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Gender and Race Intersectional Effects in the U.S. Engineering Workforce: Who Stays? Who Leaves?

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ABSTRACT
In many countries, engineering remains a field in which women are highly underrepresented, raising questions not only of equal access, but also of underutilized and wasted potential in engineering talent. The United States is one such country, with women representing only 15% of the engineering workforce. Moreover, even if initially entering the field, women in the United States are more likely than men to leave engineering altogether. This study further analyzes this situation, recognizing that women are a demographically varied group and questioning how differences among them might be reflected in engineering participation outcomes. Emphasizing race and gender, and employing logit regression and marginal effects tests, it considers intersectional configurations to examine probabilities of staying and working in engineering occupations among recipients of engineering degrees. Different gendered patterns are revealed for working in engineering among Hispanic Americans, Asian Americans, African Americans, and White Americans. Moreover, gender and race groups present varying retention rates in engineering occupations over time. Findings also confirm inter- and intra-group gender and racial/ethnic differences and disparities that would not have been revealed without attention to intersectional effects on participation in engineering fields.

KEYWORDS
Engineering; ethnicity; gender; intersectionality; race; women

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INTRODUCTION

In many countries, engineering remains a field in which women are highly underrepresented, raising questions not only of equal access, but also of underutilized and wasted potential in engineering talent. The United States is one such country, in which women represent only 15% of the engineering workforce (National Science Foundation [NSF], 2017). Moreover, even if initially entering the field and gaining employment in engineering, women in the United States are more likely than men to leave engineering altogether (Hunt, 2016; National Science Board [NSB], 2018). A variety of factors have been identified as leading to these outcomes. For example, women, along with other underrepresented groups in science and engineering, have faced persistent negative stereotypes, biases, "chilly" institutional and disciplinary cultures, harassment, a lack of mentoring and supportive policies, and an unsteady sense of belonging, all of which hinder relevant participation, inclusion, and advancement.[1] However, while such factors have been noted as influencing decisions to leave the field, they generally have not been explored relative to broader systemic and contextualized processes, which could provide a deeper understanding of embedded and institutionalized dynamics that can affect who stays in, or, indeed, who leaves engineering. It is in this sense that intersectionality—referring to the nexus of social, political, and cultural identifiers that can differentially affect lived experiences (Crenshaw, 1989, 2014)—is recognized as a particularly important analytical trope for gleaning insights into how the participation of different individuals and groups might be affected relative to the observed outcomes.

Intersectionality comes into play with effects on experience and power linked to "categories of difference" (e.g., race, ethnicity, and gender). Importantly, each category's effect is not separate from the others; rather, they intersect and interactively affect outcomes and experiences (Bhavnani & Talcott, 2012; Crenshaw, 1989; Davis, 2008). Thus, for example, intersectionality issues and professional barriers may disproportionately impact women—particularly, those from minority groups. However, with specific reference to engineering, intersectionality has been little addressed in direct terms relative to representation and participation on the basis of demographic characteristics and interconnections. Accordingly, this study acts as a hermeneutic foil and exploration of fundamental social categories (e.g., gender and race) that intersect and interact in different ways, affecting participation in engineering and related fields.

In this sense, issues of participation necessarily point to those who are underrepresented in engineering. Accordingly, this study is predicated on a fundamental and extended question: While gender may be a critical variable, what do other intersectional components and interactions imply in terms of inclusion and retention? As such, it highlights gendered and intersectional issues grounded in engineering, both as a field and as a profession, and reflected in participation processes and outcomes. The importance of participation and disciplinary cultures relative to career advancement, satisfaction, and retention for women and minorities in general has been previously documented (e.g., McNeely & Vlaicu, 2010; Rosser, 2004; Shore et al., 2011). Therefore, investigating how intersectional statuses influence engineering participation and career advancement, the research presented here considers the role of intersectionality understood relative to disciplinary contexts, focusing on questions of broadening participation in terms of intersecting social categories and the inclusion of women in engineering (Frehill & McNeely, 2011; McNeely & Husbands Fealing, 2018; Tao, 2018).

Thus, an important aim is to investigate similarities and differences in career trajectories among intersectionally differing women (and men) in engineering. As such, this study is presented as a contribution to the development of a more comprehensive understanding and application of intersectionality to engineering. It engages and explores intersectionality as a conceptual and methodological tool for interrogating and monitoring gender disparities in participation. Indeed, a crucial aim is to contribute to a growing and systematic body of research delineating the extent and impact of intersectionality on science and engineering participation more generally (McNeely & Husbands Fealing, 2018). Accordingly, this research highlights the education and careers of female engineers in the United States, both as a whole and from different identity groups. It investigates the relationship of factors such as race and gender, as major social organizing principles, to the participation of women in engineering. Examining challenges, effects, and connections across identities and intersectional configurations, the aim is to provide a better contextualized and more nuanced treatment of women in engineering as a demographically varied group.

After providing a brief profile and overview of the engineering educational and workforce situation in the United States as background, intersectionality theoretical and conceptual issues are discussed and presented as a platform for addressing questions of broader participation in engineering education and the related workforce. The research strategy is then delineated, indicating the data and methods used for the study itself, followed by a presentation of the analysis and findings. Examining outcomes relative to intersectional configurations, the analysis investigates how intersectionality operates to structure and determine career outcomes in engineering. Focusing on gender and race/ethnicity intersections and their impact on employment trajectories,[2] it analyzes propensities for working in engineering, as opposed to leaving or never entering the engineering workforce, after receiving an engineering baccalaureate (bachelor's) degree. Accordingly, findings are discussed in relation to questions of participation, representation, and inclusion in engineering and their broader implications. The final section offers an overall summary and related conclusions, along with a discussion of policy implications and limitations relative to the study's findings and broader contextual considerations.

BACKGROUND

Historically, science and engineering (S&E) fields have been male-dominated, not only in terms of numbers and representation, but also in their very nature, with women characterized as unwelcome, unrecognized, and marginalized (Tao, 2018). Yet, some change has occurred, underscoring the complexity of the situation and emphasizing the point that increasing the participation and inclusion of women depends on a variety of interrelated issues, such as access and opportunity, based on how S&E fields are socially and culturally organized and conducted (Frehill, McNeely, & Pearson, 2015). However, although, for example, increases in advanced degree attainment are now close to parity or better in some fields (e.g., life sciences), women continue to show relatively low levels of S&E education and workforce participation in general (NSF, 2017).

Of S&E fields, engineering has been one of the lowest in female degree attainment (NSF, 2017).[3] Indeed, engineering continues to have disproportionately low levels of female representation in education and workforce participation. Moreover, although the number of women earning engineering degrees has increased over the past two decades, their participation in the related workforce remains well below that of their male counterparts at all degree levels and across engineering fields (NSB, 2018; NSF, 2017).[4] For example, in 2015, women constituted 28% of S&E occupations, but only 15% in engineering, with especially low representation (9%) in mechanical engineering (NSB, 2018). Engineering continues to be marked by persistent, and in some cases increasing, underrepresentation, unequal standards and opportunities, and consistent disparities in earnings with regard to women (Hill, Corbett, & St. Rose, 2010; Tao, 2016, 2018). Accordingly, as previously mentioned, even when initially attaining related employment, women are more likely than men to subsequently leave engineering. The question here is the extent to which intersectional issues might be reflected in such outcomes, leading to a different and more in-depth understanding of affective social dynamics and relations.

Note that, although women in general are less likely than comparable men to earn engineering doctorates, differences have been found in this regard across demographic categories. For example, this gender gap is smaller among African Americans than among White Americans, Asian Americans, and Hispanic Americans (Tao, 2015). In any case, even when earning an engineering doctorate and obtaining employment in engineering, women tend to earn less than men across the board. Irrespective of demographic, education, employment, and productivity characteristics, gender pay gaps remain, with women in general earning 4% to 5% less than their male counterparts (Tao, 2018). Moreover, in-group gender earnings disparities have been found among White Americans, Asian Americans, and underrepresented minorities in general, with women showing lower earnings relative to men in S&E fields, and the widest gaps appearing among White Americans (Tao, 2018; Webber & Canche, 2015). However, in all cases, these points require broader contextualization and recognition of the embedded processes underlying them to be meaningful in light of both societal dynamics and disciplinary relations.

CONFIGURING INTERSECTIONALITY

Although increasingly challenged, the conduct and culture of S&E remain marked by inequality and inequity. However, research indicates that such issues can vary in application and effect depending on associational factors (e.g., Armstrong &

Jovanovic, 2017; Bernstein-Sierra & Kezar, 2017; Stewart, Malley, & Herzog, 2016). For a fuller understanding of participation, it is crucial to move beyond the treatment of women as a monolithic group, as well as beyond one-dimensional depictions of the disparities between women and men in S&E. Not all women may be treated equally—in negative or positive terms—such that looking to the experiences of different women (and men), framed relative to institutional and cultural structures and relations, is essential for gaining insight into varying educational and professional outcomes. Accordingly, the notion of intersectionality is engaged here as a lens through which to view and understand differential treatment and outcomes in engineering participation.

An intersectionality perspective posits that gender, race, ethnicity, and other categories of difference in individual, social, institutional, or cultural aspects of identifying societal constructions and relations can have intersecting or interactive effects on individual and group experiences, power, and status (Davis, 2008). For example, research indicates that, in higher education, academics from non-white racial or ethnic groups often face challenges associated with identity issues and marginalization processes (Dancy & Jean-Marie, 2014; Muhs, Niemann, González, & Harris, 2012; O'Brien, Blodorn, Adams, Garcia, & Hammer, 2015a; O'Brien, Garcia, Adams, Villalobos, Hammer, & Gilbert, 2015b). Intersectional gender disparities can be framed in terms of differently combined dimensions of representation (e.g., race, ethnicity, immigration status, sexuality, gender, class, disability, etc.) and outcomes (e.g., occupation, pay levels, resources, service responsibilities, promotion, retention, etc.). Pointing to connections across intersecting identities, intersectionality has been used to describe the nexus of social, political, and cultural identifiers that interact to produce different identities and effects (Crenshaw, 1989). In S&E, these issues speak further to work on the "double bind" regarding challenges faced particularly by non-white ("minority") women who find themselves marginalized in disciplinary and workforce settings (Malcom, Hall, & Brown, 1976; Malcom & Malcom, 2011). A principal contention here is that being both female and from an underrepresented minority group affects the individual's chances of entry and retention in S&E fields, especially in traditionally white male-dominated fields such as engineering. Intersectionality in this sense refers to the circular relationship in which experiences are shaped by identity factors and disciplinary cultures, and how those experiences affect career trajectories and possibilities.

Sensitivity to intersectionality dynamics and relationships brings attention to structural and systemic biases against social groups and, also, reflected in interacting forms and configurations. That is, the fundamental basis of intersectionality points to the fact that different intersectional configurations turn on axes of inequality reflected in disparities of representation, participation, and inclusion (Armstrong & Jovanovic, 2017; Bhavnani & Talcott, 2012; Charleston, Adserias, Lang, & Jackson, 2014; Leggon, 2006; McCall, 2005). Of particular concern in this regard is *representational intersectionality*, occurring when representations of a group ignore or distort the complexity of the group (Crenshaw, 2014), as can happen when women are treated as a homogenous group. Women's experiences can vary greatly, and differing intersectional configurations and in-group dynamics add even more layers of complexity to defining interactions and implications for broadening participation and inclusion (Malcom & Malcom, 2011; McCall, 2005; McNeely & Husbands Fealing, 2018). Indeed, these configurations do not refer solely to inter-group difference, but also to intra-group variation. Thus, intra-racial/ethnic (e.g., African-American women compared to African-American men) and intra-gender (e.g., Hispanic-American women compared to African-American women) differences can be found in analyses of the S&E workforce (Leggon, 2010). Arguably, "researchers need to disaggregate data when collecting and analyzing data as well as making policy recommendations because each gender and race/ethnicity can have unique educational and workforce experiences and challenges" (Tao, 2018, pp. 629–630). Intersectional configurations offer ways to understand how "systems often overlap and cross each other, creating complex interactions at which two, three, or four of these axes meet" (Crenshaw, 2014, p. 17).

Note that this is not a straightforward delineation. For example, it can reflect *experiential intersectionality*, occurring when the experience of being a member of more than one social group is bound with the experience of being a member of each (Crenshaw, 1994; Malcom & Malcom, 2011; McCall, 2005). Although not explored as such here, related identities and configurations can reflect much more complexity, as different categories often overlap and/or might be situationally affected. Accordingly, an issue such as class, which is often operationalized in keeping with factors such as parental educational attainment, is highly correlated with occupational choice and mobility (Pew Economic Mobility Project, 2011). In this sense, *structural intersectionality* occurs when social relations and structures that determine and organize different groups (e.g., race and gender) interact to produce certain effects, intentionally or unintentionally (cf. Crenshaw, 2014), and, in this case, rests on structural conditions in which disciplinary culture and privilege are determined. Structural intersectionality points to the need to change institutional cultures by targeting attitudes, beliefs, and actions that perpetuate inequality and inequity.

Women in general face obstacles in accessing resources and opportunities for advancement. Looking to intersectionality issues and career challenges that might disproportionately impact women—and especially minority women—leads to a basic question addressed in this research: To what extent, and how, do factors such as race and gender interact to affect career opportunities and retention? Moreover, do the outcomes differ by gender within a given minority group? A focus on intersectional configurations means recognizing that barriers to participation and inclusion in engineering can multiply for individuals and groups at the intersection of hierarchically bounded social identities. Accordingly, this study considers how gender interacts and is configured with other social dynamics—in particular, as related to race and ethnicity—to shape participation in engineering.

DATA AND METHODS

Data are drawn from the U.S. National Science Foundation's Scientists and Engineers Statistical Data System (SESTAT), providing longitudinal information on the education and employment of the college-educated U.S. science and engineering workforce.[5] SESTAT is a large, nationally representative dataset, covering 1993–2013 and providing information on demographic, educational, and employment characteristics for analyses related to the educational and career outcomes of individuals under the age of 76 with a baccalaureate or higher degree. While also including information on non-S&E degree recipients, it focuses on S&E degree recipients and individuals in the United States at all career stages. SESTAT has been widely used to examine the career outcomes of U.S. scientists and engineers and is the basis for the National Science Board's biennial *Science and Engineering Indicators* reports (e.g., NSB, 2018). The sample used in this study encompasses those who earned a baccalaureate in engineering, with data drawn for multiple years that were available (specifically, 1993, 1995, 1997, 1999, 2003, 2006, 2008, 2010, 2013) to investigate the intersectional effects of gender and race/ethnicity on engineering workforce participation—i.e., working in engineering as opposed to leaving or never entering the engineering workforce after receiving an engineering baccalaureate.

To examine intersectional effects of gender and race on retention or staying in engineering, logit regression and marginal effects tests were applied to the data. The dependent variable is engineering degree recipients staying in engineering (1=working in engineering occupations; 0=not working in engineering occupations). Working in engineering occupations, staying in engineering, and retention in engineering are treated as equivalent since all individuals in the sample received an engineering baccalaureate, and working in the same field as their baccalaureate is considered as retention or staying in the field. The key independent variables are gender (1=female; 0=male) and race/ethnicity (1=White American; 2=Asian American; 3=African American; 4=Hispanic American). Other racial/ethnic groups were not included due to small sample size, which would make it difficult to detect any statistically significant findings. For analysis of how intersectional effects of gender and race on retention might change over time, the survey year was also included as a key independent variable. Control variables included demographic variables (marital status; number of children; foreign-born status), parental education (at least one parent having a baccalaureate), and educational and employment variables (highest degree; years since the highest degree; current job employment sector), as well as survey year (for the full sample only). (Age is not included due to its high correlation with the number of years since obtaining the highest degree.) These variables have been found to affect a range of S&E educational and career outcomes (Bentley & Adamson, 2003; Pew Economic Mobility Project, 2011; Tao, 2018).

Logit regression was employed to analyze the relationship among the variables, given that the dependent variable is binary. Following logit regression, marginal effects tests were run to further analyze interaction effects of gender and race/ethnicity for the full sample. Data were then delineated by race/ethnicity, and logit regression and marginal effects tests were run on gender and survey year for each race/ethnicity group, allowing for a better understanding of how gender gaps in retention within a race/ethnicity group changed over time.

FINDINGS

Descriptive Results

Table 1 shows the sample size of each group in the full sample and in selected years. The three selected years—1993, 2003, and 2013—reflect 10-year intervals as exemplars indicating general trends over time. (The sample used for regression analysis includes eight waves of data from 1993 to 2013, as discussed below.) Across the years, men outnumbered women in all racial/ethnic groups. White Americans constituted the largest group, followed by Asian Americans. Especially in 1993, the numbers of African-American and Hispanic-American women were small. In fact, numbers of Hispanic and African Americans were smaller, with African Americans being the smallest for both females and males, in most years.

Table 1. Sample Size, by Gender and Race: Full Sample and Selected Years

Race/Ethnicity	White American		Asian American		African American		Hispanic American		All		
Gender	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Total
Full Sample	112,326	16,130	33,827	6,647	6,305	2,606	11,404	3,457	163,862	28,840	192,702
1993	19,810	1,915	4,375	544	704	163	1,076	163	25,965	2,785	28,750
2003	11,143	1,634	3,287	623	619	229	1,215	302	16,264	2,788	19,052
2013	10,431	1,982	4,487	1,159	776	373	1,641	657	17,335	4,171	21,506

Note: The full sample includes 1993, 1995, 1997, 1999, 2003, 2006, 2008, 2010, and 2013.

In the full sample, 59% of engineering baccalaureate degree recipients worked in engineering occupations (stayed in engineering). Also, 48% of the sample had the baccalaureate as the highest degree, while 52% also received a higher degree. In terms of gender gaps, as shown in Figure 1, women in the full sample had slightly lower percentages staying in engineering compared to men, and levels varied over time; women had a higher percentage of staying than men in 1993, but a slightly lower percentage in 2003 and 2013. Figure 2 adds intersections with race/ethnicity and shows more complexity in the findings. Compared to their male peers, White-American women had a higher percentage of staying in engineering in 1993, but a slightly lower percentage in 2003 and 2013, while Asian-American women had lower percentages in all three years. African-American women had higher percentages of staying than their male peers in 1993 and 2003, but a slightly lower percentage in 2013. Hispanic-American women had a higher percentage of staying than their male peers in all three years. While these results do not include effects of other characteristics such as marital status and highest degree, they show how essential it is to examine intersectional relations—in this case of gender and race/ethnicity—and how they can differ from a simple consideration of gender as an overarching socially affective identity category in relation to retention in engineering.

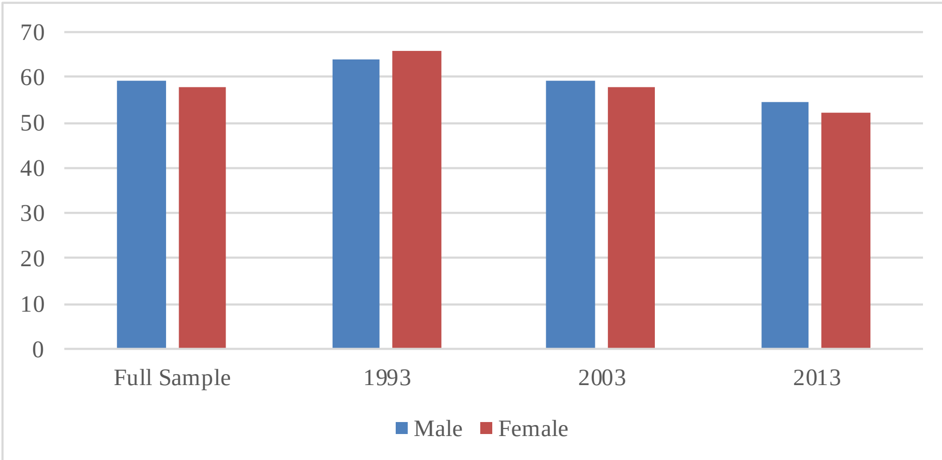

Figure 1. Percentage of Engineering Baccalaureate Recipients Working in Engineering Occupations, by Gender: Full Sample and Selected Years

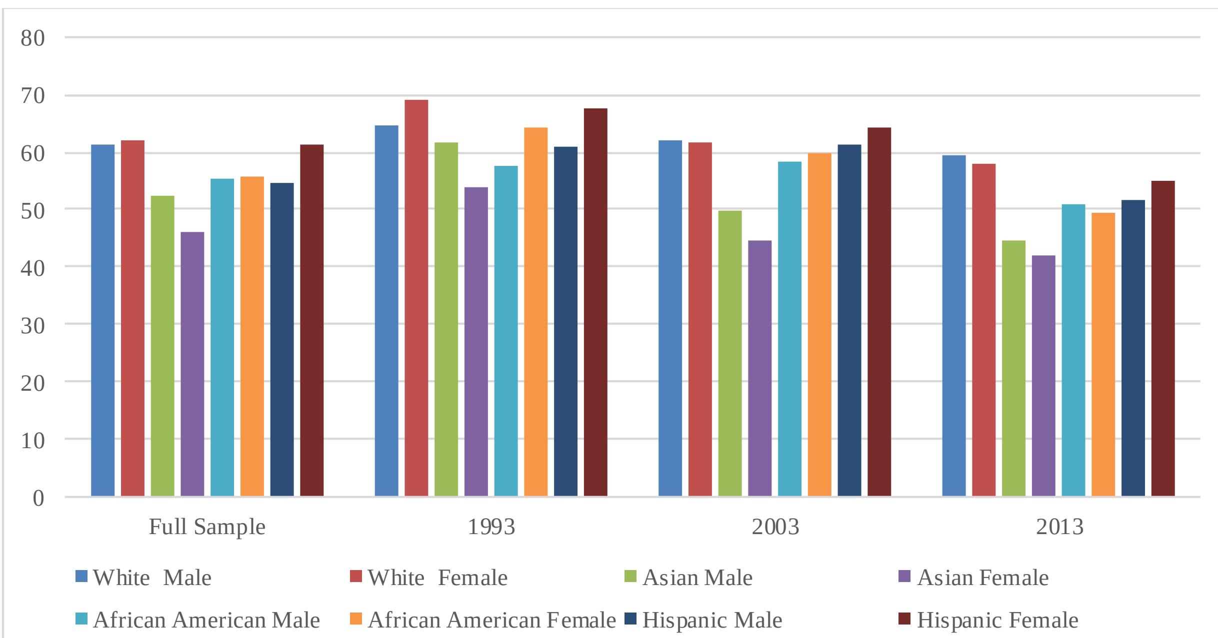

Figure 2. Percentage of Engineering Baccalaureate Recipients Working in Engineering Occupations, by Gender and Race: Full Sample and Selected Years

Regression Results

To better understand the intersectional effects of gender and race/ethnicity when other background variables are also considered, logit regressions and marginal effects tests were run to obtain the predicted probability of staying in engineering for men and women, holding all other variables in the model at their means. Regression results, as shown in Table 2, indicate that women and all racial/ethnic minority groups have lower odds of staying in engineering than their male and white counterparts, respectively. While the results also show interaction effects between gender and race, marginal effects results showing probabilities of staying in engineering (Figures 3–7) better reveal the intersectional effects of gender and race on retention in the field. As shown in Figure 3, women have a lower probability of staying in engineering (i.e., a lower stay rate) than their male counterparts among White Americans (1.7% difference), Asian Americans (7.9%), and African Americans (2.4%). While Hispanic-American women have a slightly higher stay rate than their male counterparts, this gender gap was not statistically significant. In addition, White-American men have a statistically significant, higher stay rate than all other male (and female) groups, and White-American women have a statistically significant, higher stay rate than Asian-American and African-American women (Figure 3). Also, since all racial/ethnic groups experienced gender gaps in stay rates in the full sample, further analysis was conducted to track changes in the gender gaps in stay rates among them over time. Among White Americans, gender gaps were found in 1999, 2003, 2006, and 2013, with a 3–4% difference in probability of staying in engineering. Higher female stay rates in 1993 and 1995 were not statistically significant (Figure 4). Among Asian Americans, the gender gap was found in all years except for 2008. Women had 4.3%–14% lower probability in general of staying in engineering during this period (Figure 5). Among African Americans, while a gender gap was found early in the full sample with nine years of data, no significant gap was found in any year, with the exception of 2010 in which the gender gap was marginally significant—women had 5.5% less probability of staying in engineering than their male counterparts ($p=.052$ [Figure 6]). The lack of a significant gender gap in most of the years could be due to the small sample size of African-American women in those years. No significant gender gap was found among Hispanic Americans in the full sample, nor was any significant gender gap found for any year in tests for the interaction effect of gender and year among Hispanic Americans (Figure 7).

Table 2. Logit Regression Showing Effects on Working in Engineering

	Coefficients	Standard Error
Female	-0.07***	0.02
Race/Ethnicity (Ref: White American)		
Asian American	-0.21***	0.02
African American	-0.30***	0.03
Hispanic American	-0.13***	0.02
Female x Asian American	-0.24***	0.03
Female x African American	-0.02	0.05
Female x Hispanic American	0.12**	0.04
Parental Education	-0.12***	0.01
Marital Status (Ref: Married)		
Single	0.02	0.01
Other Marital Status	-0.08***	0.02
Number of Children	-0.03***	0.00
Foreign-Born	-0.21***	0.01
Highest Degree Level (Ref: Baccalaureate)		
Master's	-0.14***	0.01
Doctorate	-0.07***	0.01
Years since Highest Degree	-0.02***	0.00
Employment Sector (Ref: Industry)		
Academia	0.02	0.02
Government	0.36***	0.02
Survey Year (Ref: 2013)		
1993	0.25***	0.02
1995	0.15***	0.02
1997	0.16***	0.02
1999	0.08***	0.02
2003	0.12***	0.02
2006	0.13***	0.02
2008	0.08***	0.02
2010	-0.03	0.02
Constant	0.74***	0.02
N	192,702	

***p<0.001, **p<0.01

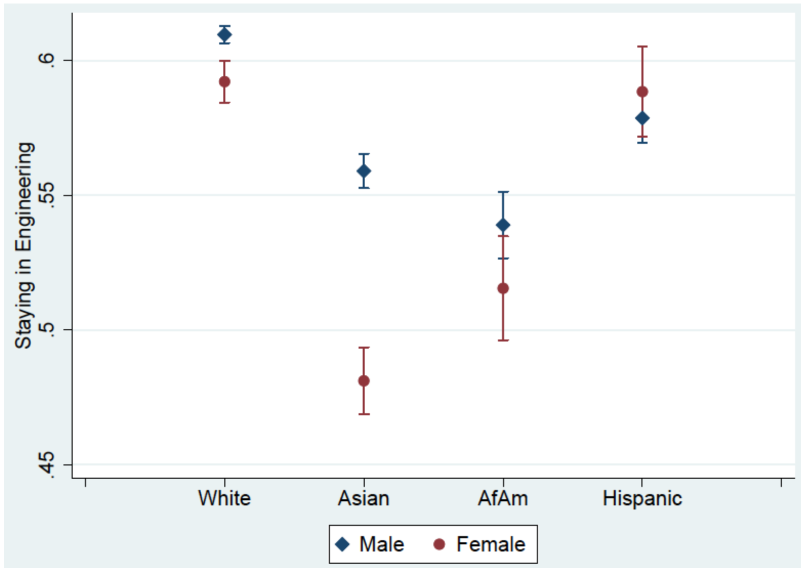

Figure 3. Engineering Stay Rate, by Gender and Race: Full Sample

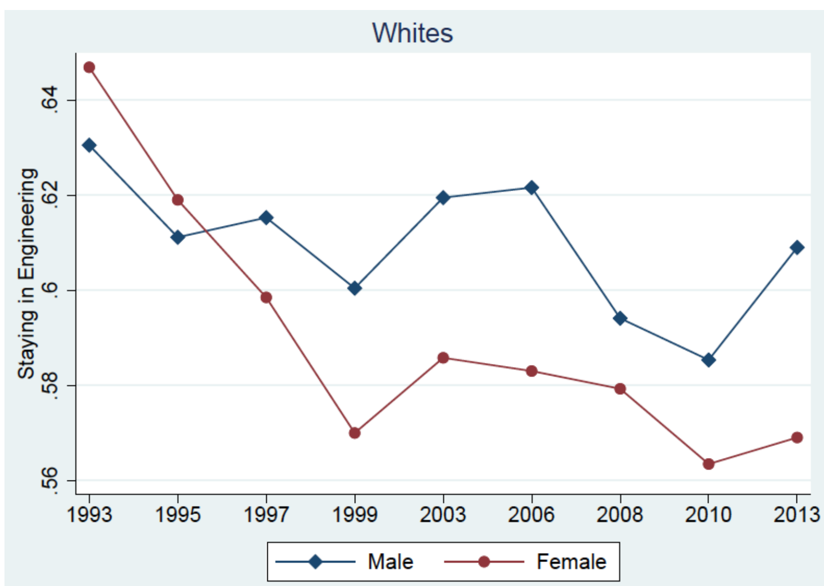

Figure 4. Engineering Stay Rate among White Americans, by Gender, 1999–2013

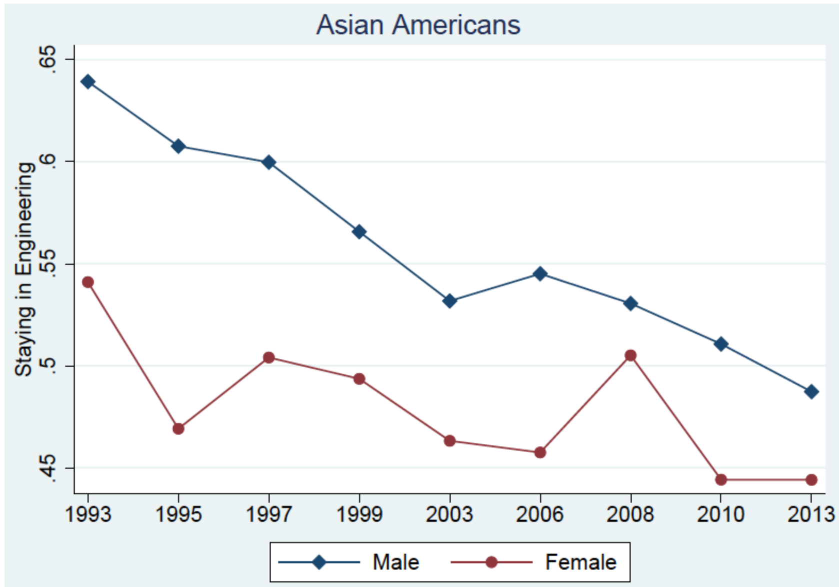

Figure 5. Engineering Stay Rate among Asian Americans, by Gender, 1999–2013

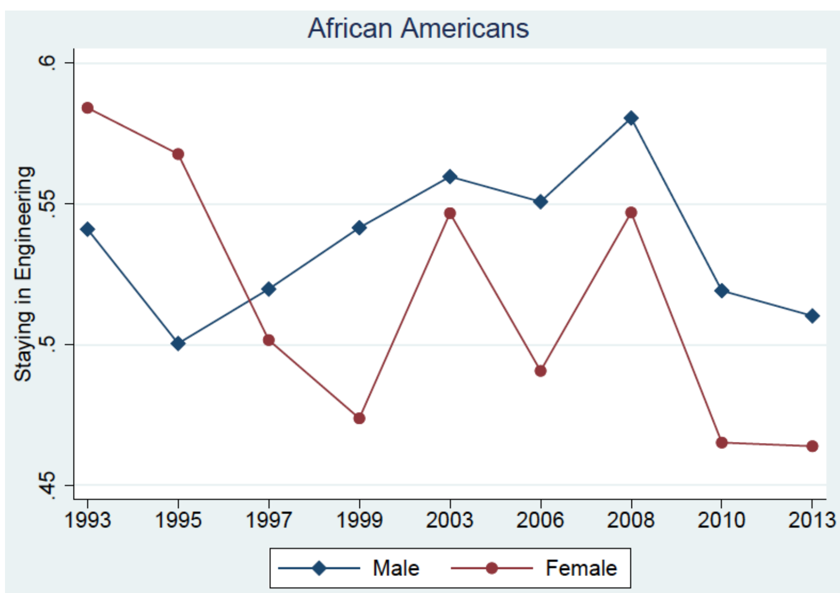

Figure 6. Engineering Stay Rate among African Americans, by Gender, 1999–2013

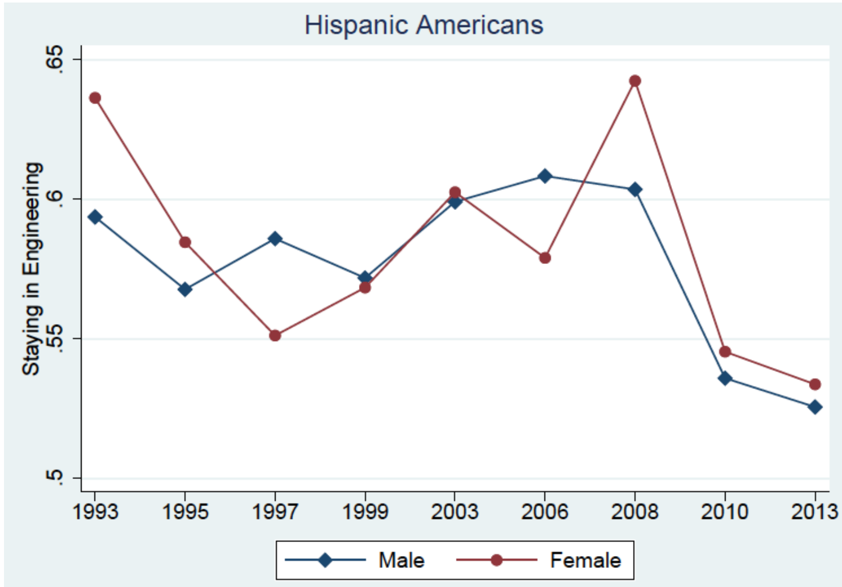

Figure 7. Engineering Stay Rate among Hispanic Americans, by Gender, 1993–2013

Another trend revealed in the data is that, while gender gaps fluctuated, many of the groups experienced declining stay rates over time. The probability of White-American men and women staying in engineering dropped from 63% and 65%, respectively, in 1993 to 61% and 57%, respectively, in 2013. Similarly, the stay rate of Asian-American men and women decreased from 64% and 54%, respectively, in 1993 to 49% and 44%, respectively, in 2013. The stay rate for African-American men and women dropped from 54% and 58%, respectively, in 1993 to 51% and 46%, respectively, in 2013. Among both White Americans and African Americans, women experienced greater declines than their male counterparts; women's stay rates were higher in 1993, yet lower in 2013 than those of their male counterparts. Among Hispanic Americans, although the gender gap did not change over time, both men and women experienced declines in stay rates—from 59% and 64%, respectively, in 1993 to 52.6% and 53.4%, respectively, in 2013.

DISCUSSION

The guiding research question here is to what extent, and how, gender and race/ethnicity might interact in affecting retention in engineering after receiving a degree in the field. The male-dominated culture of engineering has been pushing away certain individuals and groups, notably women in general, minorities, and minority women in particular, even after earning degrees in the field. The findings presented in this article revealed significant differences by race/ethnicity in gender gaps in stay rates for engineering after earning a baccalaureate or higher degree. Among all gender and race groups, White-American men have the highest stay rate, and Asian-American women have the lowest stay rate. In fact, the gender gap in stay rate is the greatest among Asian Americans, followed by African Americans and White Americans, but such a gender gap was not found among Hispanic

Americans. Among men, White Americans have the highest stay rate, followed by Hispanic, Asian, and African Americans. White-American and Hispanic-American women have higher stay rates than African-American and Asian-American women. Moreover, with some variations as indicated, a "double bind" facing some non-white female groups was found. Analyzing women as a homogeneous group would not have revealed such racial/ethnic differences in gender gaps.

A gender gap was not apparent within the Hispanic-American group, and Hispanic-American women did not differ from White-American women in terms of the probability of staying in engineering. These findings suggest that Hispanic-American women might have a relatively high level of persistence and retention in engineering, similar to some other groups with higher stay rates. However, African-American women showed lower stay rates or levels of retention, and Asian-American women had the lowest among the groups. On the one hand, these findings confirm previous research showing significant racial/ethnic differences along gender lines—e.g., the gender gap in receiving the doctorate in engineering is greater among Asian Americans than African Americans (Tao, 2015). On the other hand, such findings draw into question research indicating that, once an engineering doctorate is earned, no racial/ethnic or gender difference is apparent in working in engineering occupations, at least at some point in time (e.g., Tao & Hanson, 2015). Such differences may be explained by the use in the current study of the baccalaureate as the determinant degree. Although some individuals in the sample received higher degrees, 48% had the engineering baccalaureate as the highest degree. Also, while some research posited little difference among doctorate holders in obtaining engineering employment as a general point, it did not directly address stay rates or retention issues. It might be that, for engineering doctorate recipients, their longer-term educational investment in the field has similar effects on retention for all racial/ethnic groups and for both women and men, but this requires further study. In comparison, this study suggests that receipt only of the baccalaureate has varying effects on retention for different gender and racial/ethnic groups in engineering.

Also, while both men and women leave engineering, they appear to leave for different reasons. Additional analysis of the sample showed that, among those who responded to questions about leaving and working outside of their field of degree (about 21% of the sample), the top two reasons for women in general, in descending order, were change in career interests and job in engineering not available to them. However, racial/ethnic variations also were revealed. The top two reasons for White-American women were change in career interests and family-related reasons; for Asian-American women, the reasons were change in career interests and job not available to them. For underrepresented minority women, including African-American and Hispanic-American women, the top two reasons were job not available and change in career interests. The data suggest that women still face barriers to participation, mostly applied to minority women and, especially, to underrepresented minority women, based on the perception and reality of jobs being unavailable to them. For comparison, the top two reasons for leaving engineering for men as a group and for White-American or Asian-American men specifically were change in career interests and pay and promotion opportunities.

For African-American and Hispanic-American men, however, the top two reasons were job not available and pay and promotion opportunities. These findings are consistent with literature indicating the existence of institutional barriers to women, minorities, and—to a larger degree—minority women, for entry, retention, and advancement in engineering careers (e.g., Fouad & Singh, 2014; Johnson, 2011; Malcom & Malcom, 2011; Riley, Slaton, & Pawley, 2014; Tao, 2016). Of course, each individual, gender, and racial/ethnic group can face unique concerns when making decisions about whether to stay or leave engineering. In the meantime, while all women's groups and some men's groups report change in career interests as a primary reason for leaving engineering, such responses might be due to different underlying mechanisms and factors. For example, women, especially minority women, are more likely than men to face hostile working environments (National Research Council and National Academy of Engineering [NRC/NAE], 2014), which could be the basis for changes in career interests and leaving engineering, as could be better pay, promotion possibilities, decision-making, or other opportunities outside of engineering—although the latter are more likely for men (Tao, 2016; Yoder, 2016). While not directly explored in this study, future research might further investigate underlying mechanisms relative to various gender and racial/ethnic groups.

Another interesting finding is that, despite gender differences, all gender and racial/ethnic groups experienced a decline in stay rate over time. Women exhibited a greater decline than men (except for Asian Americans, among whom men had a greater decline than women). This finding is consistent with previous research that shows the greater likelihood of women leaving engineering (Hunt, 2016; NSB, 2018). Different gender and racial/ethnic groups, reflecting different intersectional configurations, have different career concerns, and those concerns might change over time. In further efforts to explain declining engineering stay rates—especially given a general increase in S&E jobs over time (NSB, 2018)—supplemental analysis was conducted on the same SESTAT data regarding the occupations that engineering baccalaureate recipients chose, if outside engineering, as well as changes over time. For both women and men in 1993 and 2013, if they were not working in engineering, most were working outside of S&E altogether, followed by employment in computer science—the S&E area that has shown the most growth in recent decades (NSB, 2018). However, over time, proportionately more women switched to non-S&E occupations than men, and more men switched to computer science than women.[6] These gendered patterns held for all gender and racial/ethnic groups except Asian-American women (their increase in computer science over time was greater) and Hispanic-American men (their increase in non-S&E occupations over time was greater). Future research could more systematically investigate factors that contribute to declining stay rates and, additionally, could test the intersectional effects of gender and race/ethnicity on retention by engineering subfield for even finer grained depictions of the conditions and relations leading to the observed outcomes.

CONCLUSION

This study examined likelihoods of staying and working in engineering occupations among engineering degree recipients through the lens of intersectionality based on gender and race/ethnicity. In particular, different gendered patterns were revealed for those working in engineering among White, Asian, African, and Hispanic Americans. Moreover, these gender and racial/ethnic groups also presented varying trends of staying in engineering over time. The findings also confirmed and emphasized that inter- and intra-group gender and racial/ethnic differences and gaps may not always be revealed unless attention is given to contrasting intersectional configurations affecting participation in engineering fields.

Gender disparities in participation in S&E are a topic of increasing debate in national and international arenas, with low levels of representation of women in related fields framed especially as a potential limitation to innovation and productivity, not to mention issues of equal access and rights (Hill et al., 2010; Pearson, Frehill, & McNeely, 2015). In the United States, engineering in particular remains a field in which women are highly underrepresented, marked by inequalities and gaps in participation as framed within societal relations and the social organization of the field itself, relative to education and workforce outcomes (Fouad & Singh, 2014; NSF, 2017; Pearson et al., 2015; Yoder, 2016). Accordingly, this study has presented an exploration of intersectional configurations turning on axes of race and gender in order to better understand the underlying dynamics and relations that lead to disparities and low levels of participation in engineering and other S&E fields.

Framing diversity as both innovation and capacity building for the engineering workforce (McNeely, 2019), this research addresses the need to look more closely at how intersectionality influences the ways in which engineering and other S&E fields engage factors that determine participation and disciplinary cultures—and that underlie persistent inequities. Attending to intersectionality offers a more nuanced understanding of how identities and statuses may operate to privilege or disadvantage certain individuals and groups with regard to advancing in engineering.

This research indicates the need to challenge institutional practices and disciplinary norms that directly and indirectly support the marginalization of women and their contributions in the field, and that undermine their advancement. Female and minority experiences are marked by issues such as negative stereotypes, unequal access to resources, and barriers to participation and opportunities for advancement (Nosek et al., 2009; O'Brien et al., 2015a, 2015b; Winslow & Davis, 2016). The complex intersecting biases and interactive processes leading to participatory disparities are part and parcel of the enduring nature of these outcomes, requiring contextual and ongoing interventions across levels of analysis if change is to be taken seriously as a goal. Thus, understanding how intersectional configurations operate to shape women's S&E participation can better inform related policy and program development across sectors and groups (Tao, 2018). Ideally, recognizing gender disparities in engineering as embedded in the broader societal and national context, any advances that women make—as a whole and as a highly differentiated group—can benefit everyone, leading to greater gender equity and better science and engineering, encompassing diverse perspectives (Rosenfeld, 2002; Rosser, 2012; Tao, 2018). Considering women from differing racial/ethnic groups as a way to address questions of diversity in engineering, a principal purpose of this research was to help identify target areas for strategic development aimed at recruiting, hiring, and retaining individuals from different backgrounds and with different identities (McNeely & Vlaicu, 2010). More to the point, the research presented here can be engaged to inform policies for transforming engineering into a culture of inclusion and equity, based on an understanding of intersectional configurations reflecting gender, race, and other identifying factors.

ENDNOTES

[1] See discussion and references in Blackburn (2017).

[2] For purposes of this research, "race" and "race/ethnicity" are used interchangeably. Based on convention, "race" is used as an encompassing term in reference to related social categories and perceptions. However, "race/ethnicity" also is used for analytical purposes in recognition of technical differences in social construction.

[3] Along with computer sciences and physics.

[4] The degrees earned by women tend to be in chemical, materials, industrial, and civil engineering, rather than in aerospace, electrical, and mechanical engineering (NSF, 2017).

[5] SESTAT is composed of three datasets: the National Survey of College Graduates (NSCG); the National Survey of Recent College Graduates (NSRCG); and the Survey of Doctorate Recipients (SDR). NSCG (1993–2017) covers baccalaureate recipients in both S&E and non-S&E fields residing in the United States. SDR (1973–2017) covers doctorate recipients in S&E from U.S. institutions of higher education. NSRCG provided data from 1973 to 2010 on scientists and engineers who received baccalaureate and master's degrees within two to three years in the United States; these data were included in the NSCG, starting from 2013. SESTAT covers the three datasets from 1993 to 2013. For more details regarding SESTAT, see https://www.nsf.gov/statistics/sestat/#datatables&sestat-faq. The use of NSF data does not imply NSF endorsement of the research methods or conclusions contained in this article.

[6] For both women and men receiving the engineering baccalaureate, engineering was the largest occupational category: 64% of men and 66% of women in the sample worked in engineering in 1993; 55% of men and 52% of women did so in 2013. Outside engineering, the largest category of occupations for both men and women were non-S&E occupations (e.g., 26.1% of men and 21.5% of women in 1993; and 30.2% of men and 30.3% of women in 2013), followed by computer science, with 7.4% of men and 8.7% of women in 1993, and 11.5% of men and 10.6% of women working in computer science in 2013. While the numbers and

percentages of both women and men receiving engineering baccalaureates and working in computer science or outside S&E altogether increased over time (from 1993 to 2013), the rates of change varied between women and men. Over time, proportionately more men switched to computer science (a 55% increase) than women (22%), and more women (41%) switched to non-S&E occupations than men (16%).

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