Engagement Patterns across Race, Gender and Family Income in Engineering Classrooms

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Abstract

This IUSE-funded study investigated differences in behavioral and emotional engagement that emerge across family income, gender, and race in engineering classrooms. Engagement levels and engagement patterns were measured across seven sophomore- and junior-level engineering courses at a large public university. Differences in engagement were evaluated quantitatively between the two numerical majority races in this study (Asian, white), between genders, between international and domestic students, and across three levels of family income. Sample sizes for other racial groups (black, Pacific Islander, Native American, Hispanic, and Other) were too small to support analyses by family income and were not included in this study.

Initial analyses of variance (ANOVA) revealed significant differences in at least one form of engagement between Asian and white students, between men and women, between domestic and international students, and across family income levels. As a result, all four demographic variables (race, gender, country of origin, family income) were retained in a subsequent linear regression to understand potential interactions among these demographic variables. Since these models were weak, the analysis then looked at engagement patterns rather than engagement levels.

In this next phase of analysis, scores for the five engagement variables were classified using a non-parametric *k*-means clustering approach. The data optimally separated into two main categories: less engaged students (Cluster 1) and more engaged students (Cluster 2). Among domestic students, 100% of low income Asian women and 82% of low income Asian men (82%) fell into the more engaged cluster, while high-income Asian women (83%) fell into the less engaged cluster. Among international students (who were entirely Asian in this sample), low income Asian men and high income Asian women were among those who had the highest percentage of lesser engaged students (40% of each group, respectively) while middle income Asian men and middle income Asian women had the highest percentage of more engaged students (approximately 80% of each).

Overall, the *k*-means clustering approach provided greater insight into the data than traditional statistical analysis techniques. Differences and trends among all four demographic variables (gender, family income, race, country of origin) emerged, showing that students from some demographic groups seem more susceptible to remaining less engaged in courses than other groups.

Introduction

Engineering is a highly stratified field marked by a number of disparities among gender, race, income, and other variables. With regard to gender, between 1984 and 2004, while women pursuing degrees in biology and life sciences grew to a majority percentage of 60.1%, the gains were much smaller in physics (from 15% to 22%) and engineering (10.1% to 20.5%) [1]. During the late 1990s, female degrees in computer science actually declined from 37% in 1984 to 18% in 2011[2]. As of 2017, only 21.3% of the undergraduate degrees in engineering across majors were earned by women, a drop from the 22.8% of students enrolled in engineering majors in the beginning of their degrees [3]. In other words, women not only start out in engineering as underrepresented minorities, but they are not retained in the major either, further exacerbating this difference.

This stratification within engineering fields also occurs across income. Engineering as a major primarily attracts wealthier students. One study found that students with higher socioeconomic statuses were nearly 1.447 times more likely to choose engineering as a major [4]. High socioeconomic status (a variable generally determined as a construct of multiple identifying class factors) also predicted both program retention and achievement [4]. On the other hand, students who received Pell grants (and thus were from lower income households) were statistically more likely to drop out of engineering majors than other students [5]. Thus, engineering as a field seems to attract and retain those with higher socioeconomic status.

Socioeconomic status also intersects with ethnic identity in creating imbalance in engineering, particularly with regard to underrepresented racial minorities (non-Asian students of color). Yoder [3] reported that Hispanic students accounted for only 10.7% of earned bachelor's degrees in engineering, while Black or African-American students accounted for only 3.9%. This compares to the general college population where 10.1% of undergraduate degrees are earned by Black or African-American students and 12.2% by Hispanic students [6]. In contrast, Asians account for 6.9% of the undergraduate degrees in the U.S.[6], but 13.1% of degrees in engineering [3]. Some research has suggested that this preference for engineering may be cultural, as Asian students have previously voiced a preference for high-prestige majors like engineering [9].

Additionally, international students also account for a significant portion of the undergraduate degrees awarded in the United States, but particularly in STEM fields like engineering. 9.8% of engineering undergraduate degrees in 2015 were awarded to international students [3] while only 2.2% of humanities degrees were awarded to international students among all international students in 2010 [8]. For international students, interaction with peers and professors is often a key predictor in a positive campus climate [9], which in turn predicts persistence. However, those interactions are also informed directly by how well international students prepare (particularly with language) prior to arrival at their universities [10], [11], [12] .

Background

The fact that the undergraduate engineering student population in the United States has a disproportionately high number of men, international students, Asian students, and students who come from families with high incomes merits a study of the intersections of these four

demographics. Considering multiple demographic characteristics at once is informed by prior research demonstrating that the role of identity in student learning experiences is not based on only one demographic component, but also by the ways they interact and inform each other. The concept of *intersectionality*, first coined by Kimberlé Crenshaw in 1989 [13], is explained in the context of a discussion of Black female identity and can be extended to other groups as well:

> Yet often [Black women] often experience double-discrimination—the combined effect of practices that discriminate on the basis of race, and on the basis of sex. And sometimes they experience discrimination as Black women—not the sum of race and sex discrimination, but as Black women. (p. 44).

Several scholars have adopted intersectional theory as a justification for disaggregating demographic data [14], [15], [16]. More recently, some research has been done to explore some of the intersectional experiences of engineering students. In one study that examined the effects of intersections of race, gender, and sexuality on engineering students' learning outcomes, Ro and Loya [17] found significant differences in fundamental skills at cross-sections between race and gender, suggesting that White men and Asian men differ in their self-assessment of such skills. They also found that female students of color tended to report lower design skills than white males, and that Asian students rated themselves lower in contextual competence regardless of gender.

Students themselves are aware of these intersections as well, making them all the more pertinent. For example, in a recent study of women of color in engineering, most of the students interviewed used multiple identifiers of class, race, gender, and others [18]. Yee's (2016) ethnographic study [19] also revealed that while there were comparable levels of engagement between low and middle-income students, engagement was expressed quite differently by students from diverse racial and income backgrounds. Students with different intersectional origins were found to utilize different kinds of strategies in their learning. When another study took into account income and gender alongside race, they found that while being Asian predicted student graduation rates in STEM fields, female Asians were 16% more likely to graduate than males, and that while higher family income positively predicted graduate rates as long as it was over $25,000 per year, once a family's income superseded $100,000 per year, income became a *negative* predictor of graduation [20]. As a whole, this body of literature demonstrates the ways in which gender, race, socioeconomic status, and domestic/international status intersect and influence the learning of engineering students, but also suggests a need for continued work exploring the ramifications of such intersections in order to better serve all students' learning needs in their engineering classes.

Studies that look at the intersection of multiple demographics among engineering students have primarily examined longer term academic outcomes such as persistence or graduation rates. A few have looked at observable engagement among students. To complement these studies, we choose internal forms of engagement that are more motivational in nature. The reasons for doing so are discussed next.

First, this study investigates engagement because it is a key element of academic success and has widespread impact on many other academic and psychological outcomes. Engagement has been significantly and positively associated with greater cognitive capability, including improved

critical thinking [21], [22] and integration of information [23]. Engagement is also strongly and positively linked to academic outcomes such as grades [21], [24], [25]. More highly engaged students tend to perform better academically and in turn, persist more than those who are less engaged [24], [26]. Better academic performance also leads to greater persistence through both improved engagement and other indirect pathways [27], [28]. Academic engagement also mitigates stressors for certain groups of first-year students, particularly those with lower academic abilities [29], and thus may be an indicator of some of their achievements as well. Engagement provides a more immediate measure of how students are doing in class and for this reason is particularly efficient and effective for cross-sectional studies. Engagement may be particularly important for studying at-risk populations who may not always be available for longitudinal studies, or for educators who want to enact timely interventions to support current students.

In addition to studying engagement because it provides a window into the present academic situation for students, this study also chooses engagement metrics which are all motivational in nature, as opposed to engagement variables commonly used in other studies such as time on task and time spent in specific learning activities [30]. Motivational measures are important because they reflect not only how engaged a student is in the present, but also how likely they are to remain engaged and persist with their studies in the future. Research has shown that being intrinsically or self-motivated predicts a student's desire to learn and achieve better than being extrinsic or task-oriented behavior [31]. Motivational engagement has been shown repeatedly to be a powerful predictor of a number of academic achievement measurements, such as persistence [32], goal orientation [33], literacy [34], and autonomy [35].

Two primary forms of motivational engagement are used in this study: behavioral and emotional. Behavioral engagement accounts for participation, effort, and attention and is associated with similar measures in previously established engagement variables based on time on task [36]. Emotional engagement accounts for both positive and negative student responses to their academic experiences and measures interest, enjoyment, and anxiety [37], [38]. A variety of research has established that both forms of engagement are essential to student learning [39], [40]. Both behavioral and emotional engagement reflect how a student thinks and feels about what they are doing in the classroom, thus indicating motivation, and often translating to future behavior more effectively than observable behavior such as time on task or time spent in particular learning behaviors or activities.

Research Questions

Our research was guided by three research questions, all focused on understanding how and where differences in engagement in engineering classrooms emerge across family income, gender, country of origin (i.e. domestic or international student status) and race.

Research Question #1 (RQ1):
Does engagement vary by race (Asian vs. White), gender (Male vs. Female), country of origin (International vs. Domestic status), or across family income levels?
In putting into conversation the discourses of engagement and intersectionality, this study can offer a more nuanced view of the ways in which students' identities affect their engagement and, by extension from previous research, subsequent performance, persistence, and achievement in

engineering. This is critical knowledge in addressing the severe issues of underrepresentation that plague engineering as a field in general and may help build subsequent frameworks to attract and maintain more nurturing environments for students who are less predisposed to pursue engineering.

Research Question #2 (RQ2):
Which demographic characteristics from RQ1 significantly predict engagement?
This question explores more deeply these key demographics that may be associated with engagement in engineering classes, and can address to what extent issues of underrepresentation (of women, lower family income levels) and overrepresentation (of Asian and international students) previously discussed affect this engagement. In particular, identifying the specific types of engagement each demographic group predicts the most can help instructors and engineering departments become more aware of the ways in which they might help different types of students succeed in engineering.

Research Question #3 (RQ3)
Are variations in engagement associated with any intersections between race, gender, country of origin, and income?
This question allows us to explore intersections of the demographic variables in RQ2 in a different way by looking at engagement patterns rather than engagement levels. Statistical evaluation of engagement levels does not necessarily allow for or discern different groups of students who may be engaging at different levels. Thus, even though mean measures of engagement may not appear different among certain demographic groups, it is possible that students within a particular demographic group exhibit different overall habits of engagement. This research question allows us to look at the frequencies with which different patterns prevail over these groups and has implications for educators to identify students, regardless of demographic, who may need greater support to engage in their courses.

Methods

This study is quantitative, drawing on surveys completed by students in four different engineering majors at a single large public research institution. It is part of a larger study that sought to explore different factors that informed student engagement in engineering classrooms.

Participants
This study is associated with a population consisting of 781 undergraduate students recruited across four engineering majors and nine separate classes at the sophomore and junior levels. Two of these classes were eliminated from this study because the measures were not reliable in those groups. Self-reported ethnicity occurred in the following percentages: Asian (47%), Black (3.5%), Hispanic (3.5%), White (41%), Pacific-Islander (less than 1%), Native American (less than 1%), and Other (3%). Because preliminary analyses of variance revealed substantially different engagement patterns between underrepresented minority groups and none of these groups approached more than 10% of the entire sample, all ethnic groups other than Asian and White were eliminated for the purposes of this study.

Approximately 24% of the original sample was female, with 76% male and less than 1% reporting Other. Only female and male students were retained for this study. Similarly, while

students reported their country of origin as either U.S. citizens (77%), Permanent Residents (4.8%), International (17.7%), or Other (less than 1%), ANOVA results indicated that U.S. citizens and permanent residents performed with similar engagement levels. Therefore, these groups were consolidated into domestic students (U.S. citizens and permanent residents) and international, and Other students were eliminated from this study.

Family Income status was divided into eight primary categories and coded as one through eight. Students were asked to report their family's household income as one of the following:

- below $10,000 per year (4.2%),
- between $10,000 and $20,000 per year (4.3%),
- between $20,000 and $40,000 per year (11.3%),
- between $40,000 and $60,000 per year (15.2%),
- between $60,000 and $80,000 per year (12.8%),
- between $80,000 and $100,000 per year (15.9%),
- between $100,000 and $150,000 per year (19.5%), and
- above $150,000 per year (16.6%).

Based on behaviors found in initial analyses of variance, family income levels were consolidated into three primary income categories: low income (less than $20,000 per year) at 8.5%, middle income (more than $20,000 and less than $80,000 per year) at 39.4%, and high income (more than $80,000 per year) at 52.1%. Demographic characteristics of the final sample are summarized in Table 1.

Table 1: Population Characteristics

	Asian	White	Total
Total	332	294	626
Gender			
Men	247	216	463
Women	83	75	158
Country of Origin			
U.S. Citizen or Permanent Resident	213	293	506
International Student	117	1	118
Family Income			
Less than $20,000 per year	34	5	39
Between $20,000 and $80,000 per year	136	84	220
Over $80,000 per year	139	186	325

Procedures

IRB (Internal Review Board) approval was obtained to recruit and survey 781 undergraduate students for this study. All participation was voluntary, and students were informed that their survey responses would remain confidential. In several courses, students were incentivized with a nominal amount of extra credit for the course in which they were recruited. All students completed an electronic survey online and outside of class. Surveys were collected with identifying information so that duplicates could be removed before aggregating data for analysis.

All results were cross-sectional. In the survey, students reported their perceptions of various items related to engagement, belonging, effort, peer harassment, task value, self-efficacy, TA and faculty interactions, and other measures of course achievement as well as multiple demographic items.

Instruments

The part of the study reported in this paper focuses on a five primary engagement variables and four demographic measures (gender, race, country of origin, and family income). All engagement variables are listed by category in Table 2 along with sample items and Cronbach's reliability coefficients.

The behavioral engagement scales of attention, effort, and participation were adapted from previous studies in K-12 [39] and college [41]. The original scales measuring behavioral engagement have demonstrated adequate internal consistency and construct validity [38]. Students responded to a 5-point Likert scale (strongly disagree to strongly agree) for each item. *Attention* measures to what extent students are thinking about other things besides the topics at hand in their classes. *Effort* evaluated how hard students try to work in their classes and lab/study groups. *Participation* measured how students think about their participation in class discussions. The emotional engagement scale, also adapted from Miserandino [38] and tested in a higher education setting by Floyd-Smith et al. [41], measures students' affective responses to their classes. *Positive Emotional Engagement* measured positive emotional levels students felt about learning and being in their major classes and lab/study groups. *Negative Emotional Engagement* measured the negative feelings that students felt about learning and being in their classes and lab/study groups. Although negative emotional engagement and behavioral participation had internal reliabilities that were less than the standard 0.7, there is evidence that reliability between 0.6 and 0.7 is adequate [42]. Therefore, these measures were retained for analysis.

Table 2: Engagement Variables

Primary Scale	*Sample Item*
Behavioral Attention ($\alpha = 0.83$)	When I'm in this class, my mind wanders.
	When I'm in this class, I think about other things.
Behavioral Effort ($\alpha = 0.78$)	I try hard to do well in this class.
	In this class, I work as hard as I can.
Behavioral Participation ($\alpha = 0.64$)	When I'm in this class, I participate in class. discussions with my classmates and instructors.
	When I'm in this class, I participate in class. discussions with my classmates.
Positive Emotional Engagement ($\alpha = 0.75$)	I enjoy learning new things in this class.
	In this class, when we work on something I feel interested.
Negative Emotional Engagement ($\alpha = 0.67$)	In this class, I feel discouraged.
	In this class, I feel worried.

Data Analysis

The data were analyzed using SPSS 19 to compute descriptive statistics and to test the reliability of the five engagement variables. To support RQ1, analyses of variance (ANOVA) were conducted across the sample to evaluate differences in mean values of the five measures of engagement among the three family income levels. Independent samples t-tests were conducted to measure potential differences in mean values between genders (male, female), between races (Asian, White), and between countries of origin (domestic, international). Homogeneity of variance was not assumed, and Bonferroni's correction was used in all analyses of means to account for multiple hypothesis testing and reduce Type 1 error.

Prior to conducting linear regression analyses for RQ2, bivariate Pearson correlations between the five dependent variables and the demographic variables were also analyzed to test for multicollinearity. All correlations were below .5 and therefore, all variables were retained. Demographics were then inserted into simple linear regression models to understand how they did or did not predict the five separate engagement variables (behavioral attention, effort, and participation; positive and negative emotional engagement). All demographic variables in the regression models were effect coded as summarized in Table 3.

Table 3: Effect Coding of Independent Variables for Linear Regression Models

Characteristic	*Variable Name(s)*	*Effect Coding*	
Race	Asian	White Asian	White = -1; Asian = 1
Gender	Female	Male Female	Male = -1; Female = 1
Country of Origin	Student Status	Domestic International	Domestic = -1; International = 1
Family Income	Low Income High Income	Low Income Middle Income High Income	Middle Income = -1; Low Income = 1; High Income = 0 Middle Income = -1; Low Income = 0; High Income = 1

Finally, to support examining RQ3, all engagement data were subject to a *k*-means clustering analysis using Euclidean distance to optimize the distance between clusters. *K*-means makes no assumptions about how many engagement patterns are appropriate nor which students will exhibit certain engagement patterns over others. *K*-means [43] seeks to mine data by partitioning multidimensional data into *k* clusters so that each observation is assigned to a cluster by its minimum distance to cluster mean. Multiple types of distances were used to place data into clusters in order to determine the optimal distance metric for this dataset. The optimal number of clusters is chosen based on the maximum mean silhouette value achievable for a particular set of data. The silhouette value measures how similar an observation point is to points in its own cluster. The silhouette value can range from -1 to +1 and is defined as:

$$S_i = (b_i - a_i)/\max(a_i, b_i)$$

Where S_i is the silhouette value for an observation i, a_i is the average distance from the ith observation to other observations assigned to the same cluster, and b_i is the minimum average

distance from the *i*th observation to points in a different cluster. The larger the silhouette value, the more closely a student engagement pattern belongs to its assigned cluster while a negative silhouette value indicates that the cluster assignment is likely an outlier [44]. *K*-means cluster analysis was conducted and optimized for total clusters ranging from 2 to 10 to find the optimal grouping of the engagement data. Two clusters (less engaged and more engaged) defined the optimal clustering scenario (Figure 1) and were used for subsequent demographic analysis by cluster.

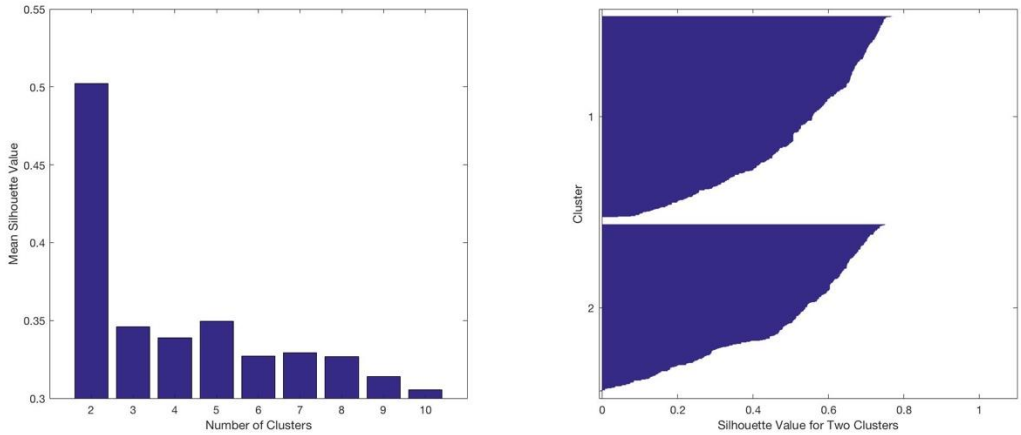

Figure 1: *k*-means clustering results for Student Engagement Data

The highest silhouette value corresponds to the "best" way to separate/cluster the data.

To confirm the findings of the *k*-means analysis and examine the intersections of the demographic variables, chi-square tests of independence were used to calculate the likelihood that distributions of students by demographic were significantly different. Chi-square was the most appropriate test to use due to the small sample size of these populations [45].

Results & Discussion

The three research questions of this study were first analyzed using descriptive statistics (RQ1) to determine significant differences in engagement variables in the overall sample across key demographics (RQ1). ANOVA and independent samples t-tests were subsequently used to find these differences. Then, a linear regression was used to understand how demographic variables predicted any of the five forms of engagement (RQ2). Despite some significant findings, none of the models provided strong effect sizes, and as a result, alternative methods using *k*-means clustering and chi-square analyses were used to determine any key intersections of demographics in determining student engagement (RQ3).

RQ1:

Does engagement vary by race (Asian vs. White), gender (Male vs. Female), country of origin (International vs. Domestic status), or across family income levels?

The descriptive statistics for the five engagement variables are summarized in Table 4. During exploratory ANOVAs and associated t-tests, significant differences were found in at least one of the five engagement variables for race, international status, and income. Post-hoc, multiple pairwise comparisons showed that significant differences across family income at all levels were present for behavioral attention and participation, but not for any of the three remaining engagement variables. The same was true by race, as Asian students expressed significantly lower (worse) negative emotional engagement than their white peers and reported significantly higher participation. And, by country of origin, international students expressed greater attention, effort, participation, and positive emotional engagement then their domestic peers, but no significant differences in negative emotional engagement. This means that international students were significantly happier in their classes but not significantly less anxious or discouraged than domestic students. Women demonstrated lower (worse) levels of negative emotional engagement than men, but this result was not significant.

Table 4: Descriptive Statistics for Student Engagement

Demographic		Mean (SD)				
		Behavioral Engagement			Emotional Engagement	
		Attention	Effort	Participation	Positive	Negative
All		*N*=659 5.53 (1.97)	*N* = 655 7.73 (1.55)	*N* = 626 6.34 (1.91)	*N*=650 13.8 (3.10)	*N*=660 6.35 (1.88)
Annual Family Income	<$20k	*N* = 39 5.9 (1.94)	*N*=39 8.03 (1.50)	*N*=37 7.05 (2.147)	*N* = 37 14.81 (3.36)	*N*=39 6.0 (1.89)
	$20k-$80k	*N* = 217 5.81 (1.94)*	*N* = 216 7.75 (1.62)	*N* = 220 6.45 (1.92)	*N* = 216 13.84 (2.99)	*N* = 218 6.3 (1.86)
	>$80k	*N* = 320 5.38 (1.96)*	*N* = 319 7.65 (1.57)	*N* = 321 6.25 (1.93)	*N* = 316 13.53 (3.13)	*N* = 320 6.37 (1.93)
Gender	Men	*N* = 455 5.58 (1.96)	*N* = 455 7.70 (1.60)	*N* = 457 6.46 (1.98)	*N* = 448 13.93 (3.06)	*N* = 456 6.41 (1.89)
	Women	*N* = 157 5.5 (1.96)	*N* = 155 7.79 (1.47)	*N* = 157 6.25 (1.85)	*N* = 156 13.52 (3.03)	*N* = 157 6.08 (1.88)
Race	Asian	*N* = 325 5.52 (1.97)	*N* = 325 7.78 (1.58)	*N* = 326 6.57 (2.00)*	*N* = 323 13.91 (3.06)	*N* = 325 6.11 (1.92)**
	White	*N* = 292 5.58 (1.96)	*N* = 290 7.66 (1.53)	*N* = 293 6.19 (1.86)*	*N* = 285 13.67 (3.08)	*N* = 293 6.57 (1.83)**
Status	Domestic	N = 499 5.48 (1.96)*	N = 496 7.7 (1.56)	N = 502 6.25 (1.92)***	N = 493 13.57 (2.98)***	N = 501 6.4 (1.86)
	International	N = 116 5.89 (1.95)*	N = 117 7.81 (1.60)	N = 115 6.99 (1.95)***	N = 113 14.81 (3.23)***	N = 127 6.07 (1.96)
Maximum Score		10	10	10	20	10
Minimum Score		2	2	2	4	2

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$ (significant differences between demographic groups)

RQ2:

Which demographic characteristics from RQ1 significantly predict engagement?

The results from the linear regressions are summarized in Table 5. All models were very weak. The strongest was behavioral attention ($R^2 = 0.03$) and positive emotional engagement ($R^2 = 0.03$), followed by participation ($R^2 = 0.02$), negative emotional engagement ($R^2 = 0.02$), and behavioral effort ($R^2 = 0.01$). However, despite the weakness of the models, some significant effects were still detected. Being an international student positively predicted both behavioral attention and positive emotional engagement, indicating that international students on average reported 0.26 more points on Attention ($p < 0.05$) and 0.5 points higher than average on positive emotional engagement ($p < 0.01$), all else held constant. Students with high income status reported significantly less behavioral attention in class (b = -0.3, p = 0.03) and significantly lower positive emotional engagement (b = -0.46, p = 0.042). Additionally, female students predicted significant lower scores on the negative emotional engagement scale (b = -0.18; p = 0.046). No other independent predictors were found to be significant. Though none of these models were statistically strong, the presence of some significant results suggested that further analysis was required to examine the nuances of these patterns.

Table 5: Linear Regression Models for Student Engagement

	B (Standard Error)									
	Behavioral Engagement						Emotional Engagement			
	Attention		Effort		Participation		Positive		Negative	
Constant	5.8 (0.15)	***	7.9 (0.12)	***	6.6 (0.15)	***	14.2 (0.23)	***	6.16 (0.14)	***
Gender	-0.03 (0.09)		0.08 (0.08)		-0.06 (0.09)		-0.20 (0.15)		-0.18 (0.09)	*
Race	-0.16 (0.09)		0.03 (0.08)		0.09 (0.09)		-0.13 (0.15)		-0.15 (0.09)	
Student Status	0.27 (0.12)	*	0.02 (0.10)		0.20 (0.12)		0.50 (0.19)	*	-0.05 0.12	
High Income (>$80k)	-0.30 (0.14)	*	-0.14 (0.12)		-0.25 (0.14)		-0.46 (0.23)	*	0.07 (0.14)	
Low Income (<$20k)	0.13 (0.22)		0.21 (0.18)		0.32 (0.23)		0.54 (0.36)		-0.16 (0.22)	
R^2	0.03		0.01		0.02		0.03		0.02	
* p < 0.05; ** p < 0.01; *** p < 0.001										

There are several reasons why women in particular may be experiencing higher levels of negative emotional engagement. Current research on minority stress indicates that students who enter programs knowing they are part of a minority group (either by gender, race, or other distinctions) will suffer from what Steele termed “stereotype threat” [46] and subsequently perform at lower levels than they might otherwise. This research also suggests that these stressors are unique to different minority groups. For example, multiple studies have found that that black students operated with significantly different coping mechanisms than other minority

groups [47], [48], [49]. Murphy et. al. [50] also reported that women in engineering programs were less likely to perform well when they entered a classroom where men made up the majority, as opposed to classrooms containing a female majority or divided evenly between genders [50]. Thus, part of what may have emerged in these models, despite the relatively low strength, is evidence of anxiety because of one's minority status.

Similarly, this may also be the reason why international student status and high-income are more likely to predict positive emotional engagement and attention in class—they are in a relative majority. While international status may be something that is outwardly more identifiable (particularly as the majority of the international students in this study identify as Asian), class is likely something that it more indicated through the use of common discourse in class. It has been suggested that engineering as a major choice is largely informed by students' parents' careers as well [55]. If that is the case, students from higher income backgrounds may be more familiar with the discourses of engineering, considering that as a field, it is relatively lucrative.

RQ3:

Are variations in engagement associated with any intersections between race, gender, country of origin, and income?

The results of *k*-means clustering of the engagement data are shown for between two and ten clusters assigned to the overall dataset (Figure 1). Optimal clustering results, represented by highest average silhouette values and least number of negative silhouette values, were found for two clusters separated by Euclidean distance measures (Figure 1). These results strongly suggest that students exhibited only two major patterns of engagement, regardless of the course structure, content, or demographics. All engagement variables are positively coded (i.e. higher values mean greater engagement) and normalized to a maximum value of 1. Engagement Pattern #1 is characterized by lower mean values on all five measures (behavioral attention, behavioral effort, behavioral participation, positive emotion, negative emotion), suggesting that this pattern represents those students who are less engaged overall.

The differences between the two major engagement patterns exhibited by students are shown graphically in Table 6. The 265 lesser engaged students represent 45.1% of the overall population, which is not surprising given the fact that most of the seven courses studied are dominated by passive, lecture-based teaching. The high engagement pattern seems to represent a group of 323 students or 54.9% of the total population.

It appears that the greatest differences between categories within a single demographic occur with student status. A significantly greater percentage of international students are more engaged compared to domestic students ($\chi^2(1) = 14.93$, $p = 0.0001$). That is, an international student is more likely to be more engaged than a domestic student. For other demographics (gender, race, family income), no significant differences (using chi-square analyses) emerge within demographic categories.

Table 6: Distribution of Engagement Patterns by Demographic					
Demographic		Low Engagement Pattern		High Engagement Pattern	
		N	%	N	%
All		265	45.1	323	54.9
Gender	Men	190	43.8	244	56.2
	Women	72	48.0	78	52.0
Race	Asian	133	43.3	174	56.7
	White	132	47.0	149	53.0
Student Status	Domestic	233	48.8	244	51.2
	International	31	28.4	78	71.6
Family Income	< $20k/year	11	30.6	25	69.4
	Between $20k and $80k/year	93	44.5	116	55.5
	> $80k/year	146	48.0	158	52.0

Intersections of these four demographics (gender, race, student status, family income) were also considered and are summarized in Table 7. Only two significant differences emerged from chi-square analyses among these intersections. Among domestic Asian females, significantly more middle income women were highly engaged compared to high income Asian women ($\chi^2(1) = 4.59$, $p = 0.032$). Although the distribution of middle income Asian women into less engaged and more engaged clusters was no different than other middle income students, high income Asian women were also more likely to be less engaged than all other groups of high income domestic students ($\chi^2(3) = 11.03$, $p = 0.011$). In combination with the regression results in Table 5 which suggests that being a woman predicts lower negative emotional engagement scores, these results are concerning. While women overall tend toward greater negative feelings about their studies, the impact on Asian women appears to be greater than for white women, leading to more students who chose to remain withdrawn or disengaged from their studies. Among international students, sample sizes were too small to evaluate the significance of intersectionality, but as discussed previously, international students as a whole tended toward high engagement, much more so than domestic students (Table 6). This sampling issue also accounts for why international status did not emerge as a significant variable in the chi-square test, but significantly predicted three of five outcomes in the linear regression models: attention, participation, and positive emotional engagement.

It is possible that female international students may experience two sides of the stereotype threat coin upon entering a class: being part of a relative majority as wealthy Asian or international students, but being part of a minority as women. A number of studies have found links between international student engagement, language, and cultural fluency [11], [54]. Others found that student-faculty interactions predict belonging and other engagement metrics for international students [9], [10]. Considering that over 60% of the currently graduate population in engineering consists of international students [3], engineering students have a high likelihood of having international TAs, which may also account for their higher than average positive emotional engagement scores. The question for engineering programs is then how to engage students of

both genders and for minorities (by race or income) without producing anxiety in those potentially suffering from unique minority stressors.

Table 7: Engagement Patterns within key Demographic Categories

Demographic			*Low Engagement Pattern*		*High Engagement Pattern*	
Gender	*Race*	*Family Income (/year)*	*N*	%	*N*	%
Domestic Students						
Men	Asian	< $20k	2	18.2	9	81.8
		Between $20k and $80k	27	49.1	28	50.9
		> $80k	29	46.0	34	54.0
	White	< $20k	1	33.3	2	66.7
		Between $20k and $80k	28	50.9	27	49.1
		> $80k	65	48.9	68	51.1
Women	Asian	< $20k	0	0.0	2	100.0
		Between $20k and $80k	14	53.8	12	46.2
		> $80k	19	82.6	4	17.4
	White	< $20k	1	50.0	1	50.0
		Between $20k and $80k	10	41.7	14	58.3
		> $80k	20	43.5	26	56.5
International Students						
Men	Asian	< $20k	6	40.0	9	60.0
		Between $20k and $80k	8	21.6	29	78.4
		> $80k	11	34.4	21	65.6
	White	< $20k	0	0.0	0	0.0
		Between $20k and $80k	0	0.0	0	0.0
		> $80k	0	0.0	0	0.0
Women	Asian	< $20k	1	33.3	2	66.7
		Between $20k and $80k	2	25.0	6	75.0
		> $80k	2	40.0	3	60.0
	White	< $20k	0	0.0	0	0.0
		Between $20k and $80k	0	0.0	0	0.0
		> $80k	0	0.0	0	0.0

Limitations and Implications

Limitations: While this study has provided confirmations of the importance of intersectional analysis as well as some of the propensities of international students and women in engineering, it does have its limitations. For one, the data is limited to a single institution, and therefore these findings may not generalize to other institutions of higher education. Another major limitation is

the sample size, which made difficult to determine the significance of some of the smaller demographic combinations and to include other racial demographics as a fuller portrait of engineering classrooms. Additionally, the study does not take into account the potential nesting effects of class, major, or section, which may further contribute to Type-1 error rate in the regression analyses. However, because of the consistency with other studies, both those that identify key anxieties present in minority groups as well as kinds of engagement practices performed by students from different gender, racial, origin, or income backgrounds, the likelihood that these effects are not present is low. Still, further research is needed, not only to explore why specifically these students are engaging or disengaging in particular ways, but also to determine whether or not these patterns are consistent across multiple settings in higher education.

Implications: The results of all three research questions imply that students from varying demographic backgrounds engage differently in engineering classrooms, particularly when certain combinations occur. For example, in a major where half of the students are likely male *and* from high income backgrounds, then the fact that being female and middle class may predict that many are engaged by also have higher *negative* engagement (e.g. anxiety) is telling, especially in light of the continued retention problems engineering—especially electrical engineering—has with women. The key engagement patterns isolated among women and middle-class students suggest that engagement may, for some disadvantaged groups, be an indicator of anxiety rather than performance. Further study is needed to explore the full extent of these anxieties and their relationships with engineering classrooms. If these results were also confirmed in larger longitudinal studies (potentially looking at retention), they might have very strong implications for the benefits of focusing on different student engagement techniques for *different demographics* in order to further diversify engineering and the field as a whole.

Concluding Remarks

This study has expanded upon previous work exploring the effects of minority and gender disparities in engineering. The sample here indicated that when comparing Asian and white students together, despite being considered "highly represented" demographics, other disparities still emerged when more nuanced combinations of student characteristics are accounted for. Gender, race, origin, and income were all associated with various engagement patterns, particularly when they intersected. In particular, we saw that while Asian women at both low and high income levels engaged at higher rates than their peers, they did so in ways that may be indicative of a combination of higher anxiety levels with positive experiences in engineering classrooms. Conversely, these results may also indicate that higher income male students were potentially less engaged than their peers, which is highly problematic considering they accounted for nearly half the sample. Future studies should not only focus on how to engage students *positively* in their classes but do so in ways that adapt to the specific socio-cultural needs of students rather than simply to the "class as a whole."

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