Is Sociotechnical Thinking Important in Engineering Education?: Survey Perceptions of Male and Female Undergraduates

Abstract

Research on engineering practice accentuates interplays between the social and technical dimensions of complex engineering problems. Yet within engineering education, relatively little content focuses on such interplays. Content in the engineering curricula often ignores the broader impacts or sociocultural contexts in which engineering designs, products, and services are created and used.

As part of a larger study, our research examines whether (compared to males) female undergraduate engineering students indicate similar or different perceptions on the integration of sociotechnical thinking in engineering curricula. The integration of sociotechnical thinking in engineering curricula represents one of several pedagogical techniques that may engage female (and perhaps also male) engineering students as a result of correlation to perceived learning preferences and broader interests.

After reviewing relevant literature, this paper analyzes quantitative survey data on student perceptions of the importance of sociotechnical integration in engineering education. Baseline sociotechnical survey data were collected in spring and fall semesters of 2018 in two (spring) and three (fall) engineering classes at two public universities: the Colorado School of Mines and University of Colorado Boulder.

Results demonstrate a greater preference for certain forms of sociotechnical thinking in engineering among women. For example, female students assigned greater importance to 'Ethical' and 'Social' considerations and skills such as 'Listen to and integrate the perspectives of both engineers and non-engineers' and 'Work with people having a diverse set of backgrounds.' Also, compared to male students, a higher percentage of female students characterized social responsibility as 'Engineers' obligations to the public' and identified the reason why engineers have special societal obligations as due to the notion that 'Engineering decisions can impact individuals, communities, and the broader public positively and/or negatively.' These results are particularly salient when considered in light of recent research accentuating the importance of contextualized engineering problem-framing and solving processes within a broader sociotechnical context. Finally, we explore ways in which the results open up multiple directions for future research.

Introduction

Most U.S. engineering curricula continue to privilege the technical over the social dimensions of problems, and to deprive students of the opportunity to develop crucial problem framing skills via focusing largely (but not exclusively) on closed-ended, decontextualized problems [1]–[4]. This trend continues despite professional engineers accentuating the importance of understanding social contexts, of how to work with non-engineers, and of how to incorporate diverse perspectives into their work [5]–[9]. To bridge this gap, it has been suggested that engineering curricula could greatly benefit from sociotechnical integration in undergraduate engineering education to encourage the development of sociotechnical thinking and habits of mind [4]. Sociotechnical thinking is defined as, "…the interplay between relevant social and technical factors in the problem to be solved" [4]. Within the term sociotechnical, the first part, social, is used as an umbrella term that covers multiple broad social dimensions of engineering problem solving, including but not limited to economic, environmental, ethical, and health and safety-related dimensions. Since the meanings of these latter terms can sometimes involve both social and technical dimensions simultaneously (e.g., environmental, safety) the term sociotechnical is particularly appropriate.

This research paper first describes the importance of sociotechnical integration in the education and professional practice of engineers as well as how sociotechnical thinking relates to efforts to increase women's participation in engineering. Following this literature review, we describe our research methods and report the results of a sociotechnical survey, which measured student perceptions of sociotechnical integration in engineering curricula, with attention to any differences between male and female respondents. We conclude with broader implications and questions for future research.

Literature Review

This literature review consists of two sections. The first explores relevant literature on the potential role of sociotechnical thinking inside engineering curricula that research indicates are often misaligned with what practicing engineers do and need to know. The second section explores research on why percentages of female engineering students have remained steady despite multiple efforts designed to increase such percentages.

Sociotechnical Thinking in Engineering Education and Workplace Contexts

Growing evidence exists indicating that the technically-based engineering curriculum is misaligned with the work of professional engineers. Although an overview of engineering workplace studies acknowledges that too few of such studies exist [6], the extant studies have similar patterns. Overall, such research suggests professional engineering practice, while heterogeneous, involves interplays between the social and technical dimensions of complex problems. For instance, a longitudinal study that involved over 300 interviews with practicing engineers, survey data from nearly 400 engineers, and multiple years of participant observations of Australasian engineers found that, "…more experienced engineers…had mostly realized that the real intellectual challenges in engineering involve people and technical issues simultaneously. Most had found working with these challenges far more satisfying than remaining entirely in the technical domain of objects" [5]. Another study, an overview of mostly U.S. workplace studies, focused primarily on U.S. engineering practice, found, "Students often have vague images of professional engineering work, and the images they do have are strongly colored by the experiences in their educational careers…As a result, students often ignore, discount, or simply do not see images of engineering that emphasize its nontechnical, noncalculative sides," [6]. That may account for why, in the study of Australasian engineers, researchers uncovered serious student misconceptions about the actual work of practicing engineers:

> Most engineering students expect that solitary technical work will be a big part of their working life and hope that they will enjoy the challenge of working with difficult technical issues in the context of advanced technology. The results of our study, particularly the relatively small proportion of time devoted to solitary technical work, have helped to explain some of the frustrations I have so frequently encountered among engineers. Many felt frustrated because they did not think that their jobs provided them with enough technical challenges. Others felt frustrated because they thought that a different career choice might have led to a job that would enable them to make more use of the advanced technical subjects they had studied in their university courses. Many of them were actually planning to leave their career in engineering. [5]

In 2017, participants in a National Academy of Engineering (NAE) workshop noted that "…the opposition between [technical and nontechnical] concepts is socially constructed," as both are inherent in solving complex engineering problems [10].

However, this idea begs an important question: is the socially constructed nature of the technical and nontechnical being challenged or reinforced by most undergraduate engineering curricula? At a minimum, the previous evidence suggests a mismatch exists between what practicing engineers do and how they are educated. Specifically, as a whole, engineering curricula privileges the technical aspects of the profession, including complicated theory, equations, and closed-ended decontextualized problem-solving, but tends to exclude or marginalize the social, contextualized dimensions of open-ended problems [5]–[8]. Thus, engineering students may be ill prepared for the forms of sociotechnical thinking required in their future profession. Jonassen, after describing multiple differences between the kinds of problems typically solved by undergraduate engineering students and by practicing engineers, concluded that "Learning to solve classroom problems does not effectively prepare engineering graduates to solve workplace problems" [7]. Thus, opportunities exist to bridge the gap between the undergraduate educational experience and the realities of professional engineering practice. One such opportunity involves the integration of sociotechnical thinking.

Implicit calls for teaching sociotechnical thinking are especially important as the role of today's engineer evolves. For example, in 2005 the NAE articulated aspirations for the engineer of 2020, including a recognition that engineering does not exist within a vacuum, particularly due to the challenges posed by a rapidly growing and evolving world. These challenges are far-reaching, as the NAE writes: "…Both on a macroscale, where the world's natural resources will be stressed by population increases, and on a microscale, where engineers need to understand how to work in teams to be effective, consideration of social issues is important to engineering," [11]. As we conduct this research, we are cognizant that we are now educating the engineers of 2020 and beyond.

The engineer of 2020 and beyond needs to be prepared for the sociotechnical realties of the engineering profession for professional success on both a personal and global level. Many of the recommendations by the NAE focus on contextualizing the role of engineers in undergraduate engineering curricula: "Technical excellence is *the* essential attribute of engineering graduates, but those graduates should also possess team, communication, ethical reasoning, and societal and global contextual analysis skills," [11]. The above quote implies that technical excellence can be readily separated from excellence in team, communication, ethical reasoning and other skills. But complex problems come as wholes, and as engineering education and science and technology studies research has accentuated, often solving social dimensions of problems can shape the technical problem framing and solving process, and vice versa [3], [12]–[17].

However, a recognition of the importance of sociotechnical thinking is only the first hurdle in educating undergraduate engineering students. To create engineers who fully consider the sociotechnical aspects of complex problems, engineering students must develop sociotechnically-aligned habits of mind. Habits of mind are defined as, "Any recurring action or activity that, through repetition, instills professional problem-definition and solving routine practices," [4]. Downey's work has identified three sociotechnical habits of mind critical for the practice of engineering. These habits of mind are

(1) Evaluating strengths and limitations of different forms of knowledge,
(2) Collaborative work integrating diverse forms of knowledge and perspectives, and
(3) Knowledge and expertise plurality in the creation of robust engineering solutions [8].

As the growing body of research indicates, sociotechnical factors are critical to the practice of engineering, but often neglected in undergraduate curricula in favor of the teaching of traditional technical concepts [3], [5]–[8]. Therefore, effective integration of sociotechnical thinking presents exciting opportunities to engage students in an area that is important to their career but also to provide one venue by which students can understand *why* many technical concepts are important professional problem-solving tools; such integration may also break down inaccurate social constructions of engineering—especially ones that pit the technical against the social, rather than seeing them as complementary problem-framing and -solving components—and better prepare future engineers for an evolving and challenging professional landscape.

Sociotechnical Thinking and Women in Engineering Contexts

Only a few studies (mentioned below) connect sociotechnical thinking and women in engineering contexts. However, it is important to emphasize that this connection appears in a historical context in which efforts to increase women's participation and retention in engineering stem back to the 1970s [18]. Despite such efforts, data on women's presence in engineering education indicate little change in admission or attrition rates dating back to the mid-1990s; given data published in 2015, women represent roughly 19% of U.S. engineering undergraduates [19]. Attrition rates of aspiring engineers vary based on educational preparation and post-graduate career, but can be as high as 50% [20], [21]. Recent data indicate women constitute just under 15% of working engineers in the US [19].

Research on why women leave engineering does not point to a single factor, but many. However, one recurring theme in such literature is that workplace climate can be critical in whether women remain in or leave engineering [20], [21]. Such studies are often placed under a "chilly climate" umbrella, which can include multiple contributing factors:

> ….negative interpersonal relations, subtle and overt denigration of skills, attribution of attainment to affirmative action policies, avoidance of eye contact, favoritism toward male and majority students, sexual harassment, and, in the workplace, a dearth of opportunities to advance, failure to be recognized for contributions, and wage disparities [22].

Some studies reinforce the notion that the culture of engineering aligns and clashes with different sets of student or employee values. For instance, although White and Asian men rarely identify *chilly climate* as a reason for leaving engineering education or workplace contexts, women and other minorities frequently mention it [22], [23].

Faulkner's ethnographic study may contribute to our understanding of why chilly climates are—or are not—perceived; her study on a building engineering environment in the UK provides insight into the relationship between technical-social dualism and gender in engineering [24]. In some ways the opposite of sociotechnical thinking, technical-social dualism refers to a cognitive separation of the technical and the social dimensions of engineering problems that results in an augmented valuation of the technical and a devaluation of the social dimensions [16], [24]. Faulkner provides evidence that "technicist" elements of engineering align with stereotypically masculine traits, and that female engineers may experience more difficulty developing a sense of belonging in engineering fields that prioritize the technical over the social elements of engineering, even if they are individually more drawn to the technical. Building on a common professional progression from (technical) design engineering into management roles, she points out that "women who move away from the more narrowly technical aspects of engineering are likely to be in greater risk of losing their membership as 'real' engineers than are men who make the same move" [24]. She concludes that "engineering as a profession must find ways to foreground and celebrate heterogeneous understandings of engineering and heterogeneous engineering identities" [24].

However, additional factors contribute to women leaving engineering. In their landmark study of science, math, and engineering (SME) students, *Talking About Leaving*, Seymour and Hewitt dispelled beliefs about abilities as a primary cause (1997). They found that students leaving SME fields were not significantly different from those who remained in terms of commonly used predictors of academic success, such as SAT scores and grade point averages. Instead, other factors were predominant, including culture/climate issues, but also faculty teaching styles [25]. On this factor, other researchers have noted that "the kinds of changes advocated in *Talking About Leaving* in order to sustain motivation and increase the retention and persistence of minorities and women in STEM were eventually recognized as advantageous not just for those groups, but for *all* students pursuing STEM majors [26]" [22].

Research on ways to address the retention and persistence of women in engineering vary based on context (academic or workplace; see [22]). Within academia, one way to do so, and often in contrast to competitive classroom contexts, is to introduce *pedagogies of engagement* such as cooperative learning, problem-based and project-based learning, case-based learning, and service learning; such pedagogies can foster more productive learning environments (see [22]). Depending on how they are implemented, such pedagogies can directly or indirectly address both the chilly climate and faculty teaching style issues; by "warming" classroom climates, the campus climate can begin to shift [22].

Other ways to (in)directly address climate and faculty issues include providing challenging material while also structuring in support for learning, creating hands-on research experiences (preferably with positive faculty mentoring), and developing or improving first-year seminars, capstone projects, learning communities, internships in industry, and access to women-focused organizations such as the Society of Women Engineers [22]. It is noteworthy that this list of strategies does *not* include accentuating sociotechnical thinking in the curriculum. In fact, much of the engineering sciences curriculum is left unchallenged in the role it might play in perpetuating the misalignment noted above between how we educate engineers and what they actually do in engineering practice or in reinforcing technical-social dualism.

While these retention issues and potential solutions may connect to our research, currently there is insufficient literature on the direct connection between retention and sociotechnical thinking within engineering education to provide an answer at this time. For those initiatives inside the curriculum, we are interested in knowing whether male and female students are (dis)engaged in similar or different ways by the presence of sociotechnical thinking *inside* their engineering courses. Since only a handful of sources directly link gender issues in engineering with sociotechnical thinking, such as [24], [27], [28], our study stands to shed new light on whether those two constructs are connected, and if so, how. By answering that question, we hope to be able to shine additional light on pedagogies of engagement that could support women—and ideally all students—in engineering.

Methods

Our broad research questions for this study are, *What are male and female undergraduate engineering students' perspectives on the integration of sociotechnical thinking in engineering curricula*? *Are there differences between such students?* To address these questions, our research team developed a sociotechnical thinking survey to measure the perspective of students and examine perception changes following interventions, as explained in [4]. Aside from question 10, which we modified as described below, survey questions have been validated based on previous studies as described in [4] and [29]–[32]. To discover whether students interpreted the survey questions as they were intended, we used a cognitive validation process wherein volunteer students completed a think aloud protocol, as described in [4]. The questions asked on the survey aimed to satisfy the following goals [4]:

1. Quantify student self-reports on their perceptions of the importance of different forms of sociotechnical thinking.
2. Measure students' perspectives on engineering habits of mind and the role of sociotechnical considerations in engineering practice.

Sociotechnical survey data collection occurred in both the spring and fall semesters of 2018 in two engineering classes at two universities, the Colorado School of Mines (CSM) and the University of Colorado Boulder (CU). All appropriate Human Subjects procedures were followed. Survey data collection also occurred in fall 2018 in a third course, designated "ME

Intro," at CSM. The engineering courses examined included a first-year engineering projects course ("Projects," CU), the second-year mechanical engineering course "ME Intro," and a third-year introductory electromagnetics course ("Electromagnetics," CSM). Most, but not all students corresponded to the grade-level associated with each course. Additionally, the first-year engineering Projects course included some students from majors other than engineering (see Appendix A). Thus, the student sample ranges in age, discipline, and institution. Table 1 shows the number of students who identified as male or female for each course. Further breakdown of the students by major for each course is located in Appendix A.

Table 1: Survey Participants and Gender for Three Courses, Spring and Fall 2018

Course (University)	**Student Year**	**N***	**Gender**	
			# of Male Students (%)	**# of Female Students (%)**
Projects (CU)	1	345	219 (63%)	126 (37%)
ME Intro (CSM)	2	133	93 (70%)	40 (30%)
Electromagnetics (CSM)	3	44	35 (80%)	9 (20%)
Total		522	347 (66%)	175 (34%)

*# of students who indicated either Male or Female on survey question 18 (see Appendix B).

Survey data resulted in a total sample size of 543 students, and of those 21 students did not indicate male or female on the survey; thus, the total sample size analyzed for this study was 522 students. Of this total, 347 identified as male (66%) and 175 identified as female (34%). CSM, a small, public STEM-focused institution, reported the undergraduate population as 30.2 percent female and 69.8 percent male for 2018 [33]. CU, a large public university, reported its undergraduate engineering population as 28 percent female and 72 percent male [34]. Thus, both populations at CSM and CU are fairly consistent with each other and the survey data collected.

Data from 21 students were excluded from the analysis, including eleven students who did not indicate a gender selection. Also, the ten students who chose to self-describe their gender or identified as transgender, non-binary, or preferred not to respond were not included in the data analysis, in part because none of these three groups of students composed a sufficient sample size for data analysis. Analysis was not performed regarding changes in perspectives as a function of age of students or differences between data collected in the spring versus the fall due to limitations in sample size within the three courses themselves, and due to the particular focus on gender in this study.

Although the survey instrument will eventually be used to contrast pre- vs. post-course survey results in intervention and non-intervention sections, the current research examines only pre-course survey results. Surveys were administered during the first part of the semester.

Following examination of student responses to the sociotechnical thinking survey, only certain questions pointed towards potential delineations in responses based on gender. The full sociotechnical thinking survey is attached in Appendix B. Questions (Q) that showed gender-based differences and were thus most relevant to our research questions in this paper include Q1, Q2, Q4, Q9, and Q10. Additional quantitative and qualitative results from this survey that are not specific to gender differentiation appear in [35].

Q1, Q2, and Q4 were analyzed by scaling student responses. Most questions allowed for four different responses, which were assigned a value of 0, 1, 2, or 3 points, with higher point value correlated with increased importance (Q1 and Q2), or increased agreement with certain statements (Q4). Average scores could then be calculated for each gender and compared. Statistical significance was determined by performing an unpaired, two-tailed t-test and calculating p-values within a 95% confidence interval ($p \leq 0.05$). Q9 and Q10 did not provide opportunities for scaling, as student responses corresponded with a multiple-choice format. Therefore, the number of students who chose each response was calculated, and a percentage based on total respondents within each gender was determined. Statistical significance was again determined by performing an unpaired, two-tailed t-test and calculating p-values within a 95% confidence interval ($p \leq 0.05$) for each permitted response.

Data are reported below in two ways. First, the results of the unpaired, two-tailed t-tests are reported, with the calculated p-values for a 95% confidence interval ($p \leq 0.05$). Next, we report the results of the same tests with Bonferroni corrections. We justify this dual result reporting by examining the contradictory literature (for and against) using Bonferroni corrections.

Whether to use Bonferroni corrections is a matter of debate among statisticians. Some recommend using those corrections when running unpaired, two-tailed t-tests and other statistical measures that involve multiple comparisons [36], [37]. Proponents claim that not using the corrections increases the chance of making a Type I error, which occurs when a result indicates statistical significance when in fact it is not—that is, it is a false discovery [36]–[38]. However, other statisticians argue against using the Bonferroni corrections [39], [40]. They claim that the corrections are excessively conservative and go too far in trying to control for Type I errors. For instance, one study claims the correction potentially increases the likelihood of identifying results as false negatives, thus reducing statistical power [40].

Given this controversy, it appears a resolution is unlikely soon. Although it introduces more ambiguity and complexity, our approach is to report the data first without the corrections and then with them. Unlike reporting the data solely with or solely without corrections, providing both sets of results allows readers the most complete rendering of the data.

Results

Given our research questions, relevant results that showed statistically significant differences between male and female survey respondents are described in this section. As noted in the *Methods* section, such differences occurred on Q1, Q2, Q4, Q9, and Q10.

Results without Bonferroni Corrections

Survey Q1: "Think about your future role as an engineer. For each of the following, rate how important you believe each of these skills will be when you practice engineering as a professional by circling the level of importance that best matches your answer."

Permitted responses for Q1 and Q2 appear in Table 2 along with the scores for each response.

Table 2: Permitted responses for Q1 and Q2 and scores assigned.

Permitted Response	Not At All Important	Somewhat Important	Very Important	Extremely Important
Score	0	1	2	3

In Q1, students were asked to rate nine different skills – listed in Table 3 – in terms of importance to their future role as engineers. Average scores were determined for both male and female students, with a higher average indicating that students believed a particular skill would be more important as a professional engineer. Additionally, p-values were calculated for each skill, indicating whether the male and female averages differed to a significant degree. Results are reported in Table 3.

Table 3: Q1 Average Scores for Each Skill by Gender

Skill	**Gender**		**P-Value**
	Male	**Female**	
Solve technical problems within familiar contexts	2.266	2.182	0.493
Apply technical knowledge to novel contexts	2.176	2.091	0.453
Work with people who define problems differently	2.366	2.309	0.593
Listen to and integrate the perspectives of both engineers and non-engineers	2.294	2.600	0.00127*
Approach problems that are not clearly defined or with uncertain parameters	2.252	2.278	0.819
Identify project-relevant sociocultural issues	1.817	2.000	0.146
Follow the rules established by local, national, and institutional authorities	2.366	2.259	0.359
Work with people having a diverse set of backgrounds	2.049	2.537	0.0000541*
Acknowledge the strengths and limitations of different forms of knowledge for solving different kinds of problems	2.217	2.218	0.989

* Statistically significant at the $p \leq 0.05$ level.

Statistically significant differences between male and female students occurred on two of the nine skills:

‘Listen to and integrate the perspectives of both engineers and non-engineers’ and
‘Work with people having a diverse set of backgrounds.’

In both cases, compared to male students, female students predicted that these skills would be more important when they will be practicing as a professional engineer.

Survey Q2: "Think about your future role as an engineer. For each of the following, rate how important you believe each of these considerations will be when you practice engineering as a professional by circling the level of importance that best matches your answer."

Q2 asked students to rate the importance of seven different considerations in their future engineering careers. These seven considerations included: Economic, Environmental, Ethical, Health & Safety, Manufacturability, Technical, and Social. Thus, the considerations represented traditional engineering considerations and those (implicitly or explicitly) embodying the integration of sociotechnical thinking. The permitted responses and corresponding scaling of responses are again those in Table 2. Therefore, higher average scores indicated increased importance as assigned by students. Calculated p-values demonstrated whether appreciable statistical difference occurred between male and female responses, as seen in Table 4.

Table 4: Average Scores for Each Consideration by Student Gender

Consideration	**Gender**		**P-Value**
	Male	**Female**	
Economic	2.169	1.963	0.0721
Environmental	2.092	2.182	0.470
Ethical	2.127	2.364	0.0468*
Health & Safety	2.401	2.545	0.159
Manufacturability	2.120	2.055	0.552
Technical	2.282	2.204	0.446
Social	1.674	2.000	0.00776*

* Statistically significant at the $p \leq 0.05$ level.

Compared to male students, female students considered both ethical and social considerations to be more important for future engineers as measured by the p-value.

Survey Q4: "Based on your understanding of engineering practice, indicate the degree to which you agree or disagree with the statements below by circling the level of agreement or disagreement:"

Q4 asked students to indicate the degree to which they agreed or disagreed with four statements about the technical, social, or sociotechnical nature of engineering work. Permitted responses were scaled as follows: 'Strongly Disagree' (0 points), 'Slightly Disagree' (1 point), 'Slightly Agree' (2 points), and 'Strongly Agree' (3 points). Thus, higher average scores for male and female students represented greater agreement with each of the four statements. Results appear in Table 5.

Table 5: Average Scores for Each Consideration by Student Gender

Statement	**Student Gender**		**P-Value**
	Male	**Female**	
Practicing engineers primarily engage in technical work.	2.175	1.964	0.0627
Practicing engineers primarily engage in nontechnical work (e.g. social, cultural, etc.).	1.308	1.455	0.221

Practicing engineers primarily engage in sociotechnical (integration of technical and social elements) work.	2.077	2.127	0.659
Social concerns are outside an engineer's responsibilities.	0.629	0.345	0.00690*

* Statistically significant at the $p \leq 0.05$ level.

Only one statement demonstrated significant differences between male and female students: 'Social concerns are outside an engineer's responsibilities.' Both male and female students generally disagreed with this statement. However, compared to male students, female students disagreed with this statement to a much larger degree.

Survey Q9: "Social responsibility is often expressed as [Select one]"

Q9 utilized a multiple-choice format, asking students to identify what they perceived to be the single best response on how social responsibility is typically expressed in engineering; on Q9, students were to select only one of the permitted responses in Table 6. Instead of scaling student responses, data analysis for Q9 tallied the number of male and female students who chose each response. P-values were also calculated to determine the significance of the two proportions, indicating whether male and female responses differed significantly. The results can be seen in Table 6.

Table 6: Breakdown of Q9 by Percentage Distribution of Answers by Student Gender

Statement	**Student Gender**		**P-value**
	Male	**Female**	
Engineers' obligations to the public	253 (72.9%)	134(81.7%)	0.0270*
Engineers using innovative experimental procedures	35 (10.1%)	18 (11.0%)	0.460
How engineers should avoid scientific misconduct	59 (17.0%)	12 (7.3%)	0.801
How scientists and engineers must protect their data	0 (0.00%)	0 (0.00%)	N/A

* Statistically significant at the $p \leq 0.05$ level.

Data analysis demonstrated that only one statement, 'Engineers obligations to the public,' proved to differ significantly between male and female students. Both male and female students selected this statement more than any other choice. Compared to male students, however, female students were statistically more likely to choose this response, indicating that they considered it a stronger definition of engineers' social responsibilities. Additionally, only 18 percent of female students selected two of the other possible responses, 'Engineers using innovative experimental procedures' and 'How engineers should avoid scientific misconduct.' A larger number of male students, nearly 27 percent, chose these other two responses.

Survey Q10: "Engineers have special obligations to society primarily because [Select one]"

Like Q9, Q10 also utilized a multiple-choice format with five potential responses. The question asked students to specify one response on why they think engineers have special obligations to society. Students who completed the survey in the Spring of 2018 commented that the original wording of Q10 was confusing and omitted a response they considered salient. Therefore, Q10 was revised, and only Fall 2018 data were analyzed for this paper (n = 144, including 102 men (71%) and 42 women (29%). The rewritten version of Q10, in which students responded by selecting one of the five answers below, appears in Table 7.

Table 7: Breakdown of Q10 by Percentage Distribution of Answers for Both Men and Women

Statement	Gender		P-Value
	Male	Female	
Engineers often have special expertise in fields that ordinary citizens do not have	16 (15.7%)	2 (4.8%)	.660
Engineering research must comply with applicable laws and regulations	3 (2.9%)	0 (0.00%)	.500
Engineering decisions can impact individuals, communities, and the broader public positively and/or negatively	79 (77.5%)	39 (92.9%)	.0190*
Engineering reputation and profitability depend on the knowledge, skillful practices of engineers	3 (2.9%)	1 (2.4%)	.512
Fulfilling such obligations upholds the reputation of the engineering profession	1 (.98%)	0 (0.0%)	0.500

* Statistically significant at the $p \leq 0.05$ level. Table breaks down only fall 2018 data.

Compared to male students, female students were significantly more likely to select 'Engineering decisions can impact individuals, communities, and the broader public positively and/or negatively.' Although this response was the most frequent choice for all students, significantly more female students selected it (93%) than male students (78%).

Results with Bonferroni Corrections

After running Bonferroni corrections, the significance level went from a 95% confidence interval to a 99.5% confidence interval. The previous significance level was .05, and since nine questions were being analyzed, .05 was divided by 9, which equated to .00555, truncated to .005. With such strict parameters, only Q1 resulted as statistically significant, as seen in Table 8. Permitted responses for Q1 are the same as reported in Table 2.

Table 8: Q1 Average Scores for Each Skill by Gender after Bonferroni Corrections

Skill	Gender		P-Value
	Male	Female	
Solve technical problems within familiar contexts	2.266	2.182	0.493
Apply technical knowledge to novel contexts	2.176	2.091	0.453
Work with people who define problems differently	2.366	2.309	0.593
Listen to and integrate the perspectives of both engineers and non-engineers	2.294	2.600	0.00127*
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Acknowledge the strengths and limitations of different forms of knowledge for solving different kinds of problems	2.217	2.218	0.989

* Statistically significant at the $p \leq 0.005$ level.

Once again, statistically significant differences between male and female students were found on the following two skills:

‘Listen to and integrate the perspectives of both engineers and non-engineers’

‘Work with people having a diverse set of backgrounds’

Compared to male students, female students were more likely to see these two skills as more important as they think of their future professional engineering careers.

Discussion

When considering the results produced without the Bonferroni corrections, the most significant findings in terms of gender differences arose from analysis of Q1, Q2, and Q4, with supporting data provided by Q9 and Q10. The survey data as a whole indicated that compared to their male peers, female engineering students place more value on some sociotechnical dimensions of engineering problem framing and solving processes. This female preference can be seen by greater ratings of the importance of ‘Social’ and ‘Ethical’ considerations and skills like ‘Listen to and integrate the perspectives of both engineers and non-engineers’ and ‘Work with people having a diverse set of backgrounds.’ Furthermore, female students tended to *disagree* in greater numbers than male students with the characterization of the engineering profession wherein ‘Social concerns are outside an engineer’s responsibilities.’ Also, more female than male students emphasized social responsibility as broadly encompassing ‘Engineers’ obligations to the public.’ Finally, compared to male students, a higher percentage of female students indicated that the reason engineers have special obligations to society is because ‘Engineering decisions can impact individuals, communities, and the broader public positively and/or negatively.' Overall, these results suggest that compared to male students, female students place greater value on sociotechnical thinking and concepts critical for acceptance of sociotechnical integration.

Q1 results suggest that female students think certain sociotechnical skills will be more important in their future engineering careers when compared to male students. For instance, female student responses differed significantly by showing greater valuation of the skills 'Listen to and integrate the perspectives of both engineers and non-engineers,' and 'Work with people have a diverse set of backgrounds'. Both of these skills align with research on the sociotechnical realities of engineering practice, cited in the above literature review; also, these skills are important in educating the engineer of 2020 as described by the NAE, as among other professional skills, engineers need "…an understanding of the complexities associated with a global market and social context." [11]. To a greater degree than their male peers, female students indicated an appreciation for some non-technical skills in professional engineering that are consistent with research implicitly or explicitly accentuating the importance of sociotechnical thinking [5]–[7].

Additionally, none of the skills representative of traditional engineering curricula (such as 'Approach problems that are not clearly defined or with uncertain parameters' and 'Solve technical problems within familiar contexts') yield significant differences between male and female responses. This may suggest that skills pertaining to sociotechnical integration are uniquely interpreted by female students, but not in such a way that traditional engineering elements are ignored or devalued by female students when compared to male students.

The results of Q2 built upon those presented by Q1. In Q2, rather than ask students about the importance of certain skills, students were asked about the importance of seven different considerations to their future engineering careers. Compared to those of their male peers, female student responses yielded significant differences for 'Ethical' considerations ($p = 0.0468$) and for 'Social' considerations ($p = 0.00776$). Similar to Q1, these results indicate that female students assign a greater degree of importance to certain considerations critical to sociotechnical integration in engineering when their future careers are considered. The other considerations, 'Economic,' 'Environmental,' 'Health & Safety,' 'Manufacturability,' and 'Technical,' did not demonstrate significant delineations between male and female responses. Since most of these other considerations are fairly traditional (albeit varying) emphases in engineering education, these results reinforce the notion that for female engineering students, greater relative valuation of sociotechnical thinking is not associated with devaluing technical thinking. Rather, the two forms of valuation are mutually compatible.

Q4 allowed students to consider the varying importance of social and technical concerns in engineering practice, by assessing how much they agreed or disagreed with four different statements. Compared to male students, female students much more strongly disagreed with the statement 'Social concerns are outside an engineer's responsibilities' ($p = 0.00690$). This strong response to devaluing social concerns supports the analysis of Q1 and Q2 that female engineering students place a higher value on sociotechnical concepts in engineering. That female students demonstrate a clearer sense that social concerns and engineering responsibilities are intertwined suggests that female students are especially interested in aspects of engineering which have direct, explicit societal benefits.

With particular statements in Q4, such as ‘Practicing engineers primarily engage in nontechnical work (e.g., social, cultural, etc.)’ or ‘Practicing engineers primarily engage in sociotechnical (integration of technical and social elements) work,’ the responses of female and male students do not differ significantly. Also, female students do not differ significantly from male students on the other end of the extreme, as seen with the statement ‘Practicing engineers primarily engage in technical work.’ These results again demonstrate that even though female engineering students value sociotechnical integration to a greater extent than male students, this does not come at the cost of devalued technical aspects of engineering.

Q9 and Q10 both consisted of a multiple-choice format designed to elicit whether students could select the answer which best encompassed the spirit of sociotechnical integration. In both cases, female students were more likely than male students to choose the response with greater sociotechnical emphasis. In Q9, students were asked how social responsibility is often expressed. Significantly more female students chose ‘Engineers’ obligations to the public’ compared to male students. Q10 asked students to consider why engineers have special obligations to society. Significantly more female students chose ‘Engineering decisions can impact individuals, communities, and the broader public positively and/or negatively’ compared their male peers. It is possible that the preference for sociotechnical factors and aspects seen by Q1, Q2, and Q4 stems from a greater understanding for the concepts analyzed by Q9 and Q10. Thus, female students can translate this preference into selecting appropriate sociotechnical responses when these types of questions are posed.

Q3 was not reported in the Results section since no statistically significant results emerged from Q3. However, the Q3 results merit noting. As noted in Table 9, Q3 listed the same seven considerations as Q2, but instead of asking them to rank their importance to students’ future roles as engineers, Q3 asked students to designate *how often* they think *practicing engineers* incorporate each consideration into their work. The permitted responses and corresponding scaling of responses included: ‘Not At All’ (0 points), ‘Once or twice a YEAR’ (1 point), ‘Once or twice a MONTH’ (2 points), ‘Once or twice a WEEK’ (3 points), and ‘Daily’ (4 points). Therefore, higher average scores indicated increased usage perceptions by students for practicing engineers. As seen in Table 9, calculated p-values showed no appreciable statistical difference between male and female responses.

Table 9: Average Q3 Scores for Each Consideration by Gender

Consideration	**Gender**		**P-Value**
	Male	**Female**	
Economic	3.236	3.018	0.155
Environmental	2.560	2.473	0.546
Ethical	2.709	2.691	0.876
Health & Safety	3.291	3.327	0.806
Manufacturability	3.177	3.291	0.413
Technical	3.454	3.564	0.350
Social	2.560	2.582	0.881

* Statistically significant at the $p \leq 0.05$ level.

That none of the seven considerations produced significant differences between male and female students' responses suggests that while such students value the importance of these considerations differently (as seen in Q2 results), male and female students do not have corresponding perceived differences in frequency of the use of these considerations in professional practice (Q3 results). Combined, these results imply that female engineering students may perceive the engineering profession, as evidenced by Q3 results, as misaligned with the sociotechnical values they express as important in Q2 results. In other words, based on their social preferences, compared to male students, female students may be more likely to interpret the practice of engineering as more substantially different than their sociotechnical values.

When considering the results with the Bonferroni corrections, the corrections clearly point to far fewer instances of statistical significance. The only question with statistically significant values after the corrections was Q1 (with confidence interval at 99.5% compared to the previous 95%). Given that p-values were significant even with such a high confidence interval, it can be concluded that there is strong evidence that men and women had highly significant differences in views with regard to two skills:

'Listen to and integrate the perspectives of both engineers and non-engineers' and
'Work with people having a diverse set of backgrounds'

That is, the results with Bonferroni corrections provide evidence that female and male students value certain professional engineering skills—related to the need to engage and integrate diverse perspectives and people with diverse backgrounds—quite differently.

Conclusion

Sociotechnical survey data of male and female undergraduate engineering students in three different classes at two public universities in Colorado were analyzed for significant differences in responses based on gender. Analyses without Bonferroni corrections demonstrated a clear difference in the perception and understanding of sociotechnical concepts in male and female students' construction of their future careers as engineering professionals as measured by several results. Analyses with Bonferroni corrections demonstrated that as male and female students' think about their future role as engineers, there is a difference in what skills they prioritize as necessary for practicing engineers.

The results of the sociotechnical survey align with the three habits of mind previously mentioned: strengths and limitations of knowledge, collaborative work integrating diverse knowledge and perspectives, and knowledge and expertise plurality in the creation of solutions. Each of these three merits additional explanation and provides a framework for making sense of the survey results.

First, by encouraging undergraduate engineering students to develop habits of mind that *assess strengths and limitations of different forms of knowledge* (a part of our intervention that will appear in future research), we hope that engineering students will use and evaluate both technical and non-technical bodies of knowledge [8]. Q2 showed that female students are significantly more likely than male students to consider 'Ethical' and 'Social' considerations important in their future roles as professional engineers. Q4 demonstrated a greater disagreement among female students than male students to the statement 'Social concerns are outside an engineer's responsibilities.' The data suggest that compared to their male peers, female students have a greater understanding, appreciation for, and valuation of non-technical knowledge as they pursue a degree in engineering. Developing this habit of mind in all students might thus have the potential to impact climate for and persistence of women in engineering. However, we need to also better understand how developing this habit of mind inside the engineering curriculum can impact all students.

Also, developing the habit of mind focused on *diverse knowledge and perspectives* will ideally encourage engineering students to understand the importance of learning how to work with different types of people who may frame and solve problems differently [8], [9]. Q1 results showed that compared to male students, female students were significantly more likely to think skills such as 'Listen to and integrate the perspectives of both engineers and non-engineers' and 'Work with people having a diverse set of backgrounds' as more important to their future role as engineers. These data suggest that female students more readily understand how important it will be to draw from a diverse pool of stakeholder perspectives when they begin a career as an engineer.

The final habit of mind, *knowledge and expertise plurality*, hopes students will construct engineering in a way that renders visible, "…the human dimensions of engineering work alongside technical problem solving" [8]. Many survey results indicated that female students appear to break down the barriers between human and technical dimensions to a larger extent when compared to male students, particularly Q9 and Q10 results. However, Q3 may indicate that female students still carry socially constructed ideas about professional engineering. Although Q2 showed a female preference for 'Ethical' and 'Social' considerations, like male students, female students still did not believe these considerations would be used more frequently among practicing engineers. Female students may understand the importance of sociotechnical considerations; however, when considered in the context of the broader literature, they may be held back by notions about engineering practice that do not align with their demonstrated preferences. As Faulkner noted in her research [24], such disconnects may result in women having a more tenuous connection to engineering than men.

Interpreting the results through the lens of Bonferroni corrections leads to much more limited results, since only one question resulted in significant p-values after the corrections were performed. However, the results can lead to a stronger conclusion of a difference in views between male and female students based on their perceived future roles as engineers.

Further Research Directions

Future research can explore several unanswered or partially answered questions. For instance, the intersection between male and female students' responses to Q2 and Q3 merits further study. Why did female students express greater value than males on particular sociotechnical aspects in Q2, but then in Q3, male and female students made similar predictions about how those same sociotechnical aspects would (not) be used frequently in engineering practice? It may be possible that female students construct engineering careers in ways that does not align to the preferences they develop for sociotechnical integration. If these assumptions could be supported with more research, the results could point towards making the engineering profession more attractive for students with diverse sociotechnical perspectives.

When the results from all questions are considered for female students as compared to their male peers, the most salient overarching finding is an increased appreciation for sociotechnical integration in engineering education and practice and a better understanding of the implications of these integrations. This preference should be explored with further research. Furthermore, the female student preference for sociotechnical integration also leads to a number of higher-level research questions, including:

1. Do male and female students define certain words or phrases critical to the concept of sociotechnical integration, such as ‘Ethical’ or ‘Social’, in different ways?
2. Do other demographics, such as age or progression through college career, affect the sociotechnical integration preferences of female and male engineering students?
3. How does the appreciation for sociotechnical considerations of professional engineers compare to that of students?
4. Do female engineering students ‘construct’ the idea of an engineering career in a manner which does not align with their sociotechnical preferences? Can this ‘construction’ account for female attrition at various points in the so-called “leaky-pipeline”?
5. Do aspects of undergraduate engineering curricula exist which allow female students to develop an appreciation for sociotechnical concepts, but not male students? If so, how can they be corrected or otherwise injected into the courses for increased male understanding? If that occurs, what effects would it have on male students’ perceptions of sociotechnical thinking?
6. While this study quantifies student self-reports on their perceptions of the importance of different forms of sociotechnical thinking, how are those same perceptions different before and after an engineering course in which sociotechnical thinking is defined, made explicit, and practiced via active-learning, sociotechnical activities?
7. Does integrating sociotechnical thinking in the engineering curriculum lead to greater or lesser degrees of satisfaction with engineering practice? Related, does an early appreciation for the value of sociotechnical considerations in engineering lead to longer/successful/more impactful engineering careers?

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Appendix A

Table A1: Major Representation of Students for the Three Courses Analyzed

Course	Year	Major Percentages (%)	
		Major	# of Students (%)
Projects	1st Year	Engineering Plus	7 (2.00%)
		Chemical Engineering	6 (1.72%)
		Chemical & Biological Engineering	3 (1.20%)
		Mechanical Engineering	78 (22.35%)
		Civil Engineering	29 (8.31%)
		Architectural Engineering	6 (1.72%)
		Environmental Engineering	24 (6.88%)
		Technology Arts & Media	5 (1.43%)
		Computer Science	7 (2.01%)
		Aerospace Engineering Sciences	44 (12.61%)
		Two or more majors	31 (8.88%)
		Undeclared	101 (28.94%)
ME Intro	2nd Year	Mechanical Engineering	121 (91.0%)
		Engineering Physics	4 (3.0%)
		Aerospace/Mechanical Engineering	2 (1.5%)
		Petroleum Engineering	2 (1.5%)
		Electrical Engineering	1 (0.8 %)
		Not Listed	3 (2.3%)
Electromagnetics	3rd Year	Electrical Engineering	41 (93.2%)
		Mechanical Engineering	2 (4.5%)
		Electrical Engineering/Applied Math	1 (2.3%)

Appendix B

Sociotechnical Survey

Section 1
Instructions: This set of questions asks about your perceptions of the field of engineering practice.

1. Think about **your future role** as an engineer. For each of the following, rate how important you believe each of these **skills** will be when you practice engineering as a professional *by circling* the level of importance that best matches your answer.

Solve technical problems within familiar contexts	Not at all Important	Somewhat Important	Very Important	Extremely Important
Apply technical knowledge to novel contexts	Not at all Important	Somewhat Important	Very Important	Extremely Important
Work with people who define problems differently	Not at all Important	Somewhat Important	Very Important	Extremely Important
Listen to and integrate the perspectives of both engineers and non-engineers	Not at all Important	Somewhat Important	Very Important	Extremely Important
Approach problems that are not clearly defined or with uncertain parameters	Not at all Important	Somewhat Important	Very Important	Extremely Important
Identify project-relevant sociocultural issues	Not at all Important	Somewhat Important	Very Important	Extremely Important
Follow the rules established by local, national, and institutional authorities	Not at all Important	Somewhat Important	Very Important	Extremely Important
Work with people having a diverse set of backgrounds	Not at all Important	Somewhat Important	Very Important	Extremely Important
Acknowledge the strengths and limitations of different forms of knowledge for solving different kinds of problems	Not at all Important	Somewhat Important	Very Important	Extremely Important

2. Think about **your future role** as an engineer. For each of the following, rate how important you believe each of these **considerations** will be when you practice engineering as a professional *by circling* the level of importance that best matches your answer.

Economic	Not at all Important	Somewhat Important	Very Important	Extremely Important
Environmental	Not at all Important	Somewhat Important	Very Important	Extremely Important

Ethical	Not at all Important	Somewhat Important	Very Important	Extremely Important
Health and Safety	Not at all Important	Somewhat Important	Very Important	Extremely Important
Manufacturability*	Not at all Important	Somewhat Important	Very Important	Extremely Important
Technical	Not at all Important	Somewhat Important	Very Important	Extremely Important
Social	Not at all Important	Somewhat Important	Very Important	Extremely Important

*the ability to manufacture a given design

3. How often do you think practicing engineers incorporate each of the following **considerations** in their work? Indicate your answer *by circling* the level of importance that best matches your answer.

Economic	Not at all	Once or twice a YEAR	Once or twice a MONTH	Once or twice a WEEK	Daily
Environmental	Not at all	Once or twice a YEAR	Once or twice a MONTH	Once or twice a WEEK	Daily
Ethical	Not at all	Once or twice a YEAR	Once or twice a MONTH	Once or twice a WEEK	Daily
Health and Safety	Not at all	Once or twice a YEAR	Once or twice a MONTH	Once or twice a WEEK	Daily
Manufacturability*	Not at all	Once or twice a YEAR	Once or twice a MONTH	Once or twice a WEEK	Daily
Technical	Not at all	Once or twice a YEAR	Once or twice a MONTH	Once or twice a WEEK	Daily
Social	Not at all	Once or twice a YEAR	Once or twice a MONTH	Once or twice a WEEK	Daily

*the ability to manufacture a given design

4. Based on your understanding of engineering practice, indicate the degree to which you **agree or disagree** with the statements below *by circling* the level of agreement or disagreement:

Practicing engineers primarily engage in technical work.	Strongly Disagree	Slightly Disagree	Slightly Agree	Strongly Agree
Practicing engineers primarily engage in nontechnical work (e.g., social, cultural, etc.)	Strongly Disagree	Slightly Disagree	Slightly Agree	Strongly Agree
Practicing engineers primarily engage in sociotechnical (integration of technical and social elements) work.	Strongly Disagree	Slightly Disagree	Slightly Agree	Strongly Agree

Social concerns are outside an engineer's responsibilities.	Strongly Disagree	Slightly Disagree	Slightly Agree	Strongly Agree

5. When solving most engineering problems in engineering practice, it is **most appropriate** to [*Select one*]
   - ☐ Identify all of the technical considerations and separate them from the nontechnical considerations
   - ☐ Recognize project-relevant interplays between technical and nontechnical considerations
   - ☐ Integrate all of the technical and nontechnical considerations
   - ☐ Partner with a social scientist who can handle nontechnical considerations

6. Are there any clarifying remarks you would like to make about your answers to the questions in this section?

Section 2

Instructions: This part of the survey has four questions. For each question, select the one response you think is best.

7. The most important reason that engineers have professional obligations to society is [*Select one*]
   - ☐ Codes of ethics make mandatory statements about social responsibility.
   - ☐ Science and technology can affect the public in profound ways.
   - ☐ Licensure (the obtaining of a professional license) of engineers requires attention to social responsibility.
   - ☐ Social responsibility is required by the U. S. government.

8. Technical decisions can have long lasting social consequences because [*Select one*]
   - ☐ Technical decisions can quickly change research methods
   - ☐ Technical decisions often result in privacy issues
   - ☐ Once technical decisions are in place, it often becomes difficult for engineers to change them
   - ☐ Technical decisions can have short-term effects on how research is carried out.

9. Social responsibility is often expressed as [*Select one*]
   - ☐ Engineers' obligations to the public
   - ☐ Engineers using innovative experimental procedures
   - ☐ How engineers should avoid scientific misconduct
   - ☐ How engineers must protect their data

10. Engineers have special obligations to society *primarily* because [*Select one*]
   - ☐ Engineers often have special expertise in fields that ordinary citizens do not have
   - ☐ Engineering must comply with applicable laws and regulations
   - ☐ Engineering decisions can impact individuals, communities, and the broader public positively and/or negatively
   - ☐ Employer reputation and profitability depend on the knowledgeable, skillful practices of engineers
   - ☐ Fulfilling such obligations upholds the reputation of the engineering profession

11. Are there any clarifying remarks you would like to make about your answers to the questions in this section?

Section 3
Instructions: this final set of questions seeks demographic and background information.

12. Relevant prior experience: have any of these experiences impacted your answers in this survey? [*Select all that apply*]
   - ☐ Employment as an engineer or engineering intern/co-op
   - ☐ Employment at a for-profit company
   - ☐ Employment at a government agency (federal, state, local)
   - ☐ Employment at a non-profit or non-government agency
   - ☐ Research assistant
   - ☐ Teaching assistant
   - ☐ Work-study student
   - ☐ University-sponsored extracurricular activities
   - ☐ Other (please specify):____

- ☐ Briefly tell how any of these experiences have impacted your perspective in this survey.

13. Future employment: immediately following graduation, which of the following are you most likely to pursue as your primary position? [*Select one*]
    - ☐ Working for a “traditional” engineering company (at least 50% focus on engineering practice within one engineering discipline)
    - ☐ Working for a multidisciplinary company (no single engineering degree field accounts for 50% or more of the company’s activities)
    - ☐ Working for local, state, or federal government
    - ☐ Working for a non-profit or non-governmental organization
    - ☐ Entrepreneur/start your own company
    - ☐ Graduate school in engineering
    - ☐ Graduate or professional school in a field other than engineering
    - ☐ Military service
    - ☐ Other (please specify)____

14. What is your major? [*Select all that apply*]
    - ☐ Aerospace Engineering
    - ☐ Chemical Engineering
    - ☐ Civil Engineering
    - ☐ Computer Science
    - ☐ Engineering Physics
    - ☐ Engineering Plus
    - ☐ Electrical Engineering
    - ☐ Mechanical Engineering
    - ☐ Technology, Arts, and Media
    - ☐ Other (please specify)____

15. If you have a minor, please write it here: ____________________________________

16. When do you expect to graduate? [*Select one*]
    - ☐ 2018
    - ☐ 2019

- ☐ 2020
- ☐ 2021
- ☐ 2022
- ☐ 2023
- ☐ 2024

17. From which university do you expect to graduate in the year you selected? [*Select one*]
    - ☐ [CSM]
    - ☐ [CU]
    - ☐ Other:____
    - ☐ Prefer not to answer

18. What is your gender? [*Select all that apply*]
    - ☐ Male
    - ☐ Female
    - ☐ Female-to-Male Transgender
    - ☐ Male-to-Female Transgender
    - ☐ Non-binary/third gender
    - ☐ I prefer to self-describe: ________________________________
    - ☐ I prefer not to respond

19. How would you describe yourself? [*Select all that apply*]
    - ☐ African American
    - ☐ Native American Indian
    - ☐ East Asian
    - ☐ South Asian
    - ☐ Hispanic
    - ☐ Native Hawaiian
    - ☐ White
    - ☐ Multi-racial
    - ☐ Other:____
    - ☐ I prefer not to respond

20. Are you an international student? [*Select one*]
    - ☐ Yes
    - ☐ No
    - ☐ Other: ____
    - ☐ I prefer not to respond

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Note: Some references have been blinded on this draft to ensure author anonymity.

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