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Intersectional Complexities of Race/Ethnicity and Gender in Engineering Students’ Professional Social Responsibility Attitudes (Research)

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Abstract

This research examined the professional social responsibility attitudes among engineering students from different demographic groups based on intersectional categories of race/ethnicity and gender. A survey instrument measured the students' attitudes toward professional connectedness (PC), a sense that engineers should apply their skills to help others, using 19 items with a 7-point Likert-type response scale. A key methodological inconsistency in the dataset was how students were allowed to report their race/ethnicity in the demographic question at the end of the survey: 1088 students selected a single race/ethnicity category, while 2305 students could identify multiple racial/ethnic categories. The results show that constraining students to select a single race/ethnicity likely fails to accurately reflect the multiracial identities of many students. For example, the percentage of students who responded to the 2014 survey and checked multiple race/ethnicity categories included 90% of Native Americans, 54% of African Americans, 35% of Hispanics, 21% of Asians, and 8% of non-Hispanic Whites. Consideration of multiracial identities is therefore very salient. The strongest professional connectedness attitudes were identified among female African American and female Hispanic students (average PC ~5.6 compared to White males 5.0). If these underrepresented female students persist to work as engineers after graduation, they may bring different feelings about their responsibility to serve society into their work as compared to majority White males. However, goal congruity theory predicts they may be at greater risk for leaving engineering if they do not perceive that engineering work helps others.

Introduction

Engineering has the potential to help improve the quality of life for people living in underserved and marginalized communities. Increasing the diversity of engineers may increase the extent to which the engineering profession is committed to fostering positive societal impacts. For example, the communal and helping goals of female science, technology, engineering, and mathematics (STEM) students has been found to be stronger than male students [1, 2]. There are also limited data showing that students from racial/ethnic groups under-represented in engineering are motivated by helping others through their work to a greater extent than White students [2, 3]. However, race/ethnicity and culture are complex ideas that may interact with gender with respect to social responsibility attitudes. Exploring these elements from the perspective of intersectional identities was the goal of this research.

Although stereotypical and historical norms promote the perspective that engineers care more about things than people [4-6], it is important that engineers are trained to consider the broad societal implications of their work [7]. In particular, there are examples where engineering projects differentially burdened minoritized populations with negative effects from infrastructure (e.g. [8]), environmental pollutants (e.g. [9]), and other systems (e.g. [10]). If individuals motivated to 'make a world of difference', in the words of the National Academy of Engineering's *Changing the Conversation* [11], choose engineering majors and retain this motivation for fostering positive societal impacts through their work, fewer negative and more positive societal benefits could be realized. While there is disagreement about the power and agency of individual engineers, no one debates the great impacts of engineered products and processes on society. And while many of these impacts are positive, others have been mixed – providing advantages to some and disadvantages to others. If the engineering profession was more representative demographically, benefits to society (e.g. creative and equitable engineered works) and individuals (e.g. stable, well-paying, and rewarding work) could result [12-14]. However, researching these issues is both philosophically and methodologically tricky. There are complex intersectional issues among demographics that may be important when we explore the professional social responsibility attitudes of engineering students. (The language used to discuss these issues is also complicated and non-standardized. In general, we preserved the language used in the study or survey items. The authors apologize if anyone feels offended or uncomfortable with these wording choices.)

Background

Professional social responsibility represents an obligation that their work as engineers should contribute to societal good. Rooted in the Ethic of Care philosophy [15-16], Canney and Bielefeldt [17] developed a model of professional social responsibility development (PSRDM) that included a personal social awareness realm, professional development realm, and professional connectedness realm. The professional connectedness realm was subdivided into two dimensions: professional connectedness (PC) and costs/benefits. The PC dimension "addresses issues of responsibility or obligation that an engineer or the engineering professional may have to help solve social problems or help others" [18, p. 455]. Feelings of personal social responsibility, such as recognizing needs in society and feeling a personal obligation to help others, merge with an understanding that engineers have the ability to help address societal problems to drive PC.

Previous research has found demographic differences in the extent to which students are motivated about and interested in the social impacts of engineering. Women tend to have a higher interest in people than men [6], higher prosocial motivations [19], higher communal goals [2], and more positive social responsibility attitudes [20, 21]. Studies have also noted high social motivations related to career goals among groups from underrepresented racial/ethnic groups [22-24]. Engineering students' motivation toward public welfare and social responsibility attitudes may decrease as they increase in rank during college [25, 26], a phenomenon Cech termed a culture of disengagement in engineering education [25]. Differences in the public welfare, helping others, and/or social responsibility attitudes of engineering students have been found among students attending different institutions [25, 27, 28], in different majors [27, 29], and among students with different religious/spiritual beliefs [28]. However, these studies have not taken an intersectional approach to demographic factors. Other factors such as culture and socio-economic status could be influential. For example, Jack [30] noted different college student experiences at the intersections of multiple factors (race, socio-economic status, high school experience). Further, many researchers believe that social identities cannot be separated and treated independently [31], calling into question the previous quantitative linear modeling approach which separately modeled the factors of gender and race/ethnicity and also applied a hypodescent approach to individuals who identified multiple race/ethnicity categories [28].

The demographics of engineering Bachelor's graduates in the U.S. is not representative of college graduates or high school graduates (Table 1) [32-35]. Under-representation in engineering is particularly notable for the intersectional groups of Black females, Hispanic females, and multiracial females. (Note: given the small percentages of underrepresented race/ethnicity groups, the unknown data from the American Society for Engineering Education (ASEE) may cause large differences). Also notable is that 2019 was the first year that race/ethnicity and gender combined data were reported by the ASEE. Among the U.S. population (based on 2013 census data), 3% of the population was multiracial (largest groups White-Black 26%, White-Asian 20%, White-American Indian 19%; 9% three races or more; note: Hispanics not considered a race group) [36].

Table 1. Gender and Race/Ethnicity Among Engineering and STEM Bachelor's degree earners in comparison to High School Graduates

Category	Gender	Engrg Bachelor's degrees 2019^[31]	STEM Bachelor's degrees 2017-18 [32]	Bachelor's degrees overall 2017-18 [32]	Public High school graduates 2012-13 [33]	Private HS graduates 2017-18 [34]
Male	M	77.3	63.5	42.1	49.5	
Female	F	22.7	36.5	57.9	50.5	
Black or African American	M	3.2	3.8	3.7	6.9	9.3
	F	1.1	3.1	6.6	7.6	
Hispanic	M	9.2	7.5	5.6	9.9	11.3
	F	2.7	4.6	8.6	10.3	
American Indian / Alaska Native	M	0.2	0.2	0.2	0.5	0.5
	F	0.1	0.2	0.3	0.5	
Native Hawaiian/ other Pacific Islander	M	0.2	0.1	w/ As	w/ As	0.8
	F	0.1	0.1	w/ As	w/ As	
Asian American	M	10.5	8.4	3.6	2.8	6.5
	F	3.9	5.7	4.4	2.8	
Multiracial	M	0.3	2.4	1.5	1.0	4.9
	F	0.1	1.6	2.2	1.1	
White	M	47.4	41.0	27.4	28.4	66.7
	F	12.7	21.2	35.8	28.1	
Unknown	M	3.8				
	F	1.2				

^ Percentages exclude nonresident aliens

It can be argued that addressing diversity issues in engineering is an ethical issue [37], itself among the professional responsibilities of our profession. Recent changes in the American Society of Civil Engineers Code of Ethics points to these responsibilities [38].

Institutional data on gender and race/ethnicity often comes in a simple format with a single identifier in each category. However, how one self-identifies may be different than 'official' records. For example, a Pew Research study in 2015 [36] found that among multiracial adults (based on the identified races of their parents and grandparents), only 39% considered themselves to be of mixed race; these percentages varied based on the mixed-race composition (highest among White-Asian at 70%, lowest among White-American Indian at 25%). Further, racial identification can change over time, and 21% of multiracial adults indicated they had experienced pressure to identify as a single race. The categories that an individual self-selects may be indicative that one has claimed a particular identity for oneself. However, the format of demographic survey items can present challenges if a survey taker does not fit into the pre-identified categories, resulting in feelings of being "other" or invisible. MultiCrit theory (an extension from Critical Race Theory) offers tenets that offer guiding principles for probing questions that include race/ethnicity; for example, the difficulties of a monoracial paradigm of race [39].

The norms for asking demographic questions on surveys have changed over time and appear to lack consensus. The old norm of binary gender identity (male or female) is no longer considered adequate. Edgar et al. [40] for the U.S. Bureau of Labor Statistics explored the gender question 'do you describe yourself as male, female, or transgender'. A more recent study [41] recommends: 'What is your current gender identity' with the response options 'check all that apply' among the options of: male, female, female-to-male / transgender male / trans man, male-to-female / transgender female / trans women, genderqueer – neither exclusively male or female, additional gender category/(or other) please specify, or decline to answer. However, in an educational quantitative study it would be unlikely that a large number of students would check one of the non-gender binary categories. Another recommendation [42] is simply an open-ended response or "I prefer not to answer"; this will require recoding by researchers if they wish to explore gender for their study.

Asking individuals about their race/ethnicity is even more challenging, with seemingly greater potential to cause misunderstanding or discomfort [43]. There have been significant changes in question format over time, specifically using the U.S. census as an example [36, 44]. The 2020 U.S. Census asked two questions, about Hispanic, Latino, or Spanish origin (described as heritage, nationality, lineage, birth country, or ancestors, not race) and race [45]. The ethnicity and race questions allow individuals to select as many categories as they choose and provides a write-in box to provide more information associated with all of the response options. This race/ethnicity question differed from the 2016 U.S. Census. Individuals reporting multiracial backgrounds are growing, particularly among younger Americans [36]. In addition, different levels of the lack of self-reporting of race/ethnicity have been found among different groups [46].

Intersectionality is "one way to highlight differences between and within groups across social identities" [47, p. 35]. It acknowledges the importance of multiple intersecting identities and social group membership that can include gender, race/ethnicity, physical disabilities, religious/spiritual, class / socio-economic status, and first-generation, among other identities [48, 49]. These multiple identities may impact the development of engineering / STEM identity, as well as feelings belonging [48] and otherness [50, 51]. Increasing attention is being devoted to exploring intersectional approaches to demographic categories (e.g. [52-54]), and multiracial groups in particular (e.g. [55-56]). This paper unpacks the complexity of trying to explore the race/ethnicity results from a study of the social responsibility attitudes among engineering students.

Research Questions

The goal of this research was to examine the social responsibility attitudes of engineering students on the basis of their gender identity and race/ethnicity identities. The extent to which engineering students felt a responsibility to help people or society in their role as engineers was examined, with attention to intersectional categories of gender and race/ethnicity.

RQ1. Does the extent of professional social responsibility motivation of engineering students, measured as professional connectedness, differ on the basis of gender identity?
RQ2. Does the extent of professional social responsibility motivation of engineering students, measured as professional connectedness, differ on the basis of racial/ethnic identity, including specific multiracial groups?
RQ3. Does the extent of professional social responsibility motivation of engineering students differ among students in different intersectional gender-race/ethnicity identity groups?

Methods

This research used a post hoc methodology, whereby the research questions were explored using existing quantitative data from two datasets. The original studies were not designed to explore intersectional race/ethnicity and gender groups among engineering students. Therefore, this work will carefully critique the methods in the earlier studies to explore the stated research questions. However, given the size of the existing datasets (combined over 3000 students), it was believed that interesting insights could be gathered.

Measuring social responsibility

The data originated from use of the Engineering Professional Responsibility Assessment (EPRA) [18], which was developed based on the PSRDM [17]. The validity and reliability metrics for the instrument were strong in a previous study with engineering students [18]. EPRA uses 50 Likert-type items to measure the professional social responsibility attitudes among engineering students. This paper focuses on the 19 items that measure the construct of *professional connectedness* (PC), feelings of responsibility or obligation that an engineer has to help solve social problems or help others through their professional capacity. Example PC survey items for illustrative purposes include:

> It is important to me personally to have a career that involves helping people.
> I feel called by the needs of society to pursue a career in engineering.
> I think it is important to use my engineering to serve others.

Among the 19 items were five negatively worded items that were reverse scored. PC item responses were on a 1 to 7 Likert-type scale (strongly disagree to strongly agree). An overall PC score for each student was computed by averaging the responses across the 19 items.

Demographic items

Demographic items were included at the end of the survey instrument. The gender question presented the choice options of male, female, and prefer not to say. When the original study was developed in 2012, the binary format for gender questions was the norm. Student's race/ethnicity was determined using a single question format rather than the two separate questions that has been the norm in recent U.S. census [44]. The question on the 2012 version of the survey only allowed students select a single response from among the options (see Table 2). Other variants of the race/ethnicity question could have been selected, such as two or more races, multi-racial or multiple ethnicities (see range of examples in [39]). In contrast, the survey was modified in 2014 to allow students to “check all that apply” from among the race/ethnicity options (see Table 2). As proposed in Patterson et al. [39] we believe “that it is preferable to specify the particular races contributing to one’s multiraciality as opposed to ascribing to a single catch-all multiracial category which effectively denies the opportunity to disaggregate the racial combinations constituting this categorization.” In this paper we will refer to the non-Hispanic White response category as ‘White’. On the 2014 survey there was also an item that asked ‘Did you grow up primarily outside of the U.S.?’ and the only response options available were yes and no. Students could skip any items on the survey.

Table 2. Format of race/ethnicity question on the two surveys and improved recommendation

2012 survey: Race	2014 survey: Race (check all that apply)	Recommendation for future surveys: Race/ethnicity with which you self-identify (check all that apply)
African American	African American	African American or Black
Hispanic	Hispanic	Hispanic / Latinx
Asian	Asian	Asian
Native American	Native American	Native American / Alaskan Native
Non-Hispanic white	Non-Hispanic white	Caucasian / White
Multiracial	Multiracial	Native Hawaiian or Other Pacific Islander
International	[I]	International: ________________
Other *	Other:____________________	Other: ________________
Prefer not to say	Prefer not to say	Prefer not to say
{could skip item}	{could skip item}	{allowed to skip item}

* The dataset includes no respondents who selected this item and therefore it was likely omitted from the online survey. [I] A separate survey question asked: did you grow up primarily outside the U.S.?

Institutions

In 2012 the survey was distributed at five institutions (for more detail see [18]). While these institutions represented different types of institutions in three different geographic areas, none had a history of a diverse population of engineering students in terms of race/ethnicity and all would be considered predominantly white institutions (PWI). In 2014 the survey was distributed at 17 different institutions (including the 5 institutions from 2014) [26]. Again, these institutions were not intentionally selected to represent institutions with a diverse student population in terms of race/ethnicity. Thus, the very high representation of White non-Hispanics in the dataset is not surprising. If a goal was to explore under-represented groups, one should intentionally select institutions with a more diverse student population. The ASEE publishes data on institutions with the highest number of Bachelor’s degrees awarded to students from different racial/ethnic groups, and appropriate partnering institutions should be selected to examine this issue.

Data

In total, this study considers 3393 student responses, including 1088 from fall 2012 (primarily from first year, senior, and graduate students majoring in mechanical, civil, and environmental engineering) and 2305 student responses from spring 2014. Previous publications have explored these response groups separately, and have not reported specifically on the professional connectedness dimension. The data sets were combined in an attempt to increase the statistical power and ability to detect differences among groups of students. Example results from power analyses are shown in Figure 1. These calculations used on online tool [57], which assumed normally distributed data; however, standard statistics are quite robust to violations of normality and ordinal Likert scale data [58]. The results reveal that in order to detect a difference of 0.2 between groups at the 'typical' average PC of 5.0 vs. 5.2 and a standard deviation of 1.0, this combined sample size could detect a difference only for groups with a ratio of majority:minority of 15:1. Alternatively if the standard deviation were smaller at 0.7, this combined sample size could detect a significant difference between 5.0 and 5.2 for a majority:minority ratio of 30:1. These power calculations imply that small sample sizes pose a problem for detecting differences between groups with low representation in engineering.

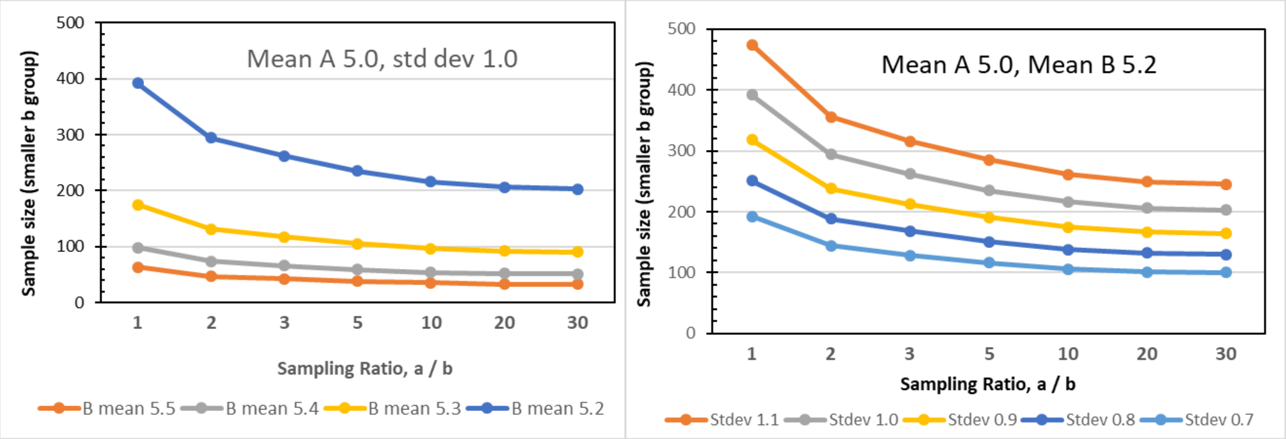

Figure 1. Sample sizes of the minority group needed to statistically detect differences with a Type 1 error rate of 5% and a power of 0.8.

Statistical comparisons were conducted among demographic groups. The averaging across 19 questions makes the response options semi-continuous (133 different discrete response levels possible). Across all 3393 responses the average was 5.11, standard deviation 0.85, skewness -0.49 (logical given the ceiling effect in the data), excess kurtosis 0.36. Overall, the results were not significantly non-normal, so statistical comparisons used typical t-tests (unpaired, unequal variance in Excel). These statistical tests have been shown to be robust for use with Likert-type data that may be non-normal [58-60]. In general, a "sub-group" of interest was compared to the most common demographic group (e.g. female compared to male; Hispanic compared to White non-Hispanic). The normality of the data for these sub-groups was not tested; due to the small number of respondents from some populations the t-test may not be robust.

While traditional statistical tests set with a restrictive alpha value help to minimize the chance of a Type I error where the null hypothesis should not be rejected (in this case, minimize our chance of erroneously identifying differences between demographic groups), it is unclear that the differences detected will be meaningful. Cohen's D was calculated to provide an indication of the meaningfulness of detected differences and increase attendance to Type II errors. Cohen's D was calculated using an online calculator [61] and can be interpreted as: d <0.20 very small difference, d 0.2 to 0.5 small difference, d 0.5 to 0.8 medium difference, d >0.8 large difference.

Limitations

Students were at different points in their education when they took the survey, ranging from incoming first-year students to graduate students (part of the fall 2012 data set). Previous research found longitudinal changes in the social responsibility attitudes of engineering students [25, 26]. The majority of the survey items were positively worded, so acquiescence or positive response bias [62, 63] could impact the data. Social desirability response bias [63-66] may also cause the responses not to accurately represent the true feelings of students. These survey response patterns are more likely for some demographic groups [67-69]. For example, among 12th graders African American students appeared to have the highest acquiescence response style, but ultimately the authors concluded "racial/ethnic and gender subgroups among adolescents in the contemporary United States are more similar than different in their questionnaire response styles" [68 p. 8]. Even the determination of whether or not to take the survey may cause the responses to not be accurately representative of students at large. For example, leverage salience theory [70] indicates students are more likely to participate if the topic is of personal interest or importance. The consent process and title of the survey itself indicated that the survey topic explored professional social responsibility, which could increase the potential that engineering students with more positive attitudes toward social responsibility would participate in the survey. As previously noted, the demographic item wording on the surveys and institutions where the surveys were administered presents challenges to a thorough exploration comparing the professional social responsibility attitudes of students with differing intersectional identities.

Results and Discussion

Gender

There was a clear difference among the responses based on student gender, as shown in Table 3 (t-test male vs. female p < .001). This result has been previously reported and discussed based on the 2012 data [21] and the 2014 data [27], and also agrees with broader literature [2, 19, 20]. In addition to the standard t-test, a Cohen's d was calculated to indicate the size of the difference; there was a medium difference between male and female students (where d of 0.50 to 0.80 is considered medium [61]).

Table 3. Summary of Professional Connectedness data based on response to gender question

Response	Average PC	Standard Deviation	n	Sign diff? p-value vs. male	Cohen's d vs. male
Male	4.97	0.86	2150	-	-
Female	5.39	0.76	1145	<.001	0.51
Prefer not to say	4.91	0.93	49	.64	0.070
Blank	5.04	0.84	49	.56	0.082

There were 1.4% of the students who selected the 'prefer not to say' (PNS) option. This selection may have included students who did not self-identify into the binary gender options provided on the survey. Nearly all of the 1.4% of the students who left the gender question blank skipped all of the demographic items (except for 4 students). The students who skipped all of the demographic items may have felt their demographic characteristics were not relevant or had tired of the survey (the median survey response time was 17 minutes).

Critiquing the study, a deficiency in acknowledging non binary genders is evident in the wording of the demographic item. Like the U.S. 2020 Census [45], "Unfortunately, this question fails to acknowledge the myriad of sexes and genders that exist." [71]. In the future an improved item could ask respondents to indicate their 'current gender identity' and provide the response options of female, male, additional gender category (or other), and decline to answer. The 2019 ASEE data noted 4 non binary and 50 other gender Bachelor's graduates [31].

Race/Ethnicity

The race/ethnicity responses among students who answered the previous gender question on the survey are summarized in Table 4. Compared with the demographics of students receiving Bachelor's degrees in engineering in the U.S. [72], the dataset included fewer students identifying with underrepresented minority racial/ethnic groups (URM), including Hispanic and Black/African American. The 2012 survey only allowed students to select a single race/ethnicity category, in contrast to the 2014 survey. On the 2014 survey, 7.4% of the students (n=169) selected multiple race/ethnicity categories, higher than individuals selecting multiracial on the 2012 survey and higher than national data (which has an unclear method by which students' race/ethnicity is determined, and likely combines different approaches used at different institutions [39]). Among the 2014 responses, looking only at the 1221 students attending the same 5 institutions as were surveyed in 2012, 4% selected more than one race/ethnicity category. The 2014 data reveals that over half of the students who selected Native American and African-American selected additional race/ethnicity categories (Table 5). It is uncertain whether these students would have selected a single "most predominant" identity category or "multiracial" under the single-selection constraint in the 2012 survey. In addition, it is worth noting that the multiracial category includes individuals with no URM identities in engineering (e.g. White and Asian American) and individuals with multiple URM identities in engineering (e.g. Black and Native American). A potential data analysis approach reclassifies the 2014 students into multiple monoracial subgroups, inflating the number of students in each race/ethnicity group but ignoring the unique multiracial identities of the students (Table 4).

Table 4. Race/Ethnicity responses of survey respondents

Race/Ethnicity	2012		2014				2012+2014	Nat'l*
	n	%	n multiple	%	% additional R/E responses	n single category	%	%
White non-Hispanic	797	75.4	1673	73.2	7.8	1574	70.9	65.9
Asian	112	10.6	303	13.2^	20.8	241	10.6	13.1
Hispanic	39	3.7	138	6.0	34.8	91	3.9	10.1
Multiracial	32	3.0	122	5.3	61.5	180	6.3	1.9
African-American	7	0.7	26	1.1	53.8	12	0.6	3.5
Native American	3	0.3	39	1.7	89.7	4	0.2	0.4
International (2012)	8	0.8	--	--	--	0	0.2	NI
Other (2014)	--	--	80	3.5^	58.8	33	1.0	
Prefer not to say (PNS)	55	5.2	146	6.4	2.1	146	6.0	
Blank (answered gender question)	4	0.4	6	0.3	0	6	0.3	
Total students (sum)	1057	(100)	2287	(113.5)		2287	3344	

^ *Some of these also grew up primarily outside the U.S.*

* *2013-2014 U.S. Engineering Bachelor degree percentages do not include foreign nationals [72]*

Table 5. Details on the 2014 students selecting multiple racial/ethnic groups

Monoracial category selected	% indicating additional category	Most common additional groups selected (n students)
White non-Hispanic	7.8	Multi 45, Asian 45, Other 42, Hispanic 30
Asian	20.8	White 45, Multi 40, Hispanic 7, Afr. Am. 4
Hispanic	34.8	White 30, Multi 26, Native Am. 12, Asian 7
African-American	53.8	Multi 8, White 8, Native Am. 6, Hispanic 6, Asian 4
Native American	89.7	White 27, Multi 13, Hispanic 12, Afr. Am. 6
Other	58.8	White 42, Multi 8, Hispanic 5, Asian 4, Native Am. 4

Among the 80 students who selected "other" on the 2014 survey, 19 also indicated that they grew up primarily outside the U.S. Among the 60 write-in responses, there were 12 Middle Eastern and 6 African, so a number of the international students may have selected the other category. There were five Hawaiian/Pacific Islander. A number of the other responses (n=35) were forms of Caucasian / White. One of the student responses seemed to indicate frustration with this type of question and/or the response options provided; i.e., "white. i dunno. American? don't we have those anymore?"

Two different methods of allocating students into race/ethnicity groups were compared, which allow the responses from 2012 and 2014 to be combined. One method averaged students in any of the race/ethnicity groups they selected (and therefore some individuals were included in multiple groups); this is identified in Table 6 as "students in multiple categories." Alternatively, student respondents from 2014 who selected multiple categories were placed into single categories using the following steps. If the respondent selected "White non-Hispanic" and other, and wrote-in a form of Caucasian, the response was identified as "White non-Hispanic." The 3 students who selected PNS and various race/ethnic categories were assigned to PNS. All of the other individuals who selected multiple responses were assigned to "multiracial" (Table 6 single categories). From this process it was found that multiracial encompassed all of the combinations of responses in Table 5. Using this 'single categories' counting, some groups have a very small number of students (e.g. Native American, African-American).

The group-level PC averages did not change significantly between the two different race/ethnicity classification methods (Table 6). Even categories where the average appeared to differ (e.g. other, Native American, multiracial) were not statistically significant differences (in two-tailed t-tests the p values were 0.11 or more). The standard deviation among the responses in a group were generally lower among students who identified a single category versus multiple categories (e.g. African American, Native American).

Counting students in any of the individual race/ethnicity categories that they identified (i.e., students in multiple categories) resulted in the following trend in the average PC values among groups:

Hispanic $\geq$ African-American $\geq$ Asian = Multiracial > White = Other $\geq$ Native American

This was generally similar to the single categorization method (although the lower numbers of students in each group reduced the ability to identify statistically significant differences):

Other $\geq$ African-American = Hispanic $\geq$ International = Asian $\geq$ Native American $\geq$ White = Multiracial

Table 6. PC results among students in different racial/ethnic groups

Race/Ethnicity	Students in Multiple Categories			Students in Single Categories		
	Avg PC	Stdev	n	Avg PC	Stdev	N
White non-Hispanic	5.10	.85	2470	5.10	.86	2371
Asian	5.18^{W}	.74	415	5.20^{W}	.72	353
Hispanic	5.29^{W}	.89	177	5.33^{W}	.87	130
Multiracial	5.17	.88	154	5.08^{H}	.87	212
African-American	5.25	.63	33	5.34^{w}	.56	19
Native American	5.03^{h}	.89	42	5.17	.85	7
International (2012)				5.23	.95	8
Other (2014)	5.08^{h}	.89	80	5.41^{W}	.75	33
Prefer not to say (PNS)	4.94^{H}	1.00	201	$4.94^{W,H}$	1.00	201
Blank				5.07^{H}	.81	59
Asian + White nonHisp				*4.97*	*.79*	*39*
Hispanic + White nonH				*4.93*	*.87*	*18*

2-tailed t-test: compared to White: ^{W} p<.05, ^{w} p<.10; compared to Hispanic: ^{H} p< .05, ^{h} p<.10

There were an array of complex multi-racial identities evident, without a large number of any particular group. The two largest specific biracial groups are shown in Table 6, and show PC averages that are more similar to the White non-Hispanic group than the other racial identity (Asian or Hispanic). [The number of biracial students in Table 6 is lower than the values in Table 5 which also includes students who selected 3 or more racial/ethnic groups.]

The results show some statistically significant differences in PC, with White students lower than Hispanic and Asian students, and likely lower than African-American students. The differences were generally small, based on the low Cohen's d values (Table 7). The lowest average PC was among students who selected PNS as their response to the race/ethnicity question; this group also had the largest standard deviation among the categories. The highest average PC, based on the single category results, was among African-American and Hispanic students.

Table 7. Cohen's d results comparing PC of different race/ethnic groups

Compared groups	Student in multiple categories	Students in single categories
Asian vs White	.10	.12
Hispanic vs White	.22	.27
African American vs White	.18	.28
Other vs White	.02	.36
PNS vs White	.19	.18

These data also show the hazards of lumping all URM students together. As a specific example, the single PC item among the 19 that showed the largest difference among race/ethnic groups was "Engineers should use their skills to solve social problems"; the average response among students who identified as Native American was 5.10 versus 5.78 among Hispanics. An artificial binary was created to simulate common practice in many studies. NonURM included White and Asian (n=2775) and URM included African American, Hispanic, Native American, and Pacific Islander (n=232). Students on the 2014 survey who identified multiple race/ethnicity categories but all falling into URM groups or nonURM were assigned accordingly. Predictably, based on the data in Table 6, URM differed from nonURM (URM avg PC 5.23±0.87, nonURM avg PC 5.11±0.84; t-test p 0.043).

Additional demographic questions illustrate other potential intersections of culture and experience. Asians who did or did not grow up primarily in the U.S. had an average PC 5.18 vs. 5.07, respectively (n=203 and 100 in the 2014 survey data, respectively). White non-Hispanic students who were also the first-generation (FG) in their family to attend college had an average PC of 4.98 compared to 5.10 for non-FG (2012 survey data only; the first-generation demographic question was not included on the 2014 survey). This indicates an area of interest for future research.

Intersection of Gender and Race/Ethnicity

The PC data for the intersectional demographic categories of gender and race/ethnicity are summarized in Table 8. The female PC average scores were higher than male average PC scores for all categories of race/ethnicity, but this difference ranged from 0.28 for Hispanics to 0.84 for the respondents who selected PNS for race/ethnicity. The gender differences in average PC scores were not statistically significant for Native Americans; the lack of statistically significant difference may be partially due to the low number of Native American students among the survey respondents. For the students in 2014 who selected ‘other’, the average PC scores were different between male and female students, using scores that included those who selected ‘other’ among additional race/ethnicity categories (p=.03).

Table 8. Average Professional Connectedness and numbers in different gender and race/ethnicity intersectional groups (students in multiple / single race/ethnicity categories)

Race/Ethnicity	Average PC multiple/single categories			Number of survey respondents in group		
	Male	Female	PNS	Male	Female	PNS
Other (2014)	$4.98/5.40^{W}$	5.47/5.57	--	60/19	22/12	2
Hispanic	$5.24/5.23^{W}$	$5.52/5.56^{Fw}$	--	111/90	50/40	1
International (2012)	5.20	5.32	-	6	2	0
African-American	5.12/5.11	$5.45/5.60^{fw}$	--	16/10	16/9	0
Asian	$5.07/5.03^{h}$	$5.47/5.48^{Fw}$	--	223/218	132/131	5
White	$4.98/4.97^{H}$	$5.39/5.36^{F}$	4.7/4.8	1482/1545	743/817	10/9
Multiracial	$4.95/4.93^{H}$	$5.43/5.33^{Fh}$	--	84/130	57/81	1
Native American	4.92/*4.77*	5.29/*5.46*^{w}	--	24/3	17/4	1
Prefer not to say (PNS)	4.73^{WH}	5.56^{Fw}	4.96	125	43	33

-- not shown since ≤5 students; 55 students provided no demographic information and have an average PC 5.05
Female different than male in same race/ethnicity group; ^{F} p<.05; ^{f} p<.10
Compared to White students in same gender: ^{W} p<.05; ^{w} p<.10; Compared to Hispanic students: ^{H} p<.05; ^{h} p<.10

The trend for average PC scores for males were:

Hispanic ≥ African American ≥ Asian ≥ White ≥ Multiracial ≥ Native Americans ≥ PNS.

Note the very large change in the average PC of the male students who selected the ‘other’ category between the two counting methods. The lower average among students who checked other in addition to a variety of different race/ethnicity categories appeared largely driven by White male students who checked other and wrote-in Caucasian and variants. In addition, many of the students who checked other were classified as multiracial when singular categories were assigned. Thus, the remaining males in the other category were largely international students. Across the race/ethnicity response categories (excluding PNS) the difference in average PC among male students was 0.32 when students were counted in their multiple monoracial groups and 0.63 when students were counted in single categories.

There were smaller differences in average PC among different race/ethnicity groups for female students compared to male students; 0.23 when female students were counted in their multiple monoracial groups and 0.28 when students counted in single categories. The trends among the average PC scores for different race/ethnicity categories of female students were harder to readily classify, based on fairly large differences among the two counting methods (perhaps due to very low numbers of students in some of the intersectional categories). Basing the classification on the ‘single category’ classifications:

African American ≥ PNS = Hispanic ≥ Asian ≥ Native American > White ≥ Multiracial.

The calculated values of Cohen’s d comparing the average PC scores based on the single race/ethnicity classification are shown in Table 9. There are some large differences evident (e.g. between male and female African American and Native American engineering students). The Cohen d values appear to show a few statistical differences that were missed by the t-test, indicating that the low sample size and restrictive 0.1 p value (to ensure a low probability of a Type I error) may have caused a high Type II error rate. For example, the Native American males likely had a lower PC than Native American females, as well as male Native Americans having a lower average PC than Hispanic males and White males

Table 9. Cohen’s d results comparing PC of different intersectional groups (based on single race/ethnicity categories); bold indicates differences >0.2 without t-test p<.1; d values below 0.2 have been italicized

Compared groups	Male vs. Female	White vs.		Hispanic vs.	
		M	F	M	F
White	0.467	--	--		
Asian	0.647	*0.071*	*0.156*	0.254	*0.121*
Hispanic	0.383	0.301	0.256	--	--
African American	0.949	*0.163*	0.307	*0.131*	*0.066*
Native American	**0.824**	**0.232**	*0.127*	**0.485**	*0.160*
Multiracial	0.473	*0.046*	*0.038*	0.326	0.323
Other	**0.327**	0.503	**0.267**	*0.197*	*0.015*
PNS	0.894	0.276	0.255	0.516	*0.001*

Conclusions and Implications

Differences were found in the average professional connectedness attitudes among the engineering students in different intersectional demographic groups. Specifically, the strongest professional connectedness attitudes were identified among female African American and female Hispanic students (average 5.60 and 5.56, respectively) and the weakest PC attitudes were among White male and multiracial male students (average 4.97 and 4.93, respectively); the average PC attitudes of the three Native American males in this study were also weaker than other groups. This study found differences in the PC attitudes among engineering students in different racial/ethnic groups that were not evident in previous studies. The study also confirmed that female students have stronger social responsibility attitudes than male students, both overall and within each racial/ethnic group (per Table 9 Cohen d values). The research also illustrates the challenges of using quantitative methods to study the attitudes of students with intersecting underrepresented identities.

While these results do not account for changes that might occur over time, this snapshot indicates that if female African American and female Hispanic engineering students persist to work as engineers after graduation, they will bring stronger feelings about their responsibility to serve society through their work. However, African American and Hispanic females may struggle to feel belonging and have few role models due to low representation, both factors that could negatively impact their persistence in the engineering workforce.

Even before entering the profession, students highly motivated to help society through their work appear to leave engineering at a higher rate than other students [73,74]. This might be due to communal goal congruity, similar to findings by [2]. The lack of visibility of how engineers help people and society may contribute to a loss of interest in engineering, which was found to be a major reason that STEM majors switch out [75]. This issue may also compound the variety of other reasons women and URM students leave STEM majors that were identified in *Talking About Leaving Revisited* [75], including the competitive climate in STEM and loss of confidence, plus STEM instructor pedagogy and curricular design (which affected a large percentage of all students).

Consideration of multiracial identities is salient. Institutions may not be accurately considering these self-identifications in their classification methods. Further, multiracial engineering students may face challenges associated with belonging. For example, do multiracial students feel they fit into groups such as the National Society of Black Engineers (NSBE), the Society of Hispanic Professional Engineers (SHPE), or the American Indian Society of Engineers and Scientists (AISES)? The experiences described in the autoethnographies in Williams and Ware [51] described how biracial students may feel caught between worlds. This issue could become even more complex for female URM students. How might they decide the extent to which they allocate time to participate in the Society of Women Engineers (SWE) or professional societies focused on racial/ethnic identities? The results of this study imply that discussing the societal impacts of engineering in these clubs could be of interest to URM and female students, which may benefit their persistence in pursing engineering degrees and entering the workforce.

More broadly, researchers should consider the relative value of focusing attention on demographic differences, versus also drawing attention to similarities [76]. In this large dataset only 9.6% of the engineering students (325 of 3371) had average PC scores below 4 that were indicative of negative attitudes toward professional social responsibility among engineers. Thus, teaching students about the societal benefits of engineering would appear to be welcomed or received neutrally by 9 of 10 engineering students. The very process of examining differences can result in furthering feelings of otherness. Being overly focused on categorization may feel limiting to students with rich multi-faceted identities. Boucher et al. [1] point out that men also value communal goals and "highlighting how individuals across genders value communal goals at differing strengths, instead of perpetuating perceptions that a certain gender alone highly values communal goals, can lead to changes in the stereotypes of STEM fields and who fits within them." (p. 8). The findings in this study reinforced that on average, engineering students in all of the intersectional gender-racial groups felt some level of professional connectedness to the social responsibilities of engineering. Thus, engineering faculty are encouraged to highlight the social benefits of engineering in their instruction.

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