of conduct, engineering design, and disasters. I would like to see more exploration of ethics at the intersection of humanitarian engineering and social justice, and the conflicting tensions that arise from trying to do good and solve problems using technology.”

Constraints to integrating ESI broadly and SJP more specifically into courses and curricula were noted, for example one survey respondent stated: “Engineering programs are too tightly scheduled to permit much introduction of this material; it is a struggle to do this even at a university with a values/ethics/social justice mission, elsewhere it is nearly impossible to get support for adding anything other than the bare minimum required by ABET. Realistically, to get this to be effective, the culture of engineering would have to be motivated to make room and provide resources for an effective and well-integrated ethics curriculum for engineers.”

**SJP Complementary to Other ESI Topics**

The SJP educators, on average, appeared to have a richer perception of the breadth of ESI topics that should be taught, based on their own teaching practices reported on the survey (among 18 ESI topics and ‘other’). SJP educators (n=483) taught on average 8.1 ESI topics compared to 5.3 topics among nonSJP educators (n= 786) (statistically significant difference based on independent samples Mann-Whitney U test, asymptotic 2-sided test sig. <.001). The most common other ESI topics listed as options on the survey that were taught in courses by those teaching SJP were: societal impacts of engineering and technology (88%), sustainability (72%), professional practice issues (72%), ethical failures and disasters (61%), and engineering decisions under uncertainty (61%). Sustainability seemed particularly congruent with SJ.
survey respondent noted, “I teach… a full course in sustainable product design where I cover ethical issues, economic issues and other matters related to health, safety and social justice. I find that a class in sustainability is an excellent place to provide such education.” An average of 10 ESI topics were taught in their courses by the 37 faculty who were interviewed, indicating rich ESI education by these potential exemplars. For example, Harper described a technical elective course on sustainable energy where teams of 4 to 5 students created videos that integrated sustainability, social justice, environmental justice, and economic issues surrounding different forms of energy (e.g. solar, wind, fossil fuels).

Course Types, Teaching and Assessment Methods

SJP issues could be integrated into any course type, although the survey data cannot be used to directly measure this. The survey asked respondents to indicate the types of courses (from among 9 choice options and other) where they taught ESI topics, but this was not a mapping of specific ESI topics to specific course types. (Results are summarized in the Appendix.) As survey respondents described particular courses where they integrated ESI, the teaching and assessment methods used in those courses were identified, among 15 and 8 options plus other, respectively. Again, specific ESI topics were not linked to specific teaching and assessment methods. Table 3 shows the teaching and assessment methods that were more commonly used by SJP instructors than non-SJP instructors.

Table 3. Use of different ESI teaching and assessment methods by SJP instructors and compared to non-SJP instructors

<table>
<thead>
<tr>
<th>ESI Teaching Method</th>
<th>Difference in % among SJP instructors minus % among non-SJP instructors</th>
<th>SJP instructors, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reflection</td>
<td>25</td>
<td>43</td>
</tr>
<tr>
<td>In-class discussion</td>
<td>23</td>
<td>85</td>
</tr>
<tr>
<td>In-class debates / role plays</td>
<td>23</td>
<td>39</td>
</tr>
<tr>
<td>Humanist readings</td>
<td>23</td>
<td>26</td>
</tr>
<tr>
<td>Videos, movie clips</td>
<td>20</td>
<td>42</td>
</tr>
<tr>
<td>Guest lectures</td>
<td>18</td>
<td>43</td>
</tr>
<tr>
<td>Service-learning</td>
<td>17</td>
<td>26</td>
</tr>
<tr>
<td>Case studies</td>
<td>15</td>
<td>78</td>
</tr>
<tr>
<td>Think-pair-share</td>
<td>13</td>
<td>23</td>
</tr>
<tr>
<td>Project based learning</td>
<td>11</td>
<td>46</td>
</tr>
<tr>
<td>Moral exemplars</td>
<td>10</td>
<td>16</td>
</tr>
<tr>
<td>Problem solving heuristics</td>
<td>9</td>
<td>20</td>
</tr>
<tr>
<td>Lectures</td>
<td>4</td>
<td>68</td>
</tr>
<tr>
<td>Examples of professional scenarios</td>
<td>4</td>
<td>63</td>
</tr>
<tr>
<td>Engineering design</td>
<td>-1</td>
<td>41</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ESI Assessment Method</th>
<th>Difference in % among SJP instructors minus % among non-SJP instructors</th>
<th>SJP instructors, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual reflective essays</td>
<td>24</td>
<td>57</td>
</tr>
<tr>
<td>Individual homework assignment or papers graded with a rubric</td>
<td>14</td>
<td>51</td>
</tr>
<tr>
<td>Other</td>
<td>12</td>
<td>21</td>
</tr>
<tr>
<td>Group-based assignment</td>
<td>9</td>
<td>39</td>
</tr>
<tr>
<td>Test and/or quiz questions</td>
<td>2</td>
<td>38</td>
</tr>
<tr>
<td>Individual homework where questions have fairly straight forward right and wrong answers</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>Do not assess</td>
<td>-8</td>
<td>8</td>
</tr>
</tbody>
</table>

Chi square test SJP vs non SJP: **p<.001, * p<.05
Faculty teaching SJP used a larger number of different teaching methods to teach students about ESI in the course where they believed they were the most effective in ESI education compared to non-SJP instructors (average 6.7 vs. 4.6; Mann-Whitney U test $p < .001$). The teaching methods with the greatest differential use by SJP educators over non-SJP educators were: reflection, in-class discussion, in-class debates/role plays, and humanist readings. SJP educators also used a wider array of methods to assess ESI student learning in their courses (2.4 vs. 1.9 non-SJP; Mann-Whitney $U$ test $p < .001$). The interviews provided examples specific to SJ topics.

**Faculty Perspectives on their SJ Instruction**

The following sections provide examples of faculty descriptions of how they integrated SJ topics into the courses they taught and/or co-curricular activities that they advised. During the interviews the faculty were asked to describe a setting where they believed their ESI instruction was the most effective. Thus, the results below are organized in the different settings that the faculty described.

**Examples in design courses**

Design courses offer a good opportunity to integrate SJP considerations. Sumner described:

Several years ago a lot of students in one of our classes were asking us, ‘well okay, we have these social justice issues, but what's the point? Like what's the end result’? And our definition of social justice positions enhancing human capacities as the end results, the desired aspirations. There's a series of 10 of those capacities that we've shared with students. And once they look at them they say ‘oh wow, I can sort of check through these at the end of my design and also during the process to see if I'm enhancing these particular human capabilities.’ Yeah, it's interesting because at the beginning of our engineering and social justice class, we do have some pushback. Like people think we are trying to push some political agenda. But by about mid-semester people realize, ‘oh these social justice dimensions are inherent in the design of this technology. It's not superimposed. They are already there.’ And then, all of a sudden, it shifts their awareness because they recognize how important it is to acknowledge those and then deal with them in a way that’s effective.

Sumner also described a design course focused on,

...it introduces students to the concept that you need to position user’s perspective prominently in the design process especially when you're defining the problem, listening to different stakeholders, and trying to get a better sense of what the user's needs are. That's a class that develops empathy skills and helps people define problems with but not for other people.

Capstone design was the second most common course type taught by those integrating SJP topics into their courses, and 25% of those integrating ESI into capstone design taught SJP (120 of 487). Among those interviewed, 16 indicated that they integrated ESI into capstone design, including 9 who taught SJP. However, only one of the three of interviews that discussed capstone design described SJP issues in the course. The instructor of a civil/environmental engineering capstone design course, Jardine, described the social justice and environmental justice questions that have been examined within some of the projects in her capstone design course. This included:
Personally, I always try to make sure that when my students leave they understand that they're doing engineering in a social context. So ramifications to society - and some of those are ethical and some of those are social justice and some of those are understanding regulatory issues and that kind of thing - always come up in my classes, not necessarily explicitly. [For example, we] talk about the ethics of placing the landfill near the low-income neighborhood…

She went on to further discuss the environmental justice issues related to selecting locations for other undesirable infrastructure such as wastewater treatment plants and incinerators: “The community [we] are working for will say, we have these four properties available. And inevitably one of those properties will be near a low income place. But the properties near high-income places are never available because the land costs more. But what that means is that people who are dealing with low income have their property values go down even more.”

Jardine also described how sustainability and specific projects foreground social justice issues:

I also teach sustainability as a concept. And sustainability is three pillars of environmental considerations, economic considerations, and social considerations. And so, we were looking at a project on the civil side where… we were going to be basically moving a homeless encampment - it’s a known homeless area - and the project was going to be developing it and displacing people from what is essentially their home. And so looking at it from a sustainability standpoint, what are the social implications of this particular project… There’s two ways to look at it. One is the community probably isn’t thrilled to have a homeless camp in there, but the homeless people still need somewhere to go. So it’s kind of a really interesting social justice quandary….

These authentic dilemmas intrinsic to these projects are unpacked and explored with students. The instruction is likely to be more impactful because it is genuine, rather than feeling like ethics or SJ issues have been ‘bolted on’ to the course, in the words of another interviewee. Design courses in other disciplines can embed universal design principles, human centered design, and other frameworks to examine relevant SJP issues [33].

**Examples in core engineering science / engineering courses**

Due to the predominance of engineering science and engineering technical courses (EES) in typical curricula, SJP integration in these courses may be the most impactful [34], by providing a counter narrative to the more traditional social : technical dualism. Among the survey respondents, 497 indicated that they integrated ESI into EES courses, and among those 113 (23%) taught SJP (although not necessarily in their EES course). Fifteen of the 37 interviewees indicated on the survey that they integrated ESI into EES courses, including 8 who taught SJP.

Sumner described a fluid mechanics course that integrated the real world context of a natural gas or oil pipeline, and expanded this discussion into the impacts on indigenous lands and the rights of communities. The Dakota access pipeline was a real-world setting where:

… you can see it's not just about fluid dynamics. You have to pay attention to broader social issues. And you have to thoroughly engage stakeholders, especially indigenous groups who don't tend to trust nonindigenous groups - American history. And then you've got an example that you worked in just kind of slyly - you're still talking about fluid dynamics, but you're showing students that fluid dynamics does not happen in a vacuum. It happens in a real social context and does have really important broader social implications.
This same instructor also indicated that wind power and prosthetics were integrated as real-world applications into a circuits course. But the specific SJP issues related to those situations were not described.

Kinsley discussed the integration of SJP into a thermodynamics course.
  For the first 10 years I taught that class I would integrate climate change and there was an ethics case study about global climate agreements and how the Global North and the Global South are in a tension about who's responsible for the state of the planet and who's responsible for making carbon reductions. How does that balance work out and who's going to feel the impacts of climate change first and how is that going to affect global security? How is it going to affect people's ability to eat? You know, just get water and [other] basic human needs.

But Kinsley then described pushback from students:
  And the first 10 years students totally got it, they were like, ‘yeah, of course this is in thermo.’ I had no resistance at all. And then one year I started [using] this book… called *Storms of my Grandchildren*[^135]… And they just said this has no place in a thermodynamics class, they totally didn't get it… So they often will say "well you're taking away time I should be using to learn whatever x content of the class is thermodynamics of engine cycles” and… if you're taking time away from that they get upset. And so the more that you can help them see that this is part of engineering [the better].

The example illustrates that small differences in how SJ-related issues are taught can result in big differences in how that integration is perceived by students.

Harper discussed his interest in integrating SJ issues into EES courses, but he had started with his technical elective course due to its more flexible learning objectives.
  I've always been fascinated about the lack of, I don't want to say ethics in general, but social justice issues and environmental issues within engineering and so wholeheartedly intending to incorporate these issues into core classes like fluid dynamics, for example, is of interest to me. And having these technical elective courses like Sustainable Energy, for example, I feel is a good test bed to do that because, you know, it's flexible. The learning objectives are flexible.

Harper had developed a 1-day activity in that technical elective course that was being piloted in fluid mechanics to debate the sustainability issues around hydraulic fracturing. This topic was of current and local interest, being a large part of the economy in the state. While currently more centered on social and environmental impacts broadly, Harper had aspirations to continue modifying the activity to draw in more social justice themes.

As another example, a materials science course taught by Meagle offered an extra credit opportunity for outreach into local schools. The students’ written reflection on the activity required students to consider elements of poverty and privilege, as a form of critical reflection.

**Examples in professional issues courses**
In a senior-level professional issues course, Tyler described teaching about ethics, and although he did not explicitly use the term social justice, his example is related.
  [Colin] Powell… he writes these, I think it's about 18 little principles he has about life. …there are leadership ideas but they're laced with ethical ideas as well. …I do talk about
him, and I get real emotion when I think about this, he dealt with Jim Crow racism as a young officer and here he is putting his life on the line for us and he's dealing with Jim Crow racism. Yet he persevered, not just he alone, but he's a historical figure that it's easy to see, that he's written about it, he's written a book about it. I think those stories, that's just an example of this, I think those stories are important, and I think those provide the teachable moments.

Tyler further described his pedagogy in the course related to ESI education:

I make them do a journal. [The students] open up…. They'll do something that will cause me to stop and think "wow the light bulb's going on." And ten years ago, I never would have believed in the value of a journal, somebody led me to it. And I’m glad because I think it's one of the best things they do. They talk about an NSPE case and how they feel, "well I don't necessarily agree with the approved solution for this one, here's what I really think." And in the privacy of the journal they can write about it and think about it and that's powerful. … It's powerful, it's a great way, it's the right way to do it.

This personal reflection through a journal is well suited to exploring SJ issues.

Kay’s goals for a required 1-credit, senior-level course focused on professional practice issues at a religiously-affiliated institution were to help students prepare for their experience as early career engineers and the “sticky, messy social problems that they will face.” He believed that the students had previous courses that had prepared them for “ethics in a very general sense” and in his course aimed to channel their ethical reasoning toward their engineering careers and professional identities. Kay designed the course so that each student would “have a very active role as a learner.” In an early exercise, students wrote on sticky notes ethical dilemmas that they anticipated encountering in the workforce, and then modules in the course were designed to address these issues. He gave an example that some students were concerned with “contrasting race and gender hiring practices against merit”. Kay discussed helping students recognize their personal privilege and acknowledge positions of power. This involved the somewhat unique activity of having the students take the Implicit Association Test (IAT) [36]. He reported that asking the students to take the IAT was a “delicate thing” because he “wanted them to feel safe taking the test… [it] exposes your biases and your prejudices.” After trusting that the students had completed the test (but not asking them to share their individual results), in-class there was a discussion about racism and gender issues. He noted,

There are questions around social attitudes that I wanted to problematize …we always take race and gender into account. When it’s white males we don’t think of it as taking race and gender into account, but we are registering in our mind that they are white and male… that effects our impression of that person. I didn’t take on the whole problem of systemic racism and systemic sexism. I wanted to, but that would have been the whole rest of the semester…. So I really just focused on implicit bias, like that you can be implicitly biased without being aware of your own bias… There was a very lively discussion. They questioned the test itself. …but I said, regardless of the science of how you fit in with the theoretical models of social attitudes, the biggest thing is how did you understand your own results? Pay attention to if you're feeling defensive towards them. Pay attention to why you might be feeling defensive toward that.

Another common model in Kay’s course was to have students complete a reading and then write a personal reflection identifying the most important sentence to them. This was followed by
small group discussions in-class. He also discussed using ethics cases, but rather than having students answer the traditional “what should Jane do” question which is generally rather obvious, he had the class “give reasons why the engineer would not do the ethical action.” Kay gave an example, “the case had to do with misrepresenting the cause of damage in a hurricane-afflicted poor area in an impoverished part of town. … to misrepresent that it was preexisting damage rather than the hurricane.” This example shows a way to bring SJ issues into a ‘typical’ ethical dilemma about honesty.

Courses focused on ethics
SJP was also integrated into courses that focused on ethics and the intersections between technology and society (modeled on science, technology, and society (STS) studies). A number of these courses were required for engineering/computing students, and some were taught by faculty with a background in social sciences and others by engineering faculty. An instructor of one of these courses, Pryor, explained, “I believe in teaching ethics from a situation perspective. Ethics is always situated. It's situated in a particular context. And the opportunity there is to have them begin to think about the potential upside or downside, positive or negative impacts of ideas and designs they might be thinking about at that time. … it's important for students to identify areas of potential conflicts, contesting where people from a social justice perspective could be hurt….” She provides two examples which she has used in her class.

So let's say you're looking at urban infrastructure as a potential way to think about how can we make cities more livable, for example, for whole populations. And then you get into a very specific community in which you're trying to work and you run up against issues you hadn't necessarily thought about at all. And how do you navigate those issues? How are you developing the capacity to hear such that you can hear different sides of the stories and figure out for yourself how you might act in that particular situation?

As a second example:

Let's say you're trying to develop a strategy for measuring concussion on the side of a football field. What are the ethical implications of that or social justice implications of that? You've got a football coach who wants to win and then you've got parents who have a kid who potentially has a concussion. Right there, you're facing a pretty significant potentially ethical [situation that involves] social justice, because you've got one population who's out there playing on the field and then you have power. And I mean, there's always going to be a power differential in every single situation you get.

Sumner noted that his course “gives them a focus on social structural conditions and what's the root cause of inequality. That does not come through in any other point in their education. Our definition of social justice positions enhancing human capacities as the end result, the desired aspirations.” Randall used role play and case studies to teach SJ issues in a required, junior level Computing Ethics course. He described the first instance of hate speech that was done over a computer where a Hispanic student sent threatening e-mails to Asian students by exploiting the Unix ‘finger’ command.

What that old Unix command does is it tells you if somebody is online, where they are, gives you their user name, which by some sort of general agreement is often the last name. But that allows you to target ethnicity, which makes them realize that you might make a design decision that makes perfect sense until you recognize that it codes for something else. Somebody can take advantage of it.
Walton taught a course focused on climate change and ethics, with social justice directly in the course name. He capitalized on his personal experience in the Marshall Islands. Bringing personal experiences and stories into our courses is a genuine way to integrate SJ into what we teach. Odell’s course followed an STS (science, technology, and society) tradition, focusing on a “range of qualitative values, including privacy, sustainability, health and social justice. We hope this will prepare students for their future careers.” A number of different instructors had developed and contributed to the course over the years, and it was still evolving; “We will continue to try new approaches and develop the course in response to student feedback.”

Kinsley went through a number of iterations of an engineering ethics course. This included a semester where it was a small, discussion-based course that allowed students to “take a lot of the lead” and the instructor explicitly “tried to empower students in the class.” The course was framed around the idea of “how can I make my life better. How can I improve the lives of others. What positive proactive steps can I take that would make things better in the world. And so it had kind of the opposite of the kind of like ‘oops, somebody did something bad let's analyze why’ to what constructive thing can I do.” The students identified a real world ethics situation that connected to engineering or technology and then they would write a two-page ‘Action Essay’ discussing concrete actions they could take. One semester some of the modules in the course originated from a documentary called Fast, Cheap & Out of Control [37]. Variously, the course also included philosophical groundings, colonialism, and masculinity.

**SJP in service-learning courses**

Courses that embed service-learning or community engagement projects may be an ideal setting for educating students to consider social justice in their work as engineers. Holt described a two-semester interdisciplinary service-learning course focused on international development issues centered on water. Via a long-term partnership with an in-country NGO, the students work in partnership with the NGO and local community; after the course the community itself builds the project. She described:

We're teaching both the engineering notions of doing rigorous engineering and also we're teaching students how to think as global citizens. So we really spend the first semester of the year learning how to think before we even allow our students to begin working on design. And we don't distinguish technical from non-technical in the classroom any more than we distinguish freshman from PhD students. Our process begins with self-exploration, which for the engineers can be immensely frustrating. They're like "what do you mean, we have to ask what our own motives are?" What I really like about this course, though, is it's kind of transformational because for a lot of our students it's the first time they confront the fact that engineering has a human component. …we'll start with some storytelling where I and [ ] alumni of the course who act as mentors that come back and share their experiences. …we talk about the times that we were there and we witnessed a man beating his wife or we talked about the time that we were working with the community and one member of the community came crying to us because her child was hungry and she was out of water while the neighbor was pulling their water, things like that.

In addition to the importance of the preparatory semester, she also indicated that living in the community was a powerful experience for students, who “suddenly realize… that we're judging these sort of things from our own notions…. “ So while SJP issues are not stated learning objectives for the course, they were integral to the community engagement process.
Kinsley described a Science and Ethics course that had a community engagement component, encompassing citizen science and community based research:

What I think was effective about that was the depth of encounter that the students had with community members; in thinking about how engineering plays out in real communities and affects real people's lives. …So that was one of the deepest experiences that the students had because it was an ethical question they had to think through. How do I know what the right thing to do is here? If I want to help this community, how do I decide what's true and what they can do as citizens to gather data? So there are some really hard questions that they kind of wrestled with through the whole semester. They had a lot of different folks in the community come in and talk to them about it. And you know the folks in the community are well educated people. One of them was a medical doctor… they dealt very directly with this ethical question of community based research, what's my obligation to the community and how do I navigate my own questions about the science as I try to serve this group of people.

Citizen science contradicts the traditional structure where power is held by formally trained and credentialed scientists. The instructor acknowledged the somewhat random nature of particular community-based projects and that as an instructor you aren’t completely in control of the situation. Instructors need to be adaptable to capitalize on teachable moments that will vary each semester due to the uniqueness of each community interaction.

Simms discussed the variety of ethical and SJ issues embedded in the community engagement courses that were part of a program focused primarily on international development. One course within the four-course certificate program was about half focused on ethical issues. Within the course they analyzed a series of case studies that they had developed based on real situations they had encountered in the over ten year history of the program. These cases contributed to exploring ideas such as grassroots diplomacy, equity, and reciprocity. Each case included both a description of a situation and supporting materials such as the Belmont Report, and then students applied a conceptual framework process for analysis. Students would review the case study materials, have a class wide discussion for 15 to 30 minutes, and then break into teams of 6-7 students “who would review their approach to the case, learn from others, and then try to reach consensus on their solution.” Simms indicated that early in the semester students were somewhat resistant to fully engaging in the discussions, but over time:

the cases were so real and some of the stuff they had to review for the cases were poignant issues on which you would always have an opinions about… [For example], one class we talked about reverse racism…. [Based on their community engagement experiences] they were emotionally invested in this set of issues. … They were really arguing from many different perspectives… they started realizing that some of these are very messy issues…

Simms also noted that the interdisciplinary nature of the students in the course was significant, including students from diverse training ranging from computer science to women’s studies. One imagines that the fact that Simms personally experienced the issues in the case studies gave him the ability to effectively facilitate a nuanced discussion of these challenging issues. In addition, the students who self-selected to participate in the program were motivated to understand these issues that reflect genuine situations they might encounter. Thus “exporting” these case studies into other courses taught by different instructors might not be as impactful.
As a counter-point, Pryor discussed concerns about some service-learning / community engagement courses.

There are other courses on campus, I've not taught them, that have people interacting with the homeless community and those kinds of things. I think there have been issues where kids have gone off campus and tried to work with communities and they've been arrogant. And I think they've been patronizing. And so we're trying to teach [and] develop courses that prepare students to be much more empathetic when they go into these off campus environments and are trying to share their technological skills, because I think there've been some missteps. I'm not personally close to any of those missteps, but I've heard rumblings about it.

In service-learning courses there are real world benefits and harms that can result from students actions, rather than providing a ‘safe place to fail’. Individuals currently the most disadvantaged in society should not be viewed as ‘training grounds’ for students, and therefore it is ethically important that community benefits outweigh considerations for student learning in these service-learning partnerships.

**SJP in co-curricular activities**

Among the survey respondents who described co-curricular activities that they advised, 30% included SJP. Among the advisors of engineering service groups, 88% included SJP. In the interviews with an Engineers Without Borders (EWB) advisor and an Engineering World Health (EWH) advisor, neither discussed SJ issues or poverty directly, despite checking SJP among the ESI topics covered in these groups on the survey. A write-in response on the survey stated, “I think the students that are pre-disposed to topics of social justice self-select to enter into extra-curricular activities like EWB. I think this is an asset to EWB and typically the students in the chapter are incredibly motivated and broad thinking.”

An advisor of a co-curricular service group focused on the local community at a religiously-affiliated institution, Meagle, discussed SJ issues.

… students collect bikes in the community. They work to repair these bikes throughout the year. And so we've done a lot of different reflection pieces on that. About things related to privilege and even some ethical considerations of… kind of that paternal sense of handing something out to children on a single day. …And it tends to attract mostly… white males…. we’re fostering this sense of service within our students. They think that they're doing this really great thing by handing out these bikes, but they don't understand necessarily some of the messages that that’s sending. … and having some conversations about some of the schools that we’re working with. And some of the dilemmas that we’re facing; how do we choose the children that get the bikes? … Just thinking a little bit more deeply about that …. how to use engineering [to] empower people as opposed to being a handout…

The description indicates that in many ways the dialogic reflection via the facilitated group discussion is where real learning can occur. The students may have joined for the hands-on nature of bike repair, but giving the activity context is an opportunity to have a conversation about SJ issues with those students.

Based on the survey results, 42% of the advisors of engineering professional societies for minoritized groups (e.g. NSBE, SHPE, SWE; n=121) indicated that SJP issues were included. An advisor for a Society of Women Engineers (SWE) chapter, Adair, talked about the
importance of supporting female college students, particularly in majors like electrical engineering where there might only be a single female student per class. She discussed the outreach activities that SWE engaged in to “make[e] the sciences accessible to people of all different backgrounds, in particular because the outreach work that we’re doing is targeted at the five area public schools that have the highest instances of free and reduced lunch. So in that regard, just the social justice aspect of it has come up a lot within the SWE group.” These groups may provide comfortable places for students from historically marginalized groups in engineering to discuss SJ issues and prepare to address them and/or face them in their work.

A lower percentage of the advisors of other types of co-curricular activities and disciplinary professional societies noted SJP integration; among 444 advisors of disciplinary professional societies (e.g. ASCE, ASME), only 6% integrated SJ and 10% poverty issues. However, some write-in comments discussed this such as: “As part of the [university] STEM Ambassadors program, science and engineering students undergo training in the fall semester related to community engagement, social justice, and communicating STEM to public audiences.” Overall, among the 235 individuals who identified SJP integration into co-curricular activities that they advised, 62% did not also integrate SJP into their courses. It is interesting that these individuals feel that SJP topics are appropriate for co-curricular settings but not integration into their courses. This brings to mind technical : social dualism, whereby SJ and ethics are sometimes viewed as distinct from the technical core of engineering [38].

Analysis

The teaching methods used for SJP issues were not dissimilar to those applied for ESI more broadly, such as recurring descriptions of reflection, discussion, and case studies. However, the readings and situations being reflected upon and the prompts to trigger reflection were targeted to draw attention to SJ issues. The personal convictions and life experiences of the faculty were important to facilitating and orchestrating student learning and ethical development. And in the majority of cases, their teaching practices in particular courses changed over time, as instructors continuously gauged the engagement of students and effectiveness for their learning. Bartell [40] described learning to teach for SJ as a “lifelong undertaking… requiring effort, perseverance, and reflection.” Although not readily apparent in the short quotes provided, most of the faculty discussed to some extent the broader curriculum and/or type of students at their institution (e.g. Christian worldview for Kay and Meagle, military-focused institution for Tyler). Thus, while a faculty member can glean ideas from this paper, they should not naively expect that a “plug and play” approach to these strategies will be effective, but rather expect to “adapt to the particular context of which they and their students are a part” [40].

Effectively engaging students in SJP issues requires moving beyond the cognitive domain to consider emotions and affect. The language instructors used in describing their practices teaching SJP issues included affective terms such as ‘emotionally invested’. Students may feel uncomfortable, and this discomfort and conflict may be a key part of the learning process [20,39]. However, this emotional discomfort may be unfamiliar for engineering students who are trained in other courses to expect that there is one right answer. Students may experience anxiety about their grades, discussed by Kinsley, which is likely detrimental to fully engaging in the learning process.
More broadly, the interviews indicated that there are “multiple understandings of teaching for social justice” and “what social justice teaching actually means is struggled over” among engineering educators, echoing the findings of SJ instruction in K12 settings [40, 41]. Faculty already engaged in integrating ESI into their teaching can likely use similar methods and make small adjustments to draw students’ attention to SJ issues.

**Limitations**

The results should not be interpreted to represent all engineering faculty. Given the survey invitation approaches and data cleaning, the survey results represent individuals engaged in teaching ethics and/or societal impacts. A large percentage of engineering faculty may not teach ESI in any form. Further, leverage salience theory [42] cautions that those who elect to respond to a survey may be more interested in the topic in comparison to non-respondents. In addition, the survey respondents are predominated by educators in the U.S. and other Anglo countries (e.g. Canada, Australia), with a small number of other countries represented. Richer data specific to SJ issues integrated into engineering education could have been acquired from more explicit design of the survey instrument, allowing SJP topics to be mapped to specific courses, and specific teaching and assessment methods used for SJ to be identified, rather than the broader ESI mapping to courses, pedagogy, and assessment.

The interviews were intentionally conducted with individuals who were believed to represent strong and diverse examples of ESI integration, not SJ instruction. Direct questions about SJ were not asked during the interviews.

The current study only provides information on teaching practices, but lacks a student perspective or alumni perspective that could shed light on the effectiveness of these educational practices. Do students in fact gain a greater appreciation for SJ issues and how they are relevant for engineers? Do students become more aware of their own biases, and begin a journey to be less biased? Do some students become motivated to work to change systems of structural bias, oppression and marginalization? Or in some cases did students feel alienated? [43]

**Implications**

The quantitative results indicated that many institutions may not expose their engineering students to ideas of social justice in their courses, at least not back in 2015 when the bulk of the data were collected. Even still, engineering students who graduate thinking about social justice issues may find these are not common ideas within the engineering profession. Given the timeframe when the majority of working engineers were educated, there is perhaps little discussion of SJ in the workplace. For example, from 2000-2009, only 0.4% of the ASEE Annual Conference papers (n=58) included social justice. Some engineers feel that engineering is value free [10], and should focus solely on merit and ability [44]. It is unclear how these different value systems may interact in the workplace.

The social unrest during summer 2020 provides a ‘teachable moment’ to integrate issues related to justice, diversity, equity, and inclusion into our teaching practices. Faculty can perhaps avoid
the term SJ if they find it too loaded, but still engage with the topic. Calling attention to SJ issues within real world situations will perhaps minimize student pushback that might result if they feel ‘preached to’.

The results provide ideas for faculty interested in integrating SJP topics into their teaching activities. Those aware of SJP issues in co-curricular activities that they advise can consider integrating these ideas into their courses. Collaboratively working with other faculty who have an interest in SJP integration may also be helpful, similar to the group lesson design practices described in [40]. Engineering students should be aware of social justice issues, and some level of integration across multiple courses and co-curricular activities would help educate students on this important macroethical issue.

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References


Appendix.

Course types with ESI integration taught by instructors who integrated SJP into their teaching compared to course types taught by those not teaching SJP

<table>
<thead>
<tr>
<th>Course type</th>
<th>SJP instructors, %</th>
<th>Non SJP ESI instructors, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>First-Year introductory*</td>
<td>38</td>
<td>28</td>
</tr>
<tr>
<td>First-Year design-focused*</td>
<td>19</td>
<td>11</td>
</tr>
<tr>
<td>Sophomore or junior level core engineering science or engineering</td>
<td>33</td>
<td>41</td>
</tr>
<tr>
<td>Design-focused course in the sophomore, junior, or senior year</td>
<td>30</td>
<td>32</td>
</tr>
<tr>
<td>Senior capstone design</td>
<td>36</td>
<td>39</td>
</tr>
<tr>
<td>Professional issues (any level, e.g. communications)</td>
<td>23</td>
<td>19</td>
</tr>
<tr>
<td>Full course on engineering ethics (any level)</td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td>Humanities and/or social science</td>
<td>17</td>
<td>5</td>
</tr>
<tr>
<td>Graduate-level (any type)*</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

*Despite interviewees discussing these course types, including some who reported integrating SJP on the survey, none of the interviews discussed SJP in these course types