AC 2011-1290: INTERSECTIONS OF GENDER AND RACE IN ENGINEERING EDUCATION

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Intersections of Gender and Race in Engineering Education

Abstract
The focus of this paper is on women studying engineering in the undergraduate academic environment, the need to recognize that changes are needed in the engineering classrooms, and the need to think about women as a diverse group. Results from this study show some interesting and statistically significant differences among women by race/ethnicity. T-test comparisons of means on questions related to classroom environments indicate that African American women report greater comfort asking questions in class and meeting professors for help than Hispanic, Native American, Asian American and white women. Meanwhile, Native American women are less likely than all other racial/ethnic groups to indicate comfort meeting with professors and asking questions in class. Even though African American women indicate greater comfort asking questions in class, they have a lower opinion that professors are good teachers compared to Hispanic, Native American and white women. In addition, while many of the women in the study are from underrepresented racial and ethnic groups in engineering, African American women are the most likely to report that they have been singled out unfairly in class because of their race/ethnicity: more likely than Hispanic, Native American, and Asian American women.

Introduction
Women in general are often thought of as a group, all with similar perceptions, experiences and beliefs. Yet, women in fact, are represented by multiple cultures, races, ethnicities, perceptions and experiences. This study clearly illustrates women of different racial/ethnic backgrounds experience engineering in different ways. The focus is on women studying engineering in the undergraduate academic environment, the need to recognize that changes are needed in the engineering classrooms, and the need to think about women as a diverse group. Female undergraduate engineering students are typically studied with little attention paid to the intersection of race/ethnicity and gender. Some researchers consider this dual minority status to be a "double-bind[1]" while other researchers look at how attributes of certain underrepresented racial backgrounds offer advantages to female students in Science, Technology, Engineering and Mathematics (STEM) fields[2]. Despite continued calls for disaggregated data on race and gender, few datasets have detailed information on student experiences with sufficient representation of underrepresented minorities to facilitate statistical analysis[3].

Using data from 21 schools that participated in the 2008 Project to Assess Climate in Engineering survey, the classroom experiences of women in undergraduate engineering majors are examined, with specific attention to the effect of race. This study explores the differences or similarities that exist between women of different race/ethnic groups with respect to their perceptions and engagement with faculty and in classrooms, where students begin their engineering careers.

Literature Review
Recent studies on the recruitment and retention of women in STEM fields have highlighted the need for research on the intersecting factors of gender and race[4, 5, 6]. Qualitative interview approaches have been successful in elucidating the perspectives of women STEM students from underrepresented groups[7, 8, 9]. However, additional research is needed in order to better understand the intersection of gender and race/ethnicity on the lived experiences of STEM

students[10]. The literature tends to examine women and ethnic minorities separately, which ignores the interdependent relationship between race and gender[11]. A 1996 review of studies on the intersection of race/ethnicity and gender revealed that extremely small sample sizes are a major obstacle to such research[12].

Research on women of underrepresented races and ethnicities demonstrates some surprising findings. The intersection of race and gender can create cumulative disadvantages or advantages for women of certain race/ethnicity groups[13, 14, 15]. This dual minority status has been referred to as the "double bind" although other research suggests that race is an asset for women of some racial minority groups. A recent study of African-American and white female science students found that a "double jeopardy" hypothesis of dual minority status may not result in the accumulation of greater disadvantages. For example, elements of African-American family culture hold women up to near equal status as men and do not place work and child-rearing at odds, suggesting that elements of African-American family support structures give these minority women more agency to be successful in science careers[16].

Past qualitative studies of women of color in science and engineering have shown that feelings of difference and visibly looking different impact the way women act in the classroom and with professors[17, 18]. For example, some students feel less inclined to ask questions in class for fear of being rebuked by the professor or being perceived as dumb either by the instructor or peers. These feelings may be amplified by gender or racial stereotypes[19]. However, in these recent qualitative studies women of color are aggregated together as a monolithic group such as "underrepresented minority".

This paper examines how women's classroom experiences vary by race and ethnicity. The objective is to identify ways to improve women's classroom experiences and thus increase their representation in the STEM workforce.

Data and Methods

The Project to Assess Climate in Engineering (PACE) study focused on engineering schools across the nation with in-depth surveys and face-to-face interviews collected with uniform methodologies, providing an unprecedented opportunity to examine undergraduate experiences in engineering. The 21 PACE schools used in this paper are composed of 81 percent public institutions, 14 percent minority-serving institutions, and 57 percent are classified by Carnegie as having very high research activity (RUVH). Analyses of the quantitative survey data are used in this paper.

Sample and Instrument

For the PACE survey, undergraduate engineering students were sampled from a diverse set of one-tiered undergraduate institutions using a stratified random sample with oversamples of women and underrepresented minorities. To reduce variation across sites, the PACE study was restricted to those undergraduate engineering programs defined as one-tiered. In other words, each of the programs either enrolls its students directly from high school into the College/School of Engineering and/or provides an engineering advisor to students during the first year who indicated an interest in engineering on their college application form. Between February and June of 2008, 38,376 engineering undergraduate students were invited to participate in the PACE online climate survey. A total of 10,554 students responded. The response rate at individual

institutions ranged from seven percent to 52 percent with an overall mean of 29 percent and a median of 28 percent. Three strategies were used to address and reduce the low response rate typically associated with web-based surveys. First, students received up to four total emails. Second, each email was sent from the local engineering dean or site liaison, and third, schools were given 100 dollars to use as a survey incentive which they could supplement with their own funds.

The PACE survey instrument was pre-tested, reviewed by a panel of experts, and approved by the University of Washington's Institutional Review Board (IRB) and each local school's IRB. The final PACE instrument took respondents approximately 15 minutes to complete 132 items. Questions were divided into the following categories: Quality of Teaching, Professors, Teaching Assistants, Labs, Resources, Student Interaction, Extracurricular Activities, Personal Experience, Perceptions of Engineering Career, Perceptions of Engineering Major, Confidence and Demographic Information. The survey instrument was analyzed and internal consistency coefficients showed adequate to excellent internal consistency with a mean α of .77.

This paper analyzes responses from women in five race/ethnic groups: African Americans, Hispanic Americans, Native Americans, Asian Americans, and white Americans. There were 4009 females included in these analyses: 164 African American, 53 Native American, 389 Hispanic, 409 Asian American, and 2994 white. The PACE survey data are unique because of the large number of underrepresented minorities (URMs) who answered the survey, enabling analysis by racial and ethnic group which is not common in engineering studies. This study answers the continued call for analyses that do not combine all URMs into one group, but instead focus on the experiences of each racial and ethnic group, as well as disaggregating by gender *and* race/ethnicity.[20, 21] This type of analysis is often difficult because of concerns about confidentiality and cell sizes too small to conduct appropriate analyses.

Variables

A total of seven variables are used to examine student perceptions and engagement with faculty and experiences in classrooms. Two factor variables, *comfortable* and *good teachers*, were created to summarize certain aspects of the student experience. *Comfortable* is a factor combining questions regarding the extent to which: students meet with their professors for extra help, are comfortable meeting with their professors for academic help, and are comfortable asking questions in class. *Good Teachers* is a factor combining questions regarding the extent to which: professors encourage students to think creatively, professors care whether or not students learn the course material, professors inspire students to study engineering, professors write helpful comments on homework, professors take student suggestions seriously, professors encourage office hours attendance, professors grade work fairly, students understand what is expected of them by professors, and quality of teaching in engineering is high.

Other variables consist of single item measures. *Professors respect* is a single item measure based on the extent to which students think their professors treat them with respect. Four questions examine stereotyping and discrimination: whether professors express *gender stereotypes, racial stereotypes,* whether students felt unfairly *singled out because of gender,* or *singled out because of race* in class. The response categories for these questions was "Yes" "No" and "Unsure." The analyses focused on stereotyping and discrimination examine only the students who responded "Yes" or "No."

Analysis Methodology

Rather than choosing one comparison group for all the different races, the research team chose to compare each of five groups to each other. For the analyses where the variable is ordinal in measurement, but the underlying construct is assumed to be interval, t-tests for differences of means are performed with the t-value and statistical significance reported in the table. In the tables with t-values, a negative t-value indicates that the column category has the higher mean while a positive t-value indicates that the row category has the higher mean.

For the analyses in which the outcome variables are nominal in measurement (stereotyping and singled out), the research team utilized 2 x 2 cross-tabulations using the Chi-square test statistic, adjusted residuals and odds ratios. Odds ratios are reported in the tables to show the strength of the association. Odds ratios can be computed for any 2 x 2 cross-tabulation, and are the "ratio of the products of cells from diagonally opposite cells"[22]. When the odds ratio equals one, there is independence between the variables. Odds ratios greater or less than one indicate a departure from independence, with increasing strength as they have increasing distance from 1.0. For example, an odds ratio of 1.25 indicates a greater likelihood of a "success" while an odds ratio of .75 indicates a lower likelihood of "success". In this study, a "success" is a "Yes" answer. The results section displays only the odds ratios and the statistical significance, not actual cells from the cross-tabulations.

Only significant differences are shown in the tables. If there was no statistically significant difference, the cell contains a "ND", indicating No Difference in means/proportions. In a handful of cases, the relationship between two groups on a particular variable was not able to be estimated. In these cases, the cell contains a "NE" for Not Estimated.

Results

By examining seven aspects of student experiences in the classroom and with faculty, the analysis below provides a multifaceted perspective of climate for women in undergraduate engineering classrooms. Table 1 shows the means, standard deviations, and percentages for female undergraduate engineering students by race/ethnicity. The descriptive statistics show higher levels of comfort in the classroom and interacting with professors for African American women than for women of other races/ethnicities. The means also suggest that African American women and Asian American women may have lower opinions of their professors as good teachers. Lastly, the percentages of women who indicated "Yes" to the singled out and stereotyping questions differ quite a bit across the different race/ethnic groups.

Table 1. Means (Standard Deviations) and Percentages for Women by Race/Ethnicity

	African American	Hispanic American	Native American	Asian American	White
Comfortable (factor)	.23	-.05	-.40	-.09	-.03
	(1.04)	(1.06)	(1.18)	(.99)	(1.01)
Good teachers (factor)	-.27	.09	.18	-.15	.01
	(1.00)	(1.06)	(1.11)	(.94)	(.92)
Professors respect	4.23	4.38	4.23	4.16	4.25
	(.72)	(.70)	(.76)	(.70)	(.67)
Singled out Race (% Yes)	17.14	3.35	3.92	2.56	0.37
Racial Stereotypes (% Yes)	18.59	9.33	3.85	8.35	6.63
Singled out Gender (% Yes)	23.78	17.27	22.45	12.69	20.14
Gender Stereotypes (% Yes)	23.68	20.70	23.53	19.40	24.72

There are differences between the experiences of women of different races/ethnicities in terms of the extent to which they meet with their professors for academic help, their comfort meeting with professors, and comfort asking questions in class. There are two main findings in Table 2. First, as indicated by the negative t-values, African American women (the column category) expressed much higher levels of comfort meeting with professors and asking questions in class than did women of all other race/ethnicities. Second, Native American women expressed the lowest level of comfort interacting with professors and asking questions in class, compared to women of all other race/ethnicities, as evidenced by the negative t-values in the Native American row and the positive t-values in the Native American column.

Table 2. Students comfortable meeting and asking questions (t-test)

	African American	Hispanic American	Native American	Asian American	White
African American					
Hispanic American	-2.85**				
Native American	-3.72***	-2.21*			
Asian American	-3.36**	ND	2.14*		
White	-3.32**	ND	2.62**	ND	

*=p<=.05, **p<=.01, ***p<=.001.

The extent to which female engineering students perceive their professors to be good teachers varies across race and ethnic groups (Table 3). Overall, both African American women and Asian American women seem to have a lower opinion of the quality of their engineering teachers than do women of other races. There is no difference between African American women and Asian American women on the degree to which they feel professors are good teachers.

Table 3. Professors are Good teachers (t-test)

	African American	Hispanic American	Native American	Asian American	White
African American					
Hispanic American	3.61***				
Native American	2.72**	ND			
Asian American	ND	-3.32**	-2.35*		
White	3.72***	ND	ND	3.29**	

*=p<=.05, **p<=.01, ***p<=.001.

There seem to be some clear trends among female undergraduate engineering students with regard to ethnicity and the degree to which they feel that professors treat them with respect (Table 4). In this case, Hispanic American women indicated that they feel they are treated more respectfully by professors than did African American, Asian American and white women. In addition, the only other finding in this table was that white women feel more strongly that they are respected by professors than did Asian American women.

Table 4. Professors treat you with respect (t-test)

	African American	Hispanic American	Native American	Asian American	White
African American					
Hispanic American	2.23*				
Native American	ND	ND			
Asian American	ND	-4.37***	ND		
White	ND	-3.43**	ND	2.46*	

*=p<=.05, **p<=.01, ***p<=.001.

The survey asked whether students felt singled out unfairly because of their gender or because of their race/ethnicity. It also included questions regarding whether students had heard engineering faculty express stereotypes about racial and ethnic groups or men and women in class. Feeling singled out and hearing stereotypes are both closely related to creating a climate in which someone feels like they do or do not belong. Tables 5 and 6 below focus on the race/ethnicity questions and Tables 7 and 8 focus on the gender questions.

The next four tables report the odds ratios from the cross-tabulation analysis. All odds ratios are positive, so the interpretations of positive and negative values from the tables above no longer apply. The column category is the group used to interpret the odds ratio. Odds ratios above 1.00 indicate that the column category has a higher likelihood than the row category of indicating "Yes" to the question of interest. An odds ratio below 1.00 indicates that the column category has a lower likelihood of marking "Yes" than the row category. Examining the "Yes" percentages in conjunction with the odds ratios can help to understand the odds ratios.

Among the women in the PACE survey, African American women were the most likely to indicate that they heard engineering faculty express stereotypes about racial/ethnic groups (Table 5). The percentage of women who indicated "Yes" to this question is in parentheses in the first column of the table below. Almost one fifth of African American women have heard racial/ethnic stereotypes from professors (18.6%). The ethnicity with the next highest percentage (10%) is Hispanic American women. The odds ratios tell us even more about the likelihood of a woman hearing faculty express racial or ethnic stereotypes. Female African American students are more likely to have heard faculty express racial/ethnic stereotypes than women of other race/ethnic backgrounds, and much more likely to hear racial/ethnic stereotypes compared to female Native American students.

Table 5. In class, I have heard engineering faculty express stereotypes about racial/ethnic groups (odds ratios)

(% Yes)	African American	Hispanic American	Native American	Asian American	White
African American (18.6%)					
Hispanic American (9.3%)	2.22**				
Native American (3.8%)	5.71*	NE			
Asian American (8.4%)	2.51**	ND	ND		
White (6.6%)	3.21***	ND	NE	ND	

*=p<=.05, **p<=.01, ***p<=.001.

Stereotypes in and of themselves can make individuals from the stereotyped group feel like they do not belong. Being singled out in class because of one's racial or ethnic background creates an even more hostile climate. Among the undergraduate women in engineering in the study, African American women were the most likely to indicate that they had been singled out unfairly in class (Table 6). The odds ratios are substantial. African American women are much more likely to indicate being singled out because of their race/ethnicity than are Hispanic American, Native American and Asian American women.

Table 6. In class, I have been singled out unfairly because of my race/ethnicity (odds ratios)

(% yes)	African American	Hispanic American	Native American	Asian American	White
African American (17.1%)					
Hispanic American (3.4%)	5.97***				
Native American (3.9%)	5.07*	NE			
Asian American (2.6%)	7.86***	ND	ND		
White (.4%)	NE	NE	NE	NE	

*=p<=.05, **p<=.01, ***p<=.001.

In contrast to the race/ethnicity finding, hearing faculty express stereotypes about men and women is a more common experience (Table 7). On average, around 20 percent of the women in each racial or ethnic group have heard gender stereotypes from faculty. There is only one statistical difference: Asian American women are a little less likely (odds ratio=.73) than white

women to report hearing gender stereotypes. In terms of percentages who indicated "yes", 19 percent of Asian American women compared to almost 25 percent of white women indicated hearing stereotypes about men and women from their engineering faculty members.

Table 7. In class, I have heard engineering faculty express stereotypes about men and women (odds ratios)

(% Yes)	African American	Hispanic American	Native American	Asian American	White
African American (23.7%)					
Hispanic American (20.7%)	ND				
Native American (23.5%)	ND	ND			
Asian American (19.4%)	ND	ND	ND		
White (24.7%)	ND	ND	ND	.733*	

*=p<=.05, **p<=.01, ***p<=.001.

Similarly, there are very few differences between women of different race or ethnic backgrounds with respect to whether they have been singled out unfairly in class because of their gender. Again, Asian American women are less likely than white women to indicate being singled out because of gender (odds ratio=.58, 13 percent vs. 20 percent, respectively). In addition, African American women are more likely than Asian American women to indicate being singled out because of their gender (odds ratio=2.15, 24 percent vs. 13 percent, respectively).

Table 8. In class, I have been singled out unfairly because of my gender (odds ratios)

(% Yes)	African American	Hispanic American	Native American	Asian American	White
African American (23.8%)					
Hispanic American (17.3%)	ND				
Native American (22.4%)	ND	ND			
Asian American (12.7%)	2.15**	ND	ND		
White (20.1%)	ND	ND	ND	.58***	

*=p<=.05, **p<=.01, ***p<=.001.

Discussion and Conclusion

Perhaps the most significant aspect of this study is the concerted and successful effort to gather enough data on women from different races and ethnicities in order to be able to assess the experiences of underrepresented minority women as well as white women. The inability to disaggregate the data obscures any racial or gender differences that may exist. Often women are treated as a single group, and thus experiences and perceptions of different groups of women in engineering are unknown. This exploratory study of women's experiences and perceptions in classroom settings demonstrates that race and ethnicity do influence perceptions.

With a large enough data set and the capability to disaggregate data, as in the PACE data, there are more opportunities to examine potential possibilities for programs, practice and policies that may influence an institution's mode of operation. For example, if interventions have been

implemented and evaluated to demonstrate their effectiveness in increasing and retaining women in science and engineering fields, then institutions have the information needed to influence policies and practices that encourage women's interest in engineering studies.

This study examined certain aspects of student experiences in the classroom as indicators of an institution's climate in engineering. The analyses shown here (feeling comfortable meeting and asking questions in class, feeling that you are treated with respect, and that your teachers are high quality) provide a glimpse into how students from different groups experience classroom environments in engineering. One might expect that majority women would feel the most comfort meeting with faculty; however, African American women expressed higher levels of comfort meeting with faculty, where Native American women felt the least comfortable.

Four questions asked if students felt "singled out" unfairly because of their race or gender and if they had heard engineering faculty express stereotypes about racial/ethnic groups or men and women. African American women were more likely to feel singled out than Hispanic American, Native American and Asian American women. Approximately twenty percent of women in each racial or ethnic group heard gender stereotypes. In order to address these types of climates, many institutions have implemented "diversity" training for faculty and teaching assistants as a mechanism for addressing insensitivity to cultural and gender differences. Other institutions have only instituted diversity training for teaching assistants and some publicly-funded institutions are unable to require the training of faculty but can require it of graduate students. The faculty members are an important link in this equation; the expression of stereotypes by faculty (role models) results in replication of the behavior among students and peers. Faculty "signal" to students, consciously and unconsciously, appropriate classroom behavior. Changes in behavior at the faculty level could have wide implications for the broader climate.

The issues surrounding stereotyping need to be addressed by institutional policies and programs and need with a focus on faculty, staff and teaching assistants. The data from PACE very clearly show that African-American women in are an environment where they observe stereotyping and feel singled out because of their race. This very environment has the potential to expose them to stereotype threats[23] which may impact their academic performance. The fact that African American women remain quite comfortable meeting with professors and asking questions in class suggest that other dynamics such as culture and family upbringing[24] may mitigate their observations of bias. This study begins to address the issues of climate in engineering for women of all races and ethnicities. Examination of other dimensions of diversity, particularly class and culture, may provide further insight into the mechanisms that enable women of certain racial/ethnic groups to persist despite being in an environment that singles them out for their underrepresented status.

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