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An Intersectional Approach to Exploring Engineering Graduate Students' Identities and Academic Relationships

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ABSTRACT

This study explores graduate engineering identity and the influence of peer and academic advisor relationships using an intersectional lens. A survey collected 1,754 U.S. engineering graduate students' reports of their experiences, identities, and motivation and explored two research questions using a combination of MANOVAs and moderated regressions. Peer and academic advisor attitudes are positively related to all aspects of graduate engineering identity. Students' identities significantly predicted mean differences across scientist, engineer, and researcher identities and their sub-constructs. Male and female Asian students scored lower than their peers in self-assessments of their scientist recognition and performance/competence, while other groups showed more variability. Advisor relationship scores were similar for all students, but peer relationship scores were lower for Students of Color. Students' social identities also led to differences in the relationships between advisor/peer relationship scores and engineering identity. Men and Women of Color often reported significantly different effects of peer relationships on identity, with men reporting positive effect and women reporting no effect. Asian women and Underrepresented Women of Color differed from White women, where Women of Color reported stronger benefits from positive academic advisor relationships. This paper explores these results and the implications for researchers and educators working with graduate populations.

KEYWORDS

engineering identity; intersectionality; peer relationships; advisor relationships; peer attitudes; advisor attitudes; engineering identity; graduate students

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INTRODUCTION

Research with undergraduates indicates that the strength of a student's engineering identity (EI) is connected to their experiences with academic advisors and peers (Robnett, 2013), and that the type and quality of these experiences -- as well as how they reinforce or detract from students' identities -- varies according to one's social identity (Wilson, Bates, Scott, Painter, & Shaffer, 2014). This study extends these findings to graduate education and contextualizes findings in terms of students' racial and gender identification. This work is beneficial in two ways. First, it expands our knowledge of engineering graduate students by bringing the existing literature about engineering identity into the graduate space, an environment marked by high attrition, motivation struggles, and the mastery of new, difficult tasks -- all hurdles which can potentially be overcome by nurturing strong engineering identification (Godwin, Potvin, Hazari, & Lock, 2016; Lovitts, 2001; Oyserman, 2015). Second, this work centers on the experiences and identities of overlooked groups, such as Women of Color, by making them the focus of this analysis.

In this work, we define graduate engineering identity (GEI) as the ways in which students describe themselves and are positioned by others as an engineering graduate student. This definition is consistent with foundational identity theories (Burke & Stets, 2009) and with research on identity in engineering education (Brickhouse, Lowery, & Schultz, 2000; Godwin, 2016). However, GEI differs from undergraduate engineering identity, as it focuses on the development of skill sets that are necessary for success in graduate school. Graduate engineering identity is theorized to consist of students' identification across disciplinary domains, (scientist, researcher, and engineer), and the strength of their identification within each domain is determined by the students' evaluations three sub-constructs: *performance/competence*, *recognition*, and domain *interest* (Carlone & Johnson, 2007; Godwin et al., 2016; Hazari, Potvin, Tai, & Almarode, 2010; Perkins et al., 2017). *Performance/competence* beliefs include how well students believe they can accomplish their work, as well as how well they can understand concepts in each domain. Performance/competence beliefs are predictors of engineering identity, but only when interest and recognition are used as mediators (Godwin, 2016; Potvin & Hasni, 2014). *Recognition* consists of students' internalized beliefs that others (i.e., peers and instructors) see them as the type of person who can do science, research, or engineering. A study examining engineering identity as a predictor of engineering career interest found that recognition was the most important sub-construct for undergraduate students (Godwin et al., 2016; Malone & Barabino, 2009). *Interest* includes students' personal (rather than situational) interest in each domain (Renninger et al., 2014). Interest predicts students' persistence in engineering: students who indicated a higher interest in engineering subjects were more likely to persist in their engineering degree pathway when controlling for major, year in school, mother's level of education (a proxy for socioeconomic status), and gender (Patrick, Borrego, & Prybutok, 2018).

Intersectionality

Crenshaw (1989) coined the term intersectionality to highlight how traditional examinations of 'race' and 'gender' erased Women of Color. This framework articulates how social identities, genders, and races or ethnicities cannot be reduced to single categories -- rather, these categories mutually construct each other and can reinforce or disrupt patterns of exclusion and marginalization (Collins, 1989; Ong, Wright, Espinosa, & Orfield, 2011). Existing work with engineering students has examined systemic inequity in the field, but often only aspects of individuals' identities are considered. For instance, the effect of engineering's masculine environment on women's identities was explored by Powell, Bagilhole, and Dainty (2009), but Women of Color were completely omitted from the conversation. Work with female doctoral students further articulated how engineering's masculine environment impacts women (e.g., sexism, microaggression, and hierarchical climates; (Barthelemy, McCormick, & Henderson, 2016; Sallee, 2011). There are similar patterns in studies that focus on race: for example, Major, Fletcher, Streets, and Sanchez-Hucles (2014) drew from a study of women to investigate the effects of the proportion of a minority group needed to overcome the negative effects of tokenism. Despite this female-focused starting point, they did not discuss gender or its effects at all in their analyses.
There are promising exceptions -- studies that focus on Black men have identified the harmful role that microaggressions play in peer and advisor relationships, and the ways in which class and race intersect for graduate students (Burt et al., 2016; Sánchez, Liu, Leathers, Goins, & Vilain, 2011). Additionally, students with intersecting identities have lower ratings of self-perceived skills than majority students, and although they are frequently clustered into a single group, there is still a great deal of unexamined latent diversity (Kirn et al., 2016; Ro & Loya, 2015). However, students who exist at the intersections are understudied and few large-scale quantitative studies include discussion of race and gender throughout their analyses. Most of this work focuses on undergraduate populations and issues, although success in graduate school is required to foster diversity in the academy broadly.

Peer & Academic Advisor Relationships in Graduate School

The literature regarding relationships in graduate school is especially sparse, although the consensus is that they are important to student success. Relationships are discussed in the context of graduate school or engineering students, the focus is on mentorship (e.g., Allen & Eby, 2007). Here, mentorship refers to a specific dynamic focusing on guidance and professional development. Although advisors and peers can be mentors, it is a not a requirement of these roles. Earlier work has identified how peer and advisor relationships can be negatively impacted by racism and sexism, and much of the research has reflected on broad patterns of socialization instead of students' immediate experiences (Gardner, 2008). Sometimes Students of Color are the focus of the study, but again, direct measures of relationship quality often are not explored (Obiomon, Tickles, Wowo, & Holland-Hunt, 2007).

To briefly summarize existing findings: positive relationships with advisors contribute to students' on-time degree progress (Ferreira, 2006; Schlosser, Lyons, Talleyrand, Kim, & Johnson, 2011), and 'good advising' consists of a wide array of behaviors, such as efficient communication, affective support, and acting as a source of knowledge (Wrench & Punyanunt, 2004; Zhao, Golde, & McCormick, 2007). Peer relationships appear to operate in similar ways -- for undergraduate Women of Color who join STEM organizations and discuss course content with their peers are more likely to persist, and close relationships with college friends provide positive experiences for first-year college students (Swenson, Nordstrom, & Hiester, 2008). Specific to engineering, female students who work in groups that are at least 50% female report more motivation, persistence, and confidence (Dasgupta, Scircle, & Hunsinger, 2015). Despite these positive and important results, there are few studies that focus on graduate students' motivation and identification as engineers, at the intersection of race and gender.

The Current Study

The previous sections describe engineering identity, intersectionality in STEM and engineering education research, and findings regarding relationships in graduate school. To summarize, most existing literature overlooks or outright erases female Students of Color due to a focus on race and gender as "single, distinct factors" (Hankivsky, 2013, p. 2; Lord et al., 2009). Thus, they do not uncover the inequities that are "the outcome of intersections of different social locations, power relations and experiences" (Hankivsky, 2013, p. 2). For those occasions when race or gender are key components in an analysis, the focus is on how students' social identities disrupt the assumed 'norm' as reported by majority students, instead of including them as part of the original population. Researchers have provided some recommendations about how to be more inclusive in research, e.g., avoiding the 'intersectional trap' (treating race and gender as separate factors), or allowing for complex and nuanced observations (Lord et al., 2009;). To this end, this study examines the quality of peer and academic advisor relationships and the strength of engineering identity while centering the experiences of intersectional groups. The approach is guided by two central research questions:

1. When engineering graduate students are clustered into groups with similar race and gender characteristics, are there systematic differences in self-evaluations of their relationships and engineering identities?
2. What are the effects of relationships on engineering identity when viewed in the context of students' social identities? In other words, is the effect of relationship quality on engineering identity moderated by race and gender?

Table 1A. Participant demographic information

Demographic	Categories	Count	Percent	Analysis Code
Race	Asian	474	0.2702	Asian
	Black or African American	37	0.0211	Underrep'd
	Hispanic, Latino/Latina/Latinx, or Spanish origin	53	0.0302	Underrep'd
	Middle Eastern or North African	49	0.0279	Underrep'd
	Native Hawaiian or Other Pacific Islander	1	0.0006	Underrepr'd
	White	846	0.4823	White
	Write-In	25	0.0143	Underrep'd
	Multiple Options Selected	124	0.0707	Underrep'd
	Not Answered	145	0.0827	-
Gender	Female	564	0.3216	Female
	Male	1020	0.5815	Male
	Genderqueer	8	0.0046	-
	Agender	1	0.0006	-
	Transgender Female	2	0.0011	Female
	Transgender Male	2	0.0011	Male
	Not Answered	157	0.0895	-
Sexuality	Heterosexual/Straight	1432	0.8164	-
	Gay/Lesbian	40	0.0228	-
	Bisexual	64	0.0365	-
	Asexual	9	0.0051	-
	Write-In	15	0.0086	-
	Not Answered	194	0.1106	-
Degree Pursued	Masters	486	0.2771	-
	PhD	1189	0.6779	-
	Other	6	0.0034	-
	Not Answered	73	0.0416	-

Table 1B. Students with Intersectional Social Identities

	Underrepresented		Asian		White	
	Count	Percentage	Count	Percentage	Count	Percentage
Male	126	.099	235	.184	401	.315
Female	86	.068	116	.091	232	.182

Note: Table *n*s reflect sample size used in analysis. Participants with missing data have been dropped.

METHOD

Participants

A nationally stratified sample of U.S. graduate students were asked to participate in a study about their experiences, identities, and motivations. The final sample (n = 1,754) was collected from over 100 universities, half of which provided 10 or more participants. Using chi-square tests and the resulting standardized residuals, we compared our participants to recent engineering graduate degree earners in the U.S. from the same time frame (NSF & NCSES, 2019; Tabachnick & Fidell, 2013). Our analysis indicates that our sample (see Table 1) differed from the comparison population described by the National Science Foundation (NSF), with multiracial students (those who indicated belonging to two or more races/ethnicities) highly over-represented and Asian and Latinx moderately underrepresented. The percentages of men and women in both sets of data did not vary significantly, and as the NSF does not provide data about participants with non-binary genders, we could not compare those values. The increase in multiracial students may be due to changing demographics in the population, a more nuanced approach to demographics collection in our survey (Fernandez et al., 2016), or over-sampling and/or self-selection biases.

Measures

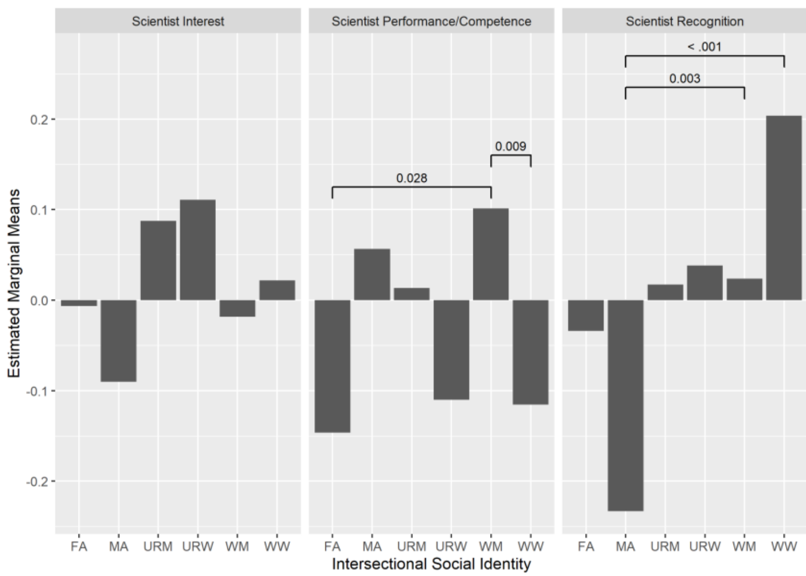
Three established scales were used to assess students' GEI, and two new short scales were used to asses peer and academic advisor relationship attitudes (Godwin, 2016; Perkins et al., 2017). Forty-five items asked about recognition, performance/competence, and interest across three identity domains (see Appendix A for a full list of items and Cronbach's alphas). Participants indicated agreement or disagreement on a 5-point Likert scale, and scores were averaged into variables identified by exploratory and confirmatory factor analysis (Perkins, et al., 2018). This process resulted in nine identity scores for each participant, with each score capturing one sub-construct (e.g., recognition) of each domain (e.g., scientist). This allows us to compare specific elements of students' identities. Relationship attitudes were assessed using 12 items that asked about peers and academic advisors (see Appendix B). These items were developed from qualitative research with graduate students in which they discussed their graduate experiences and identities and are used here as an overall measure of relationship quality (Perkins et al., 2017).

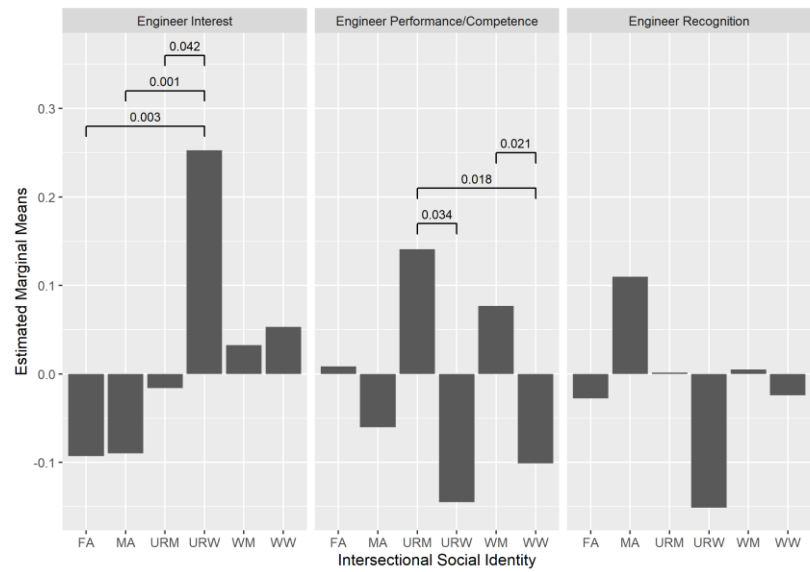
Table 2. Results of MANCOVA and ANCOVA analyses.

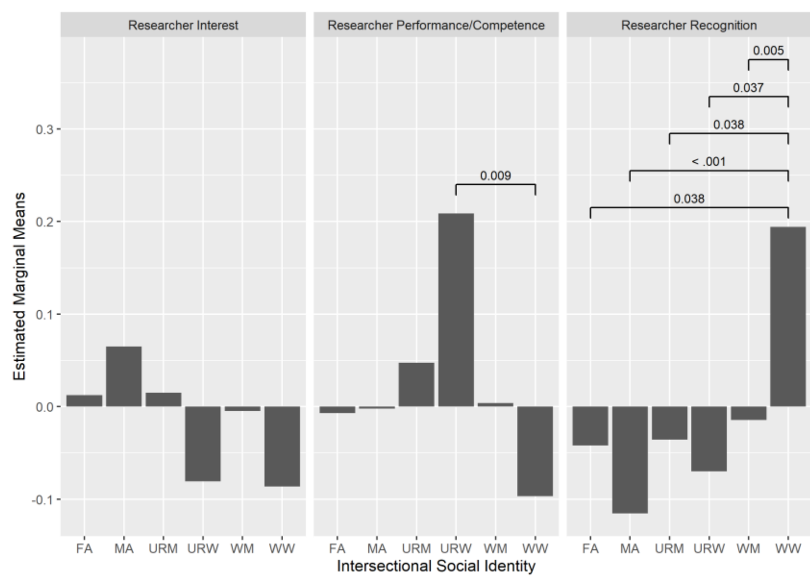
						Asian Men		Asian Women		Under-Represented Men		Under-Represented Women		White Men		White Women	
		Pillai's Trace	F-value	p-value	η_p^2	M	SE	M	SE	M	SE	M	SE	M	SE	M	SE
	All Domains, All Sub-Constructs	0.14	3.61 (45,1161)	< .001	-												
Scientist Identity	All Sub-Constructs	0.06	4.70 (15,1166)	< .001	-	-	-	-	-	-	-	-	-	-	-	-	-
	Interest		1.33 (5,1180)	0.25	-	-	-	-	-	-	-	-	-	-	-	-	-
	Performance/ Competence		3.90 (5,1180)	0.002	0.02	0.06	0.05	-0.15 (WM)	0.07	0.01	0.07	-0.11	0.08	0.10 (AW, WW)	0.04	-0.12 (WM)	0.05
	Recognition		6.34 (5,1180)	< .001	0.03	-0.23 (WM, WW)	0.06	-0.03	0.08	0.02	0.08	0.04	0.09	0.02 (AM)	0.04	0.2 (AM)	0.06
Engineer Identity	All Sub-Constructs	0.06	4.45 (5,1180)	< .001	-	-	-	-	-	-	-	-	-	-	-	-	-
	Interest		4.31 (5,1180)	< .001	0.02	-0.09 (URW)	0.04	-0.09 (URW)	0.06	-0.02 (URW)	0.06	0.25 (AM, AW, URM)	0.07	0.03	0.03	0.05	0.04
	Performance/ Competence		4.22 (5,1181)	< .001	0.02	-0.06	0.04	0.01	0.06	0.14 (URW, WW)	0.06	-0.14 (URM)	0.07	0.08 (WW)	0.03	-0.1 (URM, WM)	0.04
	Recognition		1.99 (5,1181)	0.078	-	-	-	-	-	-	-	-	-	-	-	-	-
Researcher Identity	All Sub-Constructs	0.03	2.26 (15,1168)	0.004	-	-	-	-	-	-	-	-	-	-	-	-	-
	Interest		1.05 (5,1182)	0.388	-	-	-	-	-	-	-	-	-	-	-	-	-
	Performance/ Competence		2.48 (5,1182)	0.03	0.01	-0.01	0.04	-0.01	0.07	0.05	0.06	0.21 (WW)	0.08	0.01	0.04	-0.1 (URW)	0.05
	Recognition		5.11 (5,1182)	< .001	0.02	-0.11 (WW)	0.05	-0.04 (WW)	0.07	-0.04 (WW)	0.06	-0.07 (WW)	0.08	-0.01 (WW)	0.04	0.19 (all)	0.05
	Group Is Significantly Lower than Comparison Group:					100%		100%		50%		33%		20%		40%	

* Note: Significant differences between groups are indicated by abbreviations alongside the mean: i.e., Asian Men differed significantly from White men (WM) and White women (WW).

** AM = Asian Men, AW = Asian Women, URM = Underrepresented Men, URW = Underrepresented Women, WM = White Men, WW = White Women







Figures 1-3. *Mean scores across constructs of Graduate Engineering Identity*

Demographics were collected via 11 items that included race/ethnicity and gender; these responses were combined to create an intersectional social identity variable for use in analyses (Fernandez et al., 2016). This six-level categorical variable differentiated between Asian men and women, White men and women, and Underrepresented men and women (see Table 1b). 'Underrepresented' students come from races and ethnicities that are often overlooked in analyses of race (e.g., Southeast Asian or Middle Eastern) or have borne the brunt of the worst policies of exclusion and marginalization in academia.

Analyses

Differences in Mean Scores of Relationship Attitudes and Engineering Identification (Research Question 1). Engineering identity and relationships are often significantly impacted by EGS' social identities, with students from marginalized or stereotyped backgrounds reporting weaker engineering identities or more negative relationship attitudes (Carlone & Johnson, 2007; Wilson et al., 2014). Consistent with these findings, we expected significant differences in identity and relationship attitudes between the demographic groups in our sample. We compared students' relationship and identity scores, with students grouped according to the social identity variable, using ANCOVAs and MANCOVAs to control for lack of experimental control, familywise error, and alpha inflation (Table 1).

Relationship Attitudes and Engineering Identity in their Intersectional Context (Research Question 2). We also expect the relationships between peer and academic advisor relationship attitudes and engineering identity to differ according to students' social identities. We used moderated multiple regressions to examine comparisons across selected identity groups. This allowed for comparison of relationships between variables across groups: in other words, we can compare a relationship (e.g., advisor attitudes and engineering recognition) from targeted groups against each other and determine whether these relationships are significantly different. To control for lack of random assignment and familywise error rate, all related variables are also entered into the models as covariates.

RESULTS

Race & Gender Differences in Relationship Attitudes and Identity (Research Question 1)

A MANCOVA was estimated to test for differences in GEI (graduate engineering identity) scores across social identity categories at the multivariate level, with peer and academic advisor relationship attitudes as covariates. Students' identities significantly predicted mean differences across all domains and sub-constructs of identity scores, $F(45,1161) = 3.61$, $p < .001$. Multivariate significance was also verified across the sub-constructs of each domain (all p's < .004, see Table 2). Univariate ANCOVAs tested for differences in each sub-construct of GEI scores by social identity category, and six of the nine ANCOVAs were significant (Table 2). Using the Tukey method, post-hoc pairwise comparisons were calculated for each of the significant social identity ANCOVAs (Table 2). Of the 90 possible comparisons, 32 were statistically significant.

The percentage of significantly lower identity scores were calculated for each social identity group (see Figures 1-3). For instance, when Asian men and women reported identity scores that were lower than their peers' 100% of the time. Underrepresented men and women reported lower identity scores 50% and 33% of the time, respectively, and White men and women reported lower scores 20% and 40% of the time. Differences in relationship attitudes across social identity categories were tested using two univariate ANCOVAs. Significant differences emerged in peer scores between Underrepresented women and White women, $F(5,1175) = 2.99$, $p = .011$, $\eta p2 = .01$, but not in advisor scores ($p = .11$).

Table 3. Unmoderated regression results.

	Predictors								
	Advisor Relationship Attitudes (ARA)		Peer Relationship Attitudes (PRA)		ARA x PRA Interaction				
Outcomes	Beta	*p*-value	Beta	p-value	Beta	p-value	Adj. R^2	F-value	p-value
Scientist Recognition	0.14	< .001	0.18	< .001	0.02	0.471	0.09	38.94 (3,1197)	< .001
Scientist Interest	0.06	0.009	0.09	< .001	0.05	0.012	0.03	11.83 (3,1199)	< .001
Scientist Performance/ Competence	0.12	< .001	0.09	< .001	0.04	0.036	0.07	29.39 (3,1194)	< .001
Engineer Recognition	0.17	< .001	0.08	0.006	0.05	0.051	0.05	22.26 (3,1197)	< .001
Engineer Interest	0.11	< .001	0.06	0.021	0.07	0.002	0.03	11.54 (3,1200)	< .001
Engineer Performance/ Competence	0.1	< .001	0.08	< .001	0.02	0.276	0.04	16.1 (3,1199)	< .001
Researcher Recognition	0.16	< .001	0.16	< .001	< -.01	0.865	0.12	54.9 (3,1197)	< .001
Researcher Interest	0.15	< .001	0.09	< .001	0.03	0.142	0.06	25.77 (3,1199)	< .001
Researcher Performance/ Competence	0.14	< .001	0.16	< .001	0.03	0.098	0.11	50.35 (3,1200)	< .001

Race & Gender Differences in the Effects of Relationship Attitudes on Identity (Research Question 2)

As hypothesized, peer, and advisor scores positively predicted all sub-components of GEI across all domains (Table 3). The social identity variable was used to create 3 dichotomized dummy codes, hereafter referred to as comparison groups. The three comparison groups were chosen to center Underrepresented women, highlighting how their experiences are masked in traditional gender/race analyses that frame femaleness as 'un-raced' (i.e., White) and race as 'un-gendered' (i.e., male).

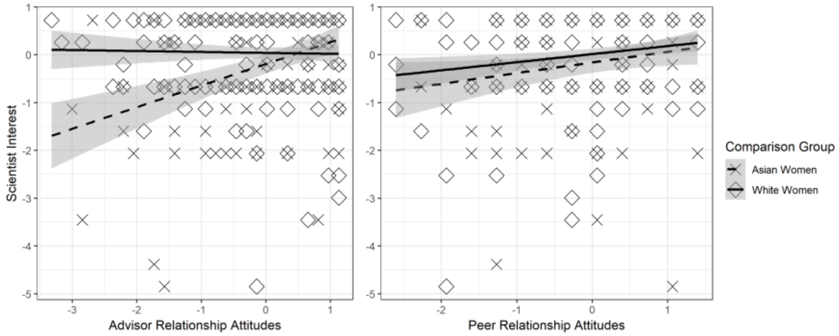


Figure 7. Moderated relationship of peer/academic advisor relationship attitudes and scientist interest, White women and Asian women.

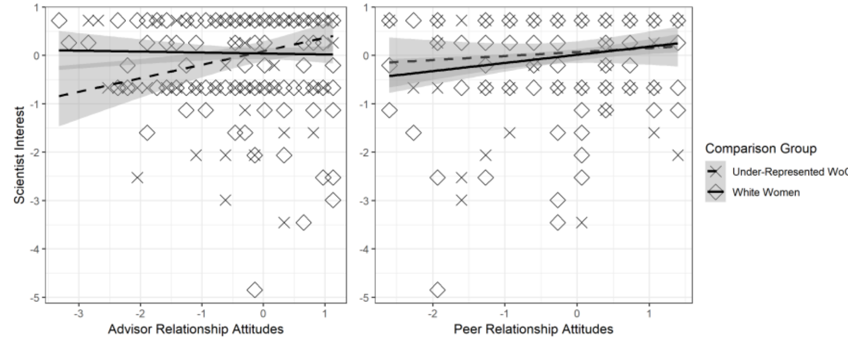


Figure 8. Moderated relationship of peer/academic advisor relationship attitudes and scientist interest, White women and Underrepresented women.

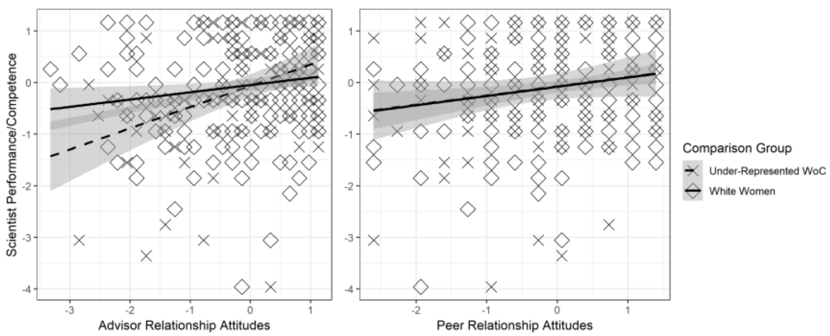


Figure 9. Moderated relationship of peer/academic advisor relationship attitudes and scientist performance/competence, White women and Underrepresented women.

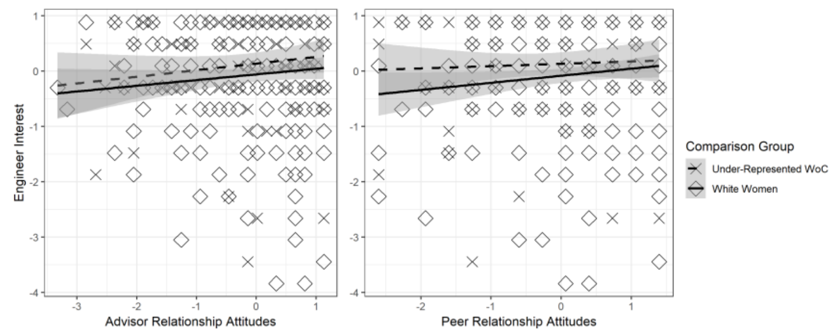


Figure 10. Moderated relationship of peer/academic advisor relationship attitudes and researcher interest, White women and Underrepresented women.

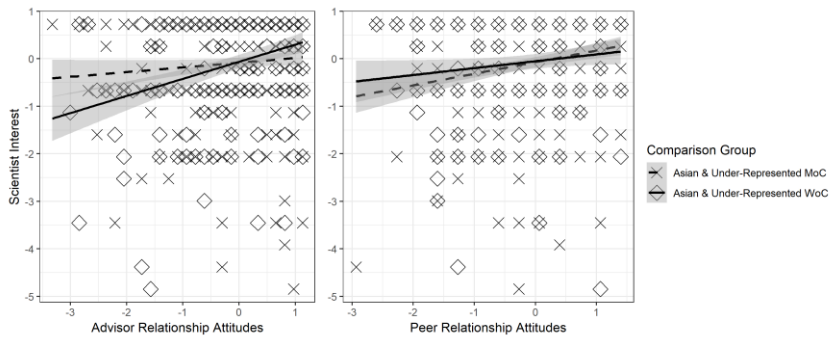


Figure 11. Moderated relationship of peer/academic advisor relationship attitudes and scientist interest, Men and Women of Color.

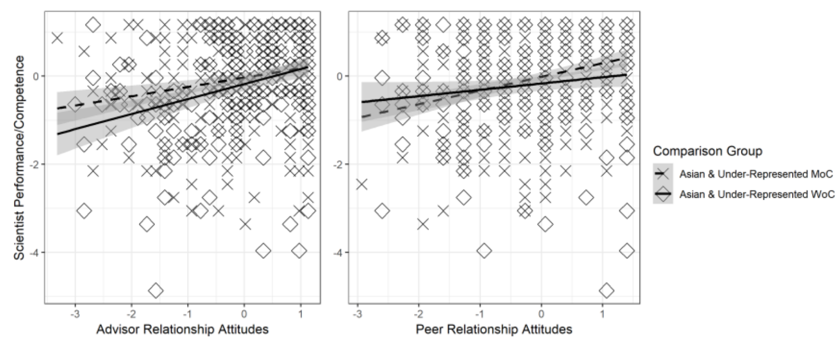


Figure 12. Moderated relationship of peer/academic advisor relationship attitudes and scientist performance/competence, Men and Women of Color.

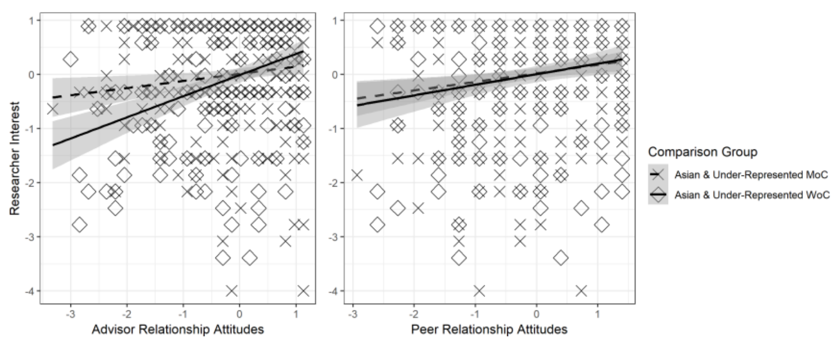


Figure 13. Moderated relationship of peer/academic advisor relationship attitudes and researcher interest, Men and Women of Color.

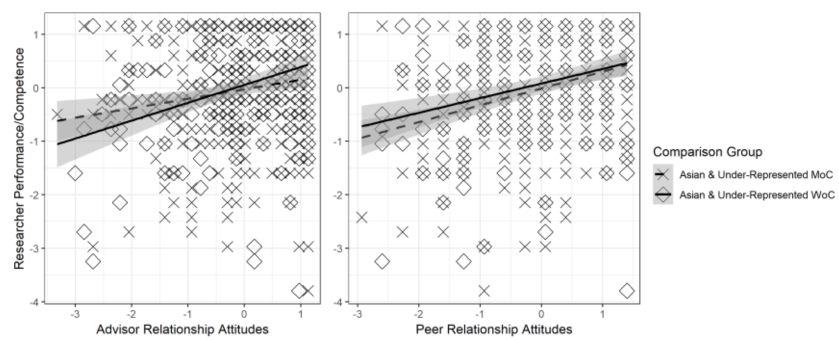


Figure 14. Moderated relationship of peer/academic advisor relationship attitudes and researcher performance/competence, Men and Women of Color.

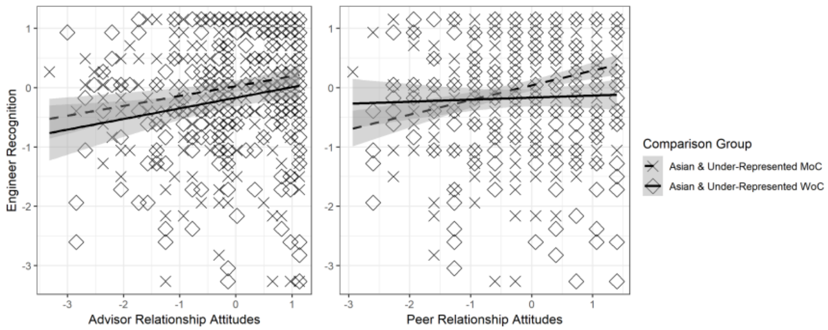


Figure 15. Moderated relationship of peer/academic advisor relationship attitudes and engineer recognition, Men and Women of Color.

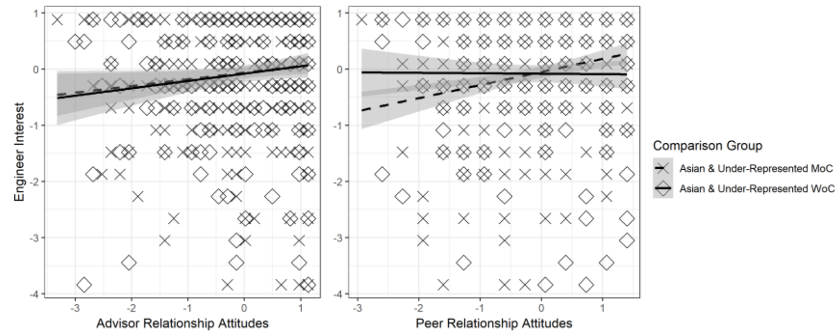


Figure 16. Moderated relationship of peer/academic advisor relationship attitudes and engineer interest, Men and Women of Color.

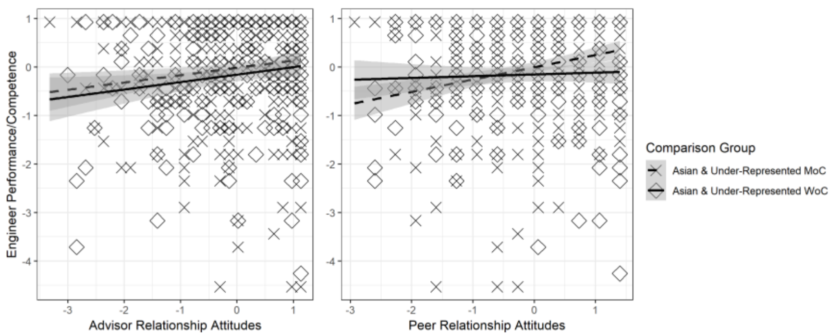


Figure 17. Moderated relationship of peer/academic advisor relationship attitudes and engineer performance/competence, Men and Women of Color.

Nine regressions were estimated for each comparison group, one for each combination of identity domain and identity sub-construct. For each regression, peer and advisor scores were entered as predictors, the comparison group as moderator, and the identity sub-construct as outcome. Significant results are depicted visually in Figures 7-17 for ease of understanding.

Comparison Group 1. The first comparison group comprised of White women (n = 231) and Asian women (n = 115). When compared to White women, Asian women reported significantly lower scientist recognition (B = -.33, p = .003) and researcher recognition (B = -.27, p = .008). Four of the eighteen unmoderated slopes were significant, but only peer relationship attitudes had a non-trivial effect size (researcher performance/ competence; $B = .24$, $p < .001$; Richardson, 2011). One attitude/identity relationship was moderated by the comparison group: the relationship between advisor score and scientist interest differed by half a standard deviation between White women and Asian women ($B = .52$, $p < .001$; Figure 7).

Comparison Group 2. The second comparison group was comprised of White women ($n = 231$) and Underrepresented women ($n = 86$). When compared to White women, Underrepresented women reported significantly higher researcher performance/competence ($B = .27$, $p = .020$; $M_0 = -.03$ $M_1 = .24$). Advisor relationship attitudes were a significant predictor of scientist performance/competence ($B = .27$, $p < .001$) and researcher recognition ($B = .24$, $p < .001$), while peer relationship attitudes were a significant predictor of researcher performance/competence ($B = .24$, $p < .001$). Four of the tested slopes were moderated, or in other words, peer and academic advisor relationships functioned differently for the comparison groups. For Underrepresented women, the relationships between peer and academic advisor relationship attitudes were positively related to scientist interest, scientist performance/competence, and researcher interest (Figures 8-10), while the peer relationship attitudes were negatively related to scientist interest (Figure 8).

Comparison Group 3. The third comparison group was comprised of Asian and Underrepresented men ($n = 361$) and Asian and Underrepresented women ($n = 201$). When compared to Underrepresented men, Asian and Underrepresented women reported significantly lower engineer recognition ($B = -.22$, $p = .009$; $M_0 = .05$, $M_1 = -.17$). Academic advisor relationship attitudes had a small effect on researcher recognition, while peer relationship attitudes had small effects on scientist interest, scientist performance/competence, engineer recognition, engineer interest, researcher recognition, and researcher performance/competence (all *B'*s > .20, *p*s < .001). Asian and Underrepresented women reported more positive effects of advisor score on scientist interest, scientist performance/competence, researcher interest, and researcher performance/competence (all *B'*s > .19, *p'*s < .04; Figures 11-14). They also reported negative effects of peer score on scientist interest, scientist performance/competence, engineer recognition, engineer interest, and engineer performance/competence (Figures 11 & 15-17).

DISCUSSION

There were two central hypotheses explored in this analysis. The first (**Research Question 1**) compares GEI and relationship attitude scores across identity categories. Results indicated that there are not significant differences in advisor scores across identity groups, and that attitudes towards academic advisor relationships are not predicted nor affected by students' social identities. This indicates that academic advisor relationship attitudes are similar for all students, even those who are underrepresented. Peer relationships scores differed for Underrepresented women and White women with the distributions of the remaining groups suggesting that all Students of Color report lower peer scores (Figure 18). There were also systematic differences in GEI scores -- for instance, white women had high recognition across scientist and researcher domains, but low performance/competence. Underrepresented women had the highest engineering and scientist interest, but average or below-average recognition and performance/competence across all domains except researcher. Asian women's scores were at or below the mean across all aspects of GEI, as were Asian men's (except for engineering recognition). Asian men also report the lowest recognition as scientists and researchers.

Research Question 2 examined how graduate engineering identity is supported by academic peer and advisor relationships, with a focus on Women of Color. For the entire population, analyses indicated that academic advisor relationships and peer relationships positively predicted identity, but most effects were marginal or trivial (e.g., effect size < .20; Richardson, 2011). However, the strength and direction of the relationships differed by students' social identities, creating a meaningful gap between groups.

The first group of moderated regressions targeted Asian and White women. This allowed for a more nuanced examination of Asian women's unique experiences – they are Women of Color in a society that marginalizes and stereotypes them, but they are also well-represented in STEM and academic environments. Although Asian women reported lower scientist interest on average, those with more positive relationships reported higher scores, suggesting that Asian women's low scientist interest scores are partially due to poor or negative academic advisor relationships. The second group of moderated regressions targeted Underrepresented women and White women. While White women reported a small but meaningful positive relationship between peer score and scientist identity (B = .19, p = .003), the moderator was significant and negative (B = -.25, p = .038) for Underrepresented women. The final group of moderated regressions, comparing Asian and Underrepresented women to their male peers, found the same pattern (see Figures 15-17). This suggests that peer relationships are less

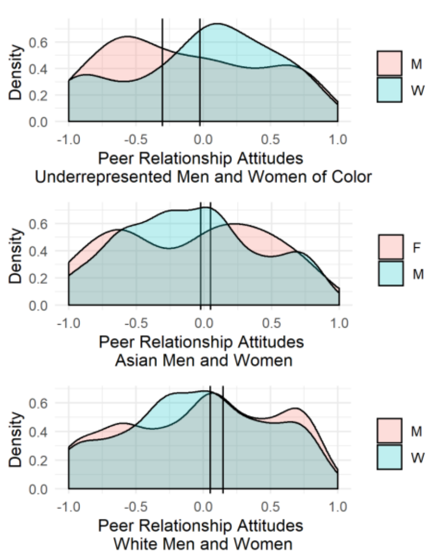


Figure 18. *Peer relationship attitude scores across intersectional social identities.*

meaningful for Underrepresented women, although they are for Men of Color and White women.

To bring these findings together: when advisor score/GEI relationships were moderated by students' social identities, they were generally more positive for the comparison groups, suggesting that poor advisor relationships may contribute to lower GEI scores, and that improving academic advisor relationships may be a viable strategy for improving GEI among Asian and Underrepresented women. Peer relationship attitudes related positively to GEI for Asian and Underrepresented men but had no relationship for Underrepresented women, suggesting that peer relationships do not benefit Women of Color as they do their counterparts. These findings reinforce and challenge conclusions from the literature in five main ways:

1.) Students of Color report lower engineering identity than their White peers, and Asian men and women consistently report the lowest scores. As Asian students have typically been stereotyped as belonging in STEM, this challenges the assumption that they experience high GEI. When asked to describe stereotypes that others have of their group, Asian men identify three stereotype clusters, two of which are 'nerd' and 'outsider' (Y. J. Wong, Owen, Tran, Collins, & Higgins, 2012). Work with Asian adolescents suggests that as their exposure to these stereotypes increases, so too does their ethnic identification and mixed feelings regarding the 'positive' stereotypes (Thompson, Kiang, & Witkow, 2016). Therefore, it may be that Asian EGS have encountered these stereotypes much more frequently in their academic careers, leading to increased ethnic and decreased engineering identity. Model minority stereotypes may also contribute to decreased scores through a second pathway: labeling of Asian students can result in discrimination and indifference regarding their needs, possibly due to the assumption that they do not require as much support (F. Wong & Halgin, 2006).

2.) Underrepresented students report low performance/competence and recognition scores, but high interest scores, with Underrepresented women reporting engineering interest significantly above the mean (Figure 5). These differences may be cultural, e.g. traditionally marginalized communities' emphasis of education as the primary pathway to success may spark and sustain interest (Cole & Omari, 2003). On the other hand, chilly climates in engineering and academia may result in an attenuation effect, in which only the most interested students persevere and the rest leave. In support of this finding, previous qualitative work with students of color suggests that men of color tend to be accepted more readily in STEM, while Black and Latina/x women report alienation and isolation (Malone & Barabino, 2009). Low recognition and performance/competence may also be effects of climate -- bias and a lack of same-race and -gender peers may decrease underrepresented students' identification as engineers despite high interest.

3.) Better relationship attitudes predict stronger GEI, consistent with studies that highlight the role of academic advisors and peers in socialization and persistence in college (Swenson et al., 2008; Zhao et al., 2007). Advisor relationship scores are similar across groups, and positively predict most aspects of GEI, but peer relationship attitudes and scores are less straightforward. Peer scores are below the mean for Underrepresented men and women and Asian men, with White women and Underrepresented women reporting the highest and lowest scores, respectively. Positive peer relationship attitudes for White women may reflect stereotypes that emphasize their warmth and sociability, or the 'women are wonderful' effect (DeWall, Altermatt, & Thompson, 2005; Eagly & Mladinic, 1994; Fiske, Cuddy, Glick, & Xu, 2002), while negative peer relationship attitudes for Underrepresented women may reflect negative stereotypes of Black and Latina/x women as 'angry' or 'loud' (Williams, Phillips, & Hall, 2014). Weak peer/identity relationships may also reflect experiences of tokenism; Students of Color are often the only representatives from their own ethnic groups (Franklin, Slate, & Joyner, 2014). These 'solo' students report more inequality from superiors and less support from colleagues, perhaps due to their small numbers and/or lingering bias (Major et al., 2014).

Asian women also face negative stereotypes, but of a different sort than those reported by other Women of Color. Much of the imagery surrounding Asian women paints them as submissive, exotic, or interpersonally incompetent (Fiske et al., 2002; Paek & Shah, 2003). Being portrayed as asocial and silent may explain why Asian women report consistently lower recognition, the most social of the identity sub-constructs. A lack of recognition in conjunction with communal or altruistic career goals has been found to significantly disrupt science identity and impede progress and performance among Women of Color (Carlone & Johnson, 2007), and traditional Asian cultural values may lead to miscommunication or neglect in advisor/advisee relationships (Schlosser et al., 2011; Ferreira, 2006).

4.) Underrepresented students report above average amounts of performance/competence as engineers and researchers. These findings highlight resilience and confidence in this population and may act as a potential source of strength that, if tapped, can help Underrepresented women increase and maintain their engineering confidence (Godwin, 2016). Previously, engineering performance/competence has been suggested as an information source for self-efficacy (Bandura, Freeman, & Lightsey, 2018). Traditionally underrepresented racial groups (e.g., Black/African American and Latino/a/x) report more self-efficacy than their White and Caucasian counterparts, while women on average report less (Williams, Phillips, & Hall, 2014). These theoretical foundations and the results reported here suggest that underrepresented Women of Color experience and report self-efficacy and performance/competence in ways distinct from White women or male Students of Color, and that further work is needed.

5.) Underrepresented women report less engineering recognition than Underrepresented men, even as their performance/competence and interest are comparable, again indicating programmatic rather than individual issues. Our results suggest that gender plays a significant role in the experiences of Students of Color: advisor score and GEI are positively related among Underrepresented women, often more positively than they are for their male counterparts, while the effect of peer relationships on identity are more positive for Underrepresented men. Peer relationships play an important role in the science identities of STEM graduate students (Robnett, 2013), and so the lack of relationship between peer relationships and GEI among Underrepresented women is unusual and potentially alarming. It may be an effect of our measure, as previous work examined belongingness, confidence, and motivational affordances from STEM peers specifically, while ours is a more generalized reflection of relationship quality. However, Asian and Underrepresented men see positive effects of peer relationships, and White women report significantly higher peer relationships than Underrepresented women, all suggesting that something unique to this sub-population is driving the lack of an effect.

Limitations

Although consistent with previous findings, there are some study limitations that should be considered. While the overall sample for this study is large, the size of some of the individual groups is comparatively small, and the groups themselves are not homogenous. 'Asian' is a single group that contains many ethnicities and nationalities. It also includes some demographic categories (e.g., South Asian) that are not categorized consistently by researchers, and so individual participants may have defined their racial background differently. The group 'Underrepresented women' is a catch-all category for a diverse group of women who -- although they share a lack of representation in STEM -- hail from a variety of racial backgrounds with correspondingly unique narratives and lived experiences. Grouping small sub-populations of students and treating them as a single group likely distorts findings in such a way as to make them fit better with dominant narratives, masking the racial/ethnic narratives that are present in richer data.

It is also impossible to make strong conclusions about causality when using cross-sectional survey data. Although theory and previous research can help us untangle some of these issues, future work should incorporate a longitudinal lens to further develop these findings. Finally, many participants left the survey when reaching the demographic section. It may be that underrepresented students worried about identifiability and were less likely to complete the survey and thus are systematically excluded from the analysis. This possibility is compounded for students who had negative experiences and thus are especially vulnerable to both normal forces of survey attrition and concerns about anonymity and retribution. This does not render the results invalid, but it is important to keep in mind that an important segment of the population may be underrepresented in the analyses.

Future Studies

Longitudinal work is needed to identify the causal mechanisms of the relationships found here. Future studies may also wish to differentiate between performance/competence components of engineering identity and engineering self-efficacy, particularly as it affects relationships and outcomes like persistence and performance. Underrepresented women report high performance/competence but low recognition, suggesting significant conflict between self-assessments and received messages about their skill and belonging; untangling these experiences may be illuminating. The relationship measures used in this study function as an overall assessment of quality, but do not capture the nuances of these relationships. Future work may seek to build on the existing measures or conduct an in-depth study of students' relationships to paint a holistic picture.

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Appendix A: Identity Scales

	Scientist	Engineer	Researcher
Recognition	1. I see myself as a SCIENTIST 2. My department faculty see me as a SCIENTIST 3. My peers see me as a SCIENTIST 4. I have had experiences in which I was recognized as a SCIENTIST 5. I want to be recognized for my contributions to SCIENCE 6. My advisor(s) see me as a SCIENTIST 7. Other scientists see me as a SCIENTIST	1. I see myself as an ENGINEER 2. My department faculty see me as an ENGINEER 3. I have had experiences in which I was recognized as an ENGINEER 4. Others ask me for help with ENGINEERING 5. I want to be recognized for my contributions to ENGINEERING 6. My advisor(s) sees me as an ENGINEER 7. Other engineers see me as an ENGINEER	1. I see myself as a RESEARCHER 2. My department faculty see me as a RESEARCHER 3. My peers see me as a RESEARCHER 4. I have had experiences in which I was recognized as a RESEARCHER 5. I want to be recognized for my contributions to RESEARCH 6. My advisor(s) see me as a RESEARCHER 7. Other researchers see me as RESEARCHER
	Cronbach's α = .91	Cronbach's α = .90	Cronbach's α = .94

Interest	8. I find satisfaction when learning SCIENCE concepts 9. I am interested in learning SCIENCE concepts 10. I enjoy learning SCIENCE	8. I find satisfaction when doing ENGINEERING 9. I enjoy learning ENGINEERING	8. I find satisfaction when learning about my RESEARCH topic 9. I am interested in learning more about how to do RESEARCH 10. I enjoy conducting RESEARCH 11. I find satisfaction when doing RESEARCH
	Cronbach's α = .95	Cronbach's α = .89	Cronbach's α = .94
Performance / Competence	11. I can overcome setbacks when learning SCIENCE 12. I am confident that I can understand SCIENCE in class 13. I am confident that I can understand SCIENCE outside of class 14. I can perform well when my SCIENCE knowledge is tested (for instance, in exams or defenses) 15. I understand concepts I have studied in SCIENCE	10. I am confident I can understand ENGINEERING in class 11. I am confident I can understand ENGINEERING outside of class 12. I can perform well when my ENGINEERING knowledge is tested (for instance, in exams or defenses) 13. I understand concepts I have studied in ENGINEERING 14. I am confident I can apply ENGINEERING to solve problems	12. I can publish RESEARCH results in my field 13. I can present RESEARCH related topics to relevant audiences 14. I am confident that I can network with other RESEARCHERS 15. I understand the concepts needed to analyze and interpret data 16. I am confident that I can design a RESEARCH study
	Cronbach's α = .88	Cronbach's α = .92	Cronbach's α = .89

Appendix B: Peer and Advisor Relationship Scales

Peer Relationships Cronbach's α = .77	When thinking about your lab or research group, to what extent do you disagree or agree with the following statements: 1. Students in my research group are supportive of one another 2. I am an active member of my research group 3. I spend time with members of my research group outside of work 4. Overall, I feel that my experience with my research group has been positive
Advisor Relationships Cronbach's α = .92	To what extent do you disagree or agree with the following statements: My advisor… 1. …has clearly stated his or her expectations for satisfactory participation in my program 2. ...is easy to approach 3. ...is knowledgeable about my research 4. ...encourages and supports my research 5. ...values my work 6. ...provides advice in a timely manner 7. ... is also my mentor 8. ...and I have a positive relationship