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Trends in the Underrepresentation of Women of Color Faculty in Engineering (2005–2018)

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Women of color (WoC) continue to be underrepresented in engineering programs across the United States. Many scholarly reports on faculty demographic characteristics do not provide measures regarding the representation of WoC faculty due to data reporting restrictions or lack of relevant data. Using 14 years of data from the American Society for Engineering Education, this study examined the trends in the prevalence of WoC faculty and PhDs in engineering between 2005 and 2018. Informed by intersectionality theory and Kanter's theory of proportions, descriptive analyses were used to disaggregate the prevalence of engineering faculty by gender, race/ethnicity, and engineering discipline. Findings indicate that there were slight growths in the representation of African American/Black, Native American/Native Hawaiian, and Hispanic/Latina women engineering faculty. The low representation of WoC is also evident among engineering PhDs. Changes in the shares of WoC in assistant, associate, and full professor ranks and in the production of PhDs provide insights for future demographic shifts in engineering education. Greater efforts and investments are needed in the recruitment of WoC into PhD programs and, subsequently, as assistant professors across engineering disciplines. Although interventions and programs aimed at helping increase the participation of WoC faculty in engineering have made progress, findings suggest that larger scale structural and cultural changes are needed to shift prevailing demographic trends in the engineering professoriate, including expanding student access to doctoral education in engineering. Research findings have the potential to provide foundational information for developing strategies to increase the representation of WoC engineering PhDs and faculty.

Keywords: women of color, engineering faculty, PhDs, intersectionality, underrepresentation

After decades of funding invested in science, technology, engineering, and mathematics (STEM) diversity initiatives, women of color (WoC) are still underrepresented in the engineering professoriate across the United States. WoC include women who identify as African American/Black, Asian/Asian American, Hispanic/Latina, and Indigenous (Main, Tan, et al., 2020; Malcolm et al., 1976; Ong et al., 2018; Seo & Hinton, 2009). Averaged across 2005 through 2016, women comprised 14% of the engineering faculty; of the women faculty, 61% identified as White, 23% as Asian/Asian American, 3.5% as African American/Black, and 4.8% as Hispanic/Latina (American Society for Engineering Education [ASEE], 2018; Main, Tan, et al., 2020). Most scholarly reports on the demographic characteristics of engineering faculty do not report the numbers of WoC faculty specifically, thus neglecting the intersection of gender, race, and engineering discipline. This is often because the data may not be disaggregated along these dimensions, or if the data are disaggregated, some of the smaller numbers may be masked to protect confidentiality (e.g., Frehill & Ivie, 2013). While there are important reasons why some of these numbers may not be reported, an unintended consequence is that the participation of WoC faculty in the engineering professoriate is at risk of being unrecognized and/or overlooked. This lack of transparency makes it difficult to identify the extent of the disparities, as well as the changes, progress, and gains that may have been made in the representation of WoC engineering faculty. Further, this lower visibility of WoC in academe may hinder efforts to address the challenges that many WoC faculty face, especially those that stem from isolation and tokenism (Armstrong & Jovanovic, 2015, 2017; Berry et al., 2014; Hess et al., 2013; McGee et al., 2021; Padilla & Chávez, 1995; Turner & González, 2011). Thus, examining the representation of engineering faculty at the intersection of gender, race/ethnicity, and engineering discipline contributes to understanding the outcomes of diversity initiatives and informs the development of strategies to recruit, retain, and foster the success of WoC.

Building on Nelson and Rogers's (2003) seminal research on the numbers of WoC faculty across the top 50 departments by research expenditure across 14 disciplines, our study examines the prevalence of WoC faculty in engineering tenure track and tenured positions across the 405 institutions represented in the American

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Society for Engineering Education (ASEE) database between 2005 and 2018. We address the following research question: How did the prevalence of WoC faculty in engineering change between 2005 and 2018 by engineering discipline? Our research findings contribute to the literature by preserving and documenting the historical changes in the composition of WoC faculty in engineering across the nation over time. We also highlight the role of professional societies in stewarding critical data useful toward facilitating transformations in higher education. By documenting the trends in WoC representation in engineering, we provide evidence for academic administrators, policy makers, and other key stakeholders to reflect on the progress of diversity initiatives across institutions; to propagate effective programs, policies, and practices; and to identify new opportunities for diversifying the engineering professoriate.

Literature Review

Diversity in Engineering

Many studies on faculty diversity tend to focus on STEM disciplines rather than engineering specifically. However, engineering lags behind many science disciplines in terms of faculty diversity. For example, 34.5%, 3.5%, and 4.9% of the aggregated science and engineering faculty in 2017 identified as women, African American/Black, and Hispanic/Latinx, respectively (National Science Foundation [NSF], 2019b). Focusing specifically on engineering, tenured, and tenure-track women engineering faculty comprised only 17.6% of the professoriate, with subdisciplines ranging from 11.8% women in aerospace engineering to 28.9% women in environmental engineering (Roy, 2019). Among men and women engineering faculty, only 2.4% identified as African American/Black and 3.8% as Hispanic/Latinx in 2018, Asian/Asian Americans comprised 28.3% of the engineering faculty that same year (Roy, 2019).

Diversity in the engineering professoriate at the intersection of gender, race, and engineering discipline is critical for several reasons. First, a diverse faculty helps attract and retain a diverse student body and workforce (Abdul-Raheem, 2016; Espinosa & Rodríguez, 2013; Main, Tan, et al., 2020). Second, a diverse faculty provides a larger pool of diverse role models and mentors for students and other faculty, who benefit from increased social and professional support, reduced feelings of isolation, increased retention, some protection and buffer from racism and discrimination, and increased scholarly performance (e.g., Main, 2018; Main & Schimpf, 2017; McGee et al., 2021; Mondisa & McComb, 2018; Tan & Main, 2021). Third, racial and gender diversity in higher education creates more inclusivity and the promotion of policies that can potentially interrogate and dismantle systemic racism and oppressive practices that commonly impede the success of WoC in the academy (Harper, 2012; McGee, 2020). Fourth, diversity yields more expansive ideas and innovative solutions to solve 21st century engineering and STEM problems, outcomes often linked to national competitiveness (Rodriguez & Lehman, 2017; refer also Lichtenstein et al., 2014; McGee, 2020). Further, diversity within and across engineering disciplines contributes to the breadth of these innovations. Fifth, Black and Brown STEM professionals who are marginalized (e.g., by race and/or gender) and who demonstrate an *equity ethic*, a concern for helping others (McGee & Bentley, 2017a), are likely to use their engineering-specific skills and/or their positions to address equity concerns within and outside of academia (Naphan-Kingery et al., 2019). Overall, diversity in the engineering professoriate has wide-ranging implications for more inclusive academe, for advancing social justice efforts, and for advancing scientific and technological innovations.

Experiences of WoC Faculty

Across disciplines, faculty of Color have documented marginalization, discrimination, racism, and sexism that affect promotion, tenure, teaching evaluations, collegial inclusion, and well-being in the academy (e.g., Carroll, 2017; Orelus, 2020; Settles et al., 2019). We examine the representation of WoC at the intersection of race and gender because evidence suggests that the “double bind” of sexism and racism has adverse effects beyond that of sexism alone or racism alone (Collins, 1998; Crenshaw, 1989; Malcolm et al., 1976). As the lens of intersectionality theory suggests, WoC faculty experience unique challenges that differentiate their experiences from women, in general, and from men of Color (Collins, 1998; Crenshaw, 1989). Crenshaw (1989) and other scholars have argued that treating Black women, for example, as solely women or solely Black has repeatedly ignored specific challenges that Black women face as a group. Thus, intersectionality allows a prism to bring to light the dynamics of systemic marginalization and discrimination against women who are raced (Ong et al., 2011).

Studies investigating the experiences of WoC in STEM fields consistently demonstrate barriers and systemic marginalization underlying recruitment, persistence, and retention (Alfred et al., 2019; Johnson, Thomas, et al., 2017; McGee & Bentley, 2017b; Ross et al., 2015; Wilkins, 2017). Difficulties faced by WoC faculty stem from structural and interpersonal racism, microaggressions and microinvalidations, impostor syndrome, institutional climates that privilege White men, and racialized and gendered experiences (Corneille et al., 2019). These issues are also prevalent among WoC engineering faculty, including hardships in their tenure and promotion process (Corneille et al., 2019), lack of mentorship (Buzzanell et al., 2015; Long et al., 2018), and bias in teaching evaluations (Rios & Stewart, 2015; Robinson et al., 2016; Soto, 2014).

In terms of faculty experiences at the intersection of race and gender in engineering, Ross et al. (2015) highlighted a myriad of issues associated with stereotype bias, departmental culture and climate, and tenure and promotion among African American/Black women faculty in engineering. Sambamurthy et al. (2016) explored the literature on Asian/Asian American women faculty and found that they experienced qualitatively different but nevertheless repressive stereotypes related to the intersection of race and gender. Although Asian faculty are not typically considered underrepresented in engineering, comprising approximately 23% of engineering faculty (Roy, 2019), Asian women faculty, similar to African American/Black and Hispanic/Latina faculty, continue to face discrimination and marginalization, and therefore are included in studies of WoC in STEM disciplines (e.g., Chinn, 2002; Hailu et al., 2019; Johnson, 2011; Johnson, Ong, et al., 2017). Sanchez-Peña et al. (2016) reviewed the literature related to the intersecting identities of Latina engineering faculty and found similar themes related to systemic marginalization, as well as highlighting the strategies that Hispanic/Latina faculty enacted to thrive in the professoriate.

McGee et al. (2021) conducted interviews with 56 WoC engineering faculty and found several sources of support for persisting and thriving in the professoriate: supportive colleagues within their departments and institutions, supportive colleagues outside of their institutions, proactive leadership committed to institutional diversity, and opportunities for professional development. McGee et al. (2021) also noted that many of the African American/Black women engineering faculty who participated in the interviews discussed the importance of spirituality and faith-based support. Meanwhile, the Latina engineering faculty participants described professional networks, such as the Society of Hispanic Professional Engineers and the Society of Women in Engineering, and the Asian/Asian American women engineering faculty discussed supportive colleagues and administrative leadership, when discussing the sources of support for their persistence (McGee et al., 2021).

The Ramifications of Aggregated Data

Data presented in the aggregate can easily hide underrepresentation and small numbers, both within specific contexts and for groups of people with intersecting minoritized identities. Indeed, to avoid identifiability, even national studies (e.g., National Science Foundation, 2019b) do not report on small numbers of participants, or avoid disaggregating data related to gender, race, and discipline because of ethical ramifications. At the same time, in order to demonstrate issues of tokenism more concretely, it is important to disaggregate data to examine (a) the representation of faculty, as well as PhDs, by gender and race and (b) how the representation of WoC varies by engineering discipline and apart from science, technology, and mathematics.

While STEM can be a convenient grouping for faculty who engage with technical content (Kachchaf et al., 2015), there are significant disciplinary differences between not only the types of research conducted, but also the disciplinary expectations for publication, research, and promotion. Durodoye et al. (2020) authored a quantitative article that disaggregated faculty experience by race, gender, and tenure-track faculty rank (i.e., assistant, associate, or full professor) as well as discipline. They argued that "[f]ailing to incorporate academic discipline into analyses of differences in faculty career trajectories ignores the ways departmental norms influence career outcomes" (p. 2). Indeed, scholars in engineering education are increasingly disaggregating analyses by engineering field (e.g., Knight et al., 2012; Lord et al., 2019; Main et al., 2022; Main, Johnson, et al., 2020).

It is important to disaggregate WoC faculty who work in engineering disciplines from other STEM disciplines. Aggregated data that reflects combining all STEM disciplines together, all women faculty together, or all faculty of Color together can hide underrepresentation (Frehill & Ivie, 2013; Leggon, 2010; Mack et al., 2013). Yet, very few studies disaggregate data by race, gender, engineering disciplines, and institution types to present quantitative evidence on the prevalence of WoC faculty, given the myriad issues associated with data availability (e.g., Berry et al., 2014; Nelson & Madsen, 2018; Nelson & Rogers, 2003). In addition, the employment institutions of WoC faculty are an understudied area and need more research attention. Using ASEE data, for example, Berry et al. (2014) demonstrated that in 2012, African American engineering faculty were still underrepresented in all engineering disciplines, and that the underrepresentation is particularly prominent in computer and electrical engineering. Berry et al. (2014) also showed that, as of 2012, there were fewer than 150 African American/Black engineering women faculty across all career stages and engineering disciplines, and that a third of these faculty were employed at historically Black colleges and universities (HBCUs).

Contributions of the Present Study

This study demonstrates the empirical trends in the representation of WoC engineering faculty. The few existing journal articles that explore the experiences of WoC engineering faculty tend to use qualitative methods, highlighting the scarcity of WoC engineering faculty. Studies have noted the challenge of lack of data in their studies of women or underrepresented racially minoritized (URM) faculty (e.g., Aguirre, 2000). Despite the proportions of Asian/Asian American faculty generally being larger than the proportions of URM faculty, "most surveys do not contain sufficient numbers for reliable analysis or do not gather information that allows multivariate analysis" (Lee, 2002, p. 700). As Durodoye et al. (2020) noted, larger, quantitative studies often aggregate data in ways that hide problems for populations with intersecting minoritized identities. Furthermore, few studies focus within engineering apart from STEM. Our study fills these gaps in our knowledge about WoC faculty in engineering education by using a larger-scale data set to exhibit the recent trends in the prevalence of WoC faulty, showing empirically how the trends differ by faculty rank and engineering discipline. We complement the analysis on faculty by demonstrating the prevalence of WoC PhDs in engineering. The present study addresses gaps in the literature by documenting changes in the prevalence of WoC faculty in engineering tenure track and tenured positions across the ASEE member institutions from the years 2005–2018.

Our findings extend what is ordinarily found in ASEE reports (e.g., Roy, 2019) by providing the trends over time and disaggregating by gender and race/ethnicity, and comparing these trends to those of WoC PhDs. In relation to reports from the National Science Foundation (NSF), we provide trends disaggregated by engineering discipline. Altogether, our study seeks to address the lack of information surrounding the participation of WoC in the engineering professoriate. We further offer suggestions for faculty, academic administrators, and key stakeholders to consider the experiences of WoC faculty in engineering toward greater diversity in faculty employment and retention.

Theoretical Framework

We use intersectionality theory (Collins, 1998, 2000; Collins & Bilge, 2016; Crenshaw, 1989) and Kanter's (1977) theory of proportions to inform our study. Intersectionality theory acknowledges the importance of investigating the experiences of individuals at the intersection of multiple marginalized categories of identity, such as race and gender simultaneously, rather than by race alone or by gender alone (Collins, 1998, 2000; Collins & Bilge, 2016; Crenshaw, 1989). That is, certain dimensions and aspects of identity are more vulnerable to inequalities and oppression, and these inequalities are compounded for individuals who embody multiple marginalized identities (Crenshaw, 1989; Collins, 1993). As an analytical tool, intersectionality addresses issues, to varying extents, associated with "inequality, relationality, power, social context, complexity, and social justice" (Collins & Bilge, 2016, p. 25). The engineering education literature has employed intersectionality in a number of studies (e.g., Cross et al., 2017; Main, Tan, et al., 2020; McGee et al., 2021; Ong et al., 2020; Ro & Loya, 2015). In this study, we focus on issues at the intersection of race and gender in the social context of the representation and tokenism of WoC in the engineering doctorate and professoriate (Kanter, 1977).

Kanter (1977) proposed that the relative representation of social groups within an organization has important implications for the organization's culture, its climate, and the experiences of the members of the different social groups (Wharton et al., 1992; Zucker, 1987). In organizations with relatively fewer women than men, women are more likely to be regarded as "tokens," to be isolated, and/or to be excluded from opportunities afforded to men (Kanter, 1977). The organizational climate, however, can shift as the proportion of women rises, such that the environment may become more favorable to women, whereas it was previously unwelcoming under conditions of lower diversity. Integrated with intersectionality theory, Kanter's theory of proportions suggests that as the number of WoC increases, issues associated with tokenism will abate, and the organizational climate for WoC will improve.

A number of studies have provided empirical evidence of the importance of the relative representation of social groups (Callister, 2006; Fox & Mohapatra, 2007; Main, 2018; Main, Tan, et al., 2020; Settles et al., 2006). In particular, diversity in the professoriate has been linked with diversity among undergraduate students (Bach & Perrucci, 1984; Beutel & Nelson, 2006; Kulis et al., 1999; Main, Tan, et al., 2020; Turner & Myers, 2000). In engineering specifically, Main, Tan, et al. (2020) found that the number of degrees awarded to WoC undergraduate students is correlated with the number of WoC faculty employed in the same engineering department. Thus, the study of the prevalence of WoC faculty—the representation of WoC faculty by engineering department—has important implications for the experiences of WoC faculty, as well as for the WoC students in their respective engineering departments.

Data

Our data come from the ASEE database, which provides faculty and PhD demographic information disaggregated by race, gender, and engineering discipline. We also collected institution-level data from the Integrated Postsecondary Education Data System (IPEDS), which provides Carnegie Classification, including institution type, level of urbanicity, and whether the institution is an HBCU. ASEE collects annual data on the number of engineering faculty and PhDs from its member institutions. Not all of the member institutions provided data every year between 2005 and 2018, such that there is variation in the number of institutions represented each year. The number of ASEE institutions with reported faculty data ranges from 319 to 379. In 12 out of the 14 years between 2005 and 2018, at least 350 institutions provided data. The year with the fewest participating institutions is 2018, with 319. Appendix Table A1 summarizes the number of ASEE member institutions that provided data by year.

The ASEE database includes data on 20 different engineering disciplines offered across its member institutions (Appendix Table A2). We provide the statistics on the demographic characteristics of faculty and PhD recipients across all of these engineering disciplines. For our analyses disaggregating by engineering discipline, we focus on a subset of seven engineering disciplines: biomedical, chemical, civil, computer science, electrical and computer, industrial, and mechanical. The engineering disciplines offered at each institution vary. Given our research design and concerns regarding statistical power, we focused on the seven engineering disciplines present in at least one-quarter of the ASEE membership institutions, which is equivalent to a cutoff point of 80 institutions (Appendix Table A2). Among these engineering disciplines, biomedical, chemical, civil, electrical/computer, and mechanical engineering also each comprise at least 5% of the engineering faculty population across the ASEE database. Two additional engineering disciplines, metallurgical and materials engineering and aerospace engineering, would have been included if we had chosen a different cutoff point of 40 institutions (12.5% of all ASEE membership institutions). The results for these two additional engineering disciplines are shown in Appendix Figure A1 for reference.

The summary statistics of our sample are presented in Table 1. Table 1 Panel A presents the 2018 institution-level characteristics of the ASEE member institutions from IPEDS. Based on the Carnegie Classification, the ASEE institutions tend to be public (64%), rather than private, and over half are designated as Research I or Research II institutions. Research I are doctoral universities with very high research activity, while Research II are doctoral universities with high research activity. Over 60% of ASEE engineering programs are located in cities.

The first column of Table 1 Panel B shows the demographic characteristics of the engineering faculty in the 2018 ASEE data. These statistics include faculty who identified as U.S. citizens and non-U.S. citizens. Consistent with previous reports, engineering faculty were predominantly men (83%) and over half of the 2018 engineering faculty identified as White (52%). African American/Black engineering faculty and Hispanic/Latinx engineering faculty comprised 2.2% and 3.5% of the faculty, respectively. Meanwhile, Asian/Asian Americans comprised 26.5% of the engineering faculty. Examining the prevalence of WoC faculty, Asian/Asian American women, African American/Black women, and Hispanic/Latina women constituted 4.4%, 0.5%, and 0.7% of the total engineering faculty. In terms of the engineering disciplines, 21% of the faculty were in electrical/computer engineering and 18% in mechanical engineering. The engineering disciplines with the smallest proportions of faculty are architectural, mining, and petroleum engineering and engineering management.

The second column of Table 1 Panel B presents the demographic characteristics of engineering PhDs in 2018. Among all engineering PhDs, 24% were women. Unlike the faculty data, the ASEE database only provides race/ethnicity information for PhDs who identified as U.S. citizens. PhDs who are non-U.S. citizens are aggregated into a single category, and in 2018, approximately 56% of PhDs were included in this category. Among engineering PhDs who identified as U.S. citizens, 3.8%, 0.4%, and 5.4% identified as African American, Native American/Native Hawaiian, and Hispanic/Latinx, respectively. While 26.5% of the engineering faculty identified as Asian/Asian American, only 12.8% of the engineering PhDs identified as Asian American. The representation of PhDs across the engineering disciplines was similar to that of the faculty, although there were some differences.

Method

We addressed our research question, How did the prevalence of WoC faculty in engineering change between 2005 and 2018, by engineering discipline? using descriptive analysis and trend figures. Our analyses focused on the change in WoC faculty representation

Table 1
Descriptive Statistics of the Analytic Sample

Panel A	
Institution-level characteristics (2018)	%
Private	36.3
Public	63.7
Research I	31.7
Research II	22.4
All other carnegie classifications	45.9
HBCU	2.3
City	64.0
Suburban	22.1
Town	13.2
Rural	0.7
N	319

Panel B		
Demographic characteristics (2018)	% of faculty	% of PhDs
Women	17.5	23.9
Men	82.5	76.1
African American/Black	2.2	3.8
Native American/Native Hawaiian	0.3	0.4
Asian/Asian American	26.5	12.8
Hispanic/Latinx	3.5	5.4
White	52.3	57.0
Other race/ethnicity	15.1	20.6
U.S. citizen	—	44.5
Women		
African American/Black	0.5	1.2
Native American/Native Hawaiian	0.0	0.0
Asian/Asian American	4.4	3.8
Hispanic/Latina	0.7	1.2
White	9.1	12.4
Other race/ethnicity	2.8	5.3
Men		
African American/Black	1.7	2.6
Native American/Native Hawaiian	0.3	0.5
Asian/Asian American	22.2	8.6
Hispanic/Latino	2.8	4.2
White	43.3	44.8
Other race/ethnicity	12.3	15.4
Engineering discipline		
Aerospace	2.6	3.2
Architectural	0.3	0.1
Biological and agricultural	1.6	1.0
Biomedical	6.0	8.4
Chemical	8.1	9.3
Civil	12.9	9.2
Computer	1.7	2.2
Computer science (within engineering)	9.6	8.0
Electrical/computer	20.6	21.1
Engineering (general)	1.5	0.9
Engineering management	0.4	1.1
Engineering science and engineering physics	1.3	1.3
Environmental	0.7	1.5
Industrial/manufacturing/systems	4.1	3.6
Mechanical	18.0	14.0
Metallurgical and materials	3.7	6.9
Mining	0.3	0.2
Nuclear	0.8	1.5
Petroleum	0.6	1.0
Other engineering disciplines	5.0	5.4
N	29,294	13,023

(*table continues*)

Table 1 (*continued*)

Note. ASEE = American Society for Engineering Education; HBCU = historically Black colleges and universities. Missing observations are omitted from the summary statistics calculations on an item-by-item basis. The faculty proportions are calculated over the total number of faculty. Institution-level factors are from the Integrated Postsecondary Education Data System. Faculty demographic characteristics are from the ASEE database.

by engineering discipline, and these changes reflect entry of new individuals, departure of individuals, and movement of individuals across institutions (Krathwohl, 1998). Our descriptive analysis summarizes the race/ethnicity distribution of women engineering faculty by academic rank (i.e., assistant, associate, or full professor) and by engineering discipline (summarized in Table 2). In this descriptive analysis, we also considered faculty rank because previous literature has shown that academic rank demonstrates different levels of privilege and prestige, with more being ascribed to full professors and less to assistant professors (Tien & Blackburn, 1996). Additionally, the relative proportions of faculty across ranks provide insights regarding new entries into the field, as well as some indication of promotion and persistence patterns.

To show the changes over time, we compared the numbers and proportions of women engineering faculty composition by race/ethnicity, faculty rank, and engineering discipline between 2005 and 2018. Table 2 presents these statistics for all engineering disciplines, as well as for disaggregated engineering disciplines focusing on biomedical, chemical, civil, computer science, electrical/computer, industrial, and mechanical. Consistent with intersectionality theory (Crenshaw, 1989) and Kanter's (1977) theory of proportions, we present the shares of WoC faculty at the intersection of gender and race/ethnicity relative to the total number of faculty in their respective engineering discipline. That is, the proportions that are reported were calculated relative to the total number of faculty, including both men and women, in that engineering discipline.

To illustrate the changing dynamics of the prevalence of WoC faculty across time (2005 through 2018), we generated trend figures for each engineering discipline and also for all engineering disciplines aggregated. Figure 1 aggregates engineering disciplines and shows trends for WoC faculty and for WoC engineering PhDs (who are U.S. citizens). Figure 2 focuses on faculty and provides trends disaggregated by engineering discipline to reveal discipline-

Table 2
The Demographic Composition of Women Engineering Faculty by Race/Ethnicity and by Engineering Discipline (2005 vs. 2018)

Engineering discipline race/ethnicity	2005					2018				
	Total (*N*)	Total (%)	Assistant professor (%)	Associate professor (%)	Full professor (%)	Total (*N*)	Total (%)	Assistant professor (%)	Associate professor (%)	Full professor (%)
All engineering										
Total women	2,564	10.6	18.2	12.4	6.1	5,124	17.5	24.8	20.2	12.2
Total WoC	681	2.8	6.8	2.6	1.0	1,656	5.6	8.5	7.3	3.4
African American/Black	84	0.3	0.7	0.4	0.1	153	0.5	0.8	0.7	0.3
Native American/Native Hawaiian	3	0.0	0.0	0.0	0.0	14	0.0	0.1	0.1	0.0
Asian/Asian American	490	2.0	5.2	1.6	0.8	1,278	4.4	6.6	5.5	2.6
Hispanic/Latina	104	0.4	0.9	0.5	0.2	211	0.7	0.9	0.9	0.5
White	1,646	6.8	9.8	8.6	4.5	2,652	9.1	11.5	10.4	7.0
Other	237	1.0	1.6	1.2	0.6	816	2.8	4.8	2.5	1.8
Biomedical										
Total women	138	16.1	22.9	19.7	7.7	407	23.2	29.8	25.0	17.8
Total WoC	28	3.3	5.5	4.2	0.6	113	6.4	7.5	9.1	4.1
African American/Black	2	0.2	0.7	0.0	0.0	11	0.6	1.4	0.8	0.0
Native American/Native Hawaiian	0	0.0	0.0	0.0	0.0	2	0.1	0.2	0.0	0.1
Asian/Asian American	24	2.8	4.9	3.8	0.3	83	4.7	4.5	6.8	3.6
Hispanic/Latina	2	0.2	0.0	0.5	0.3	17	1.0	1.4	1.4	0.4
White	105	12.2	16.7	14.6	6.8	259	14.8	19.1	13.8	12.5
Other	5	0.6	0.7	0.9	0.3	35	2.0	3.2	2.1	1.2
Chemical										
Total women	221	11.7	19.9	16.9	6.9	477	20.0	28.2	26.7	13.2
Total WoC	53	2.8	6.4	4.3	1	142	5.9	9.6	8.1	3.3
African American/Black	7	0.4	0.5	0.5	0.3	15	0.6	0.8	0.6	0.6
Native American/Native Hawaiian	0	0.0	0.0	0.0	0.0	2	0.1	0.0	0.2	0.1
Asian/Asian American	28	1.5	3.5	2.7	0.4	96	4.0	7.2	6.0	1.7
Hispanic/Latina	18	1.0	2.4	1.2	0.4	29	1.2	1.5	1.3	1.0
White	146	7.7	12.2	10.4	5.2	254	10.7	14.2	14.4	7.3
Other	22	1.2	1.3	2.2	0.7	81	3.4	4.4	4.2	2.6
Civil										
Total women	385	11.7	20.6	14.9	5.7	770	20.3	31.3	23.2	12.6
Total WoC	86	2.6	6.2	3	0.7	199	5.2	7.2	7.5	2.9
African American/Black	14	0.4	0.7	0.7	0.1	20	0.5	0.6	0.8	0.3
Native American/Native Hawaiian	0	0.0	0.0	0.0	0.0	4	0.1	0.2	0.1	0.1
Asian/Asian American	54	1.6	4.2	1.6	0.4	134	3.5	5.3	4.9	1.8
Hispanic/Latina	18	0.5	1.3	0.6	0.1	41	1.1	1.2	1.7	0.7
White	266	8.1	12.7	10.6	4.5	423	11.2	16.7	12.2	7.5
Other	33	1.0	1.7	1.3	0.5	148	3.9	7.4	3.5	2.2

(*table continues*)

Table 2 (*continued*)

Engineering discipline race/ethnicity	2005 Total (*N*)	2005 Total (%)	2005 Assistant professor (%)	2005 Associate professor (%)	2005 Full professor (%)	2018 Total (*N*)	2018 Total (%)	2018 Assistant professor (%)	2018 Associate professor (%)	2018 Full professor (%)
Computer science (within engineering)										
Total women	252	12.7	16.5	11.0	10.8	485	17.2	20.9	18.4	14.0
Total WoC	82	4.1	8	1.9	2.6	203	7.2	9.2	9.2	4.7
African American/Black	7	0.4	0.6	0.2	0.2	13	0.5	0.7	0.6	0.2
Native American/Native Hawaiian	0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0
Asian/Asian American	70	3.5	7.4	1.2	2.1	178	6.3	7.9	8.5	4.0
Hispanic/Latina	5	0.3	0.0	0.5	0.2	12	0.4	0.6	0.1	0.5
White	157	7.9	7.7	8.9	7.3	225	8.0	7.5	7.9	8.3
Other	13	0.7	0.8	0.2	0.9	57	2.0	4.2	1.3	1.0
Electrical/computer										
Total women	496	9.0	15.9	10.3	5.3	818	13.6	18.7	16.3	10.3
Total WoC	172	3.2	8.3	2.1	1.4	316	5.3	7.4	7.2	3.5
African American/Black	16	0.3	0.8	0.2	0.1	26	0.4	0.5	0.8	0.2
Native American/Native Hawaiian	0	0.0	0.0	0.0	0.0	2	0.0	0.0	0.1	0.0
Asian/Asian American	139	2.5	6.7	1.6	1.2	266	4.4	6.3	5.9	3.0
Hispanic/Latina	17	0.3	0.8	0.3	0.1	22	0.4	0.6	0.4	0.3
White	283	5.1	6.1	7.4	3.5	376	6.2	7.8	7.3	5.1
Other	41	0.7	1.5	0.8	0.4	126	2.1	3.5	1.8	1.7
Industrial										
Total women	187	15.9	24.6	18.3	9.1	245	20.3	26.8	21.2	15.1
Total WoC	50	4.2	8.2	5.4	1.1	90	7.5	10.6	8.7	4.5
African American/Black	11	0.9	1.0	1.9	0.2	8	0.7	0.8	1.0	0.4
Native American/Native Hawaiian	1	0.1	0.0	0.3	0.0	2	0.2	0.3	0.3	0.0
Asian/Asian American	27	2.3	5.5	1.6	1.0	67	5.5	9.4	5.2	3.0
Hispanic/Latina	11	0.9	1.7	1.6	0.0	13	1.1	0.3	2.1	1.1
White	121	10.3	14.0	12.1	6.8	110	9.1	8.6	11.1	8.4
Other	16	1.4	2.4	0.8	1.2	45	3.7	7.6	1.4	2.2
Mechanical										
Total Women	343	7.9	17.2	8.4	3.9	757	14.4	20.5	16.7	9.2
Total WoC	102	2.4	6.7	2.2	0.7	254	4.8	7.5	5.7	2.7
African American/Black	17	0.4	1.0	0.5	0.1	23	0.4	0.6	0.8	0.1
Native American/Native Hawaiian	0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0
Asian/Asian American	72	1.7	4.8	1.4	0.5	209	4.0	6.4	4.4	2.3
Hispanic/Latina	13	0.3	0.9	0.3	0.1	22	0.4	0.5	0.6	0.3
White	201	4.6	8.6	5.4	2.6	373	7.1	9.3	8.8	4.7
Other	40	0.9	1.9	0.8	0.6	130	2.5	3.7	2.2	1.8

Note. ASEE = American Society for Engineering Education. The proportions are calculated over the total numbers of faculty within a discipline. Data are from the ASEE database (2005 and 2018).

specific progress in terms of diversification. Due to sample size issues, there are no corresponding disaggregated figures by engineering discipline for WoC PhDs. Together, Figures 1 and 2 help provide foundational information to illuminate structural inertia and agility in responding to calls and interventions for greater faculty diversity in engineering.

Limitations

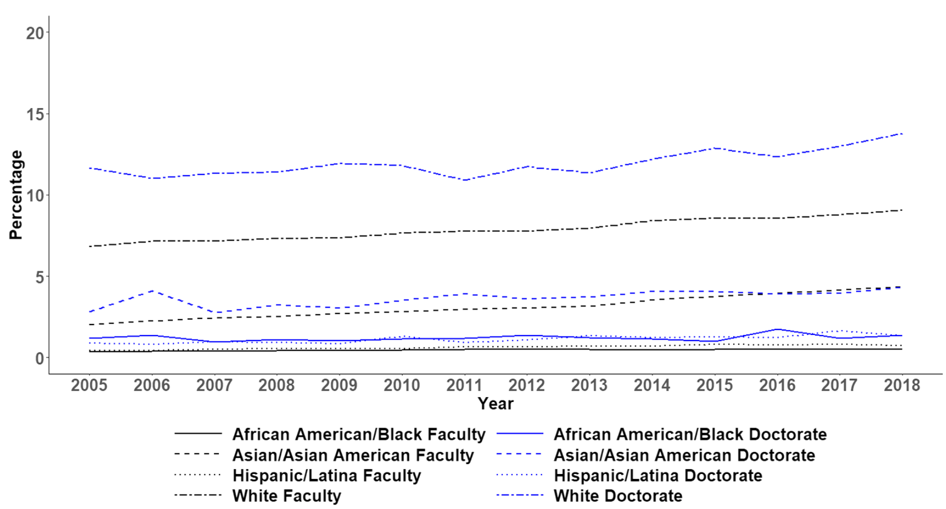
The ASEE database represents only a subset of the engineering institutions across the United States. There are many more engineering programs in the United States, and therefore, a limitation of our study is that our findings are representative of only ASEE member institutions, which also tend to have programs that are Accreditation Board for Engineering and Technology, Inc. (ABET) accredited. Our results are not representative of all U.S. institutions with accredited and nonaccredited engineering programs. Hence, our analyses may be biased if WoC are more or less likely to be tenured or to be tenure-track faculty members at non-ASEE member institutions than ASEE member institutions. To help address this possibility, we compared the 2017 ASEE data with reports from the National Science Foundation (2018), which are nationally representative (Appendix Table A3). Even though fewer institutions are represented in the ASEE database compared to the NSF data, the ASEE statistics on WoC are generally consistent with those from the NSF report. For example, in 2017, the total number of African American/Black women faculty in engineering was reported as 143 by ASEE and as 150 by NSF with corresponding proportions of 0.5% and 0.6%, respectively (Table A3). The statistics for the aggregated engineering disciplines are generally consistent between ASEE and NSF. Furthermore, there are benefits associated with using the ASEE database in that ASEE includes statistics for engineering disciplines disaggregated.

Another potential concern with the use of the ASEE database is that all counts are self-reported by the relevant engineering departments and institutions. To address potential concerns with the self-reported nature of the data collected, ASEE checks and validates the reported numbers annually for consistency and accuracy. Further, as Table A3 demonstrates, the ASEE numbers are generally consistent with those reported by NSF. An important note regarding the information from the ASEE database is that all numbers of faculty include both U.S. citizens and non-U.S. citizens. In 2017, the NSF reported that 23% of engineering faculty at U.S. institutions were international scholars (National Science Foundation, 2019a). For reference, Appendix Table A4 provides the proportions of WoC engineering faculty who are U.S. citizens. Among engineering faculty in 2017, 51% of Asian/Asian American women faculty identified as U.S. citizens, compared to 91% of African American/Black and 83% Hispanic/Latina women faculty. In terms of WoC PhDs, the ASEE database only reports race/ethnicity numbers for those who identified as U.S. citizens. PhDs who identified as non-U.S. citizens are grouped together. This is a limitation of the data because more than half of the PhDs identified as non-U.S. citizens and thus the data are not representative. Comparisons between PhDs and faculty need to be interpreted with caution.

While we disaggregated our descriptive analysis by engineering discipline, we focused on the seven most prevalent engineering disciplines in the ASEE database, such as mechanical and civil engineering. Our findings are therefore not representative of smaller enrollment engineering disciplines, such as aerospace, mining, or nuclear engineering. For reference, Appendix Figure A1 shows the faculty demographic trends in aerospace engineering (Panel 1) and in metallurgical and materials engineering (Panel 2). Future work should focus on smaller enrollment disciplines, as they may provide additional insights regarding the trends in the prevalence of WoC faculty and the relative agility of smaller programs to respond to diversity initiatives. Another direction for future work is an investigation of which types of institutions and the geographic locations of institutions where WoC tends to be hired. Our findings

Figure 1

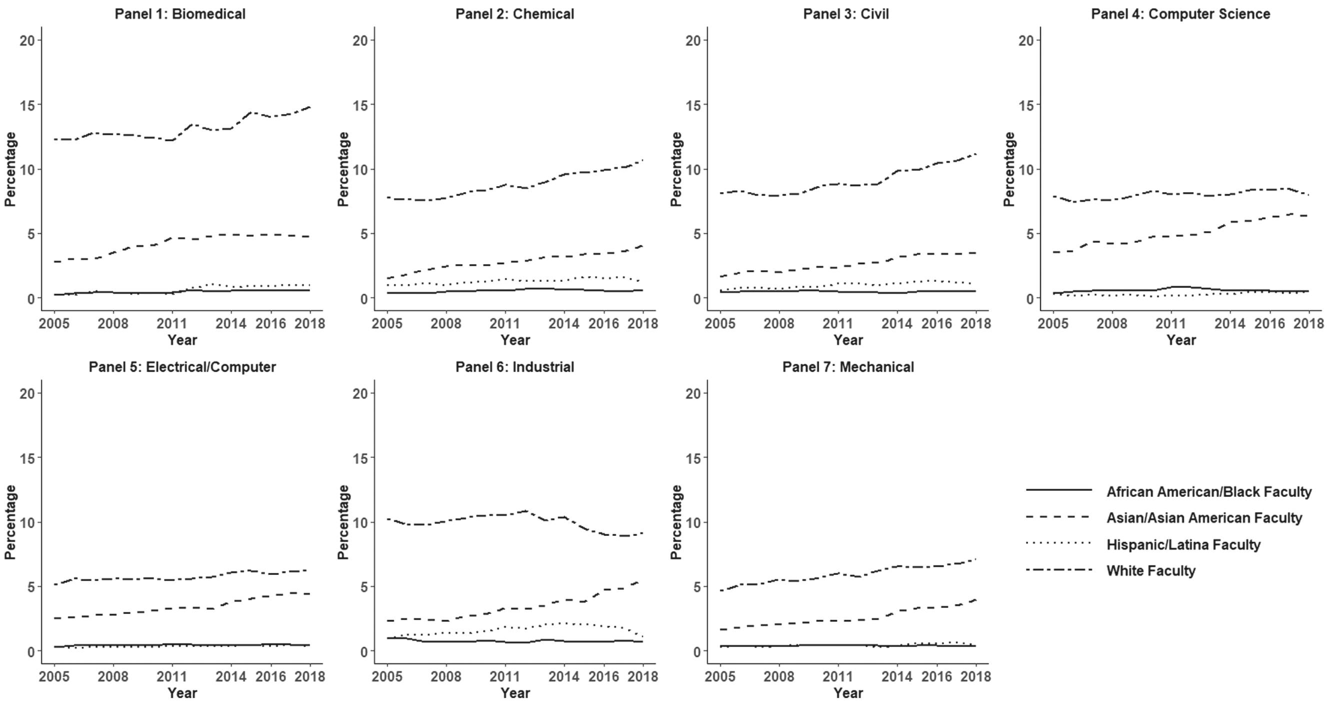
Trends in the Composition of Women Faculty and PhDs by Race/Ethnicity From 2005 Through 2018 (All Engineering Disciplines)



Note. See the online article for the color version of this figure.

Figure 2

Trends in the Composition of Women Faculty Composition by Race/Ethnicity and by Engineering Discipline From 2005 Through 2018



speak only to more prevalent engineering disciplines and to the institutions represented in the ASEE database, which tend to be research-intensive universities with ABET-accredited programs.

Results

Table 2 presents the demographic composition of women engineering faculty by race/ethnicity and by engineering discipline in 2005 and in 2018. We provide the total numbers (*N*), as well as the proportions (%), of engineering faculty by race/ethnicity across all engineering disciplines, and separately for each of the following disciplines: biomedical, chemical, civil, computer science (within engineering colleges), electrical/computer, industrial, and mechanical. Figure 1 illustrates the trends in women faculty composition by race/ethnicity for all engineering disciplines aggregated from 2005 to 2018. Figure 1 also includes the trends in the representation of women PhDs by race/ethnicity for all engineering disciplines. Meanwhile, each panel in Figure 2 focuses on a specific engineering discipline.

All Engineering

Across all engineering disciplines, the number of WoC engineering faculty increased from 681 in 2005 to 1,656 in 2018, which corresponds to an increase from 2.8% to 5.6% of the faculty. This increase also corresponds with a greater proportion of WoC holding full professor positions in 2018 (3.4%) compared to 2005 (1.0%), as well as increases in the proportions of WoC holding associate and assistant professor positions. However, at the intersection of gender and race/ethnicity, there was little to no increase in the proportion of African American/Black, Hispanic/Latina, and Native American/Native Hawaiian women in assistant, associate, or full professor positions.

The trends in the demographic composition of engineering faculty from 2005 through 2018 are illustrated in Figure 1. Over time, there have been slight increases among women engineering faculty across race/ethnicity, although the increasing trends are relatively more prominent for White and Asian/Asian American women faculty. Meanwhile, the trends in engineering doctorate degrees earned by WoC students who are U.S. citizens are relatively consistent with the WoC engineering faculty compositions. During this time period between 2005 and 2018, there were modest increases in the proportions of White women earning engineering PhDs. Meanwhile, the proportions of Asian American, African American, and Hispanic/Latina women engineering PhDs fluctuate and largely remain stagnant. These results need to be interpreted with the caveat that only PhDs who identified as U.S. citizens are included in these trends.

By Engineering Discipline

Biomedical Engineering

The number and proportion of WoC faculty in biomedical engineering increased from 28 (3.3%) in 2005 to 113 (6.4%) in 2018. While there are increases among WoC faculty across the assistant, associate, and full professor ranks, the largest increase is among the associate professors, from 4.2% in 2005 to 9.1% in 2018. This suggests that in biomechanical engineering, WoC are being promoted through the faculty ranks, and that WoC biomedical engineering PhDs are also being hired as assistant professors.

In 2018, 4.7% of all biomedical engineering faculty were Asian/Asian American women, 0.6% African American/Black women, 1% Hispanic/Latina women, and 0.1% Native American/Native Hawaiian women. In terms of counts, there were only two African/African American women faculty in biomedical engineering in 2005, and by 2018, this number increased to 11. Across the 14 years from 2005 to 2018, the proportions of African American/Black, Native American/Native Hawaiian, and Hispanic/Latina women faculty increased by 0.4%, 0.1%, and 0.8%, respectively. These trends are also illustrated in Figure 2 Panel 1.

Chemical Engineering

The number and proportion of WoC faculty in chemical engineering have also increased from 53 (2.8%) in 2005 to 142 (5.9%) in 2018. In chemical engineering, the proportions of WoC assistant and associate professors have increased at relatively faster rates than the proportion of WoC full professors. For example, the proportion of assistant professors increased from 6.4% in 2005 to 9.6% in 2018, whereas the proportion of full professors increased from 1% in 2005 to 3.3% in 2018. However, this trend is not apparent among Hispanic/Latina women; the share of Hispanic/Latina women assistant professors decreased from 2.4% in 2005 to 1.5% in 2018. Across all faculty ranks in chemical engineering, the number of Hispanic/Latina women was 18 in 2005 and 29 in 2018—an overall increase of 11 Hispanic/Latina women faculty during this time period. Between 2005 and 2018, the shares of African American/Black and Native American/Native Hawaiian women faculty ranged from 0.0% to 0.6%. The trends in the demographic composition of chemical engineering faculty are also shown in Figure 2 Panel 2. There is very little change in the shares of WoC faculty over time, although the proportions of Asian/Asian American women faculty have slowly increased from 1.5% to 4% of all chemical engineering faculty.

Civil Engineering

Between 2005 and 2018, the number and proportion of civil engineering WoC faculty increased from 86 (2.6%) to 199 (5.2%). Across all ranks, the number of Native American/Native Hawaiian women faculty increased from 0 to 4, whereas the number of African American/Black women faculty increased from 14 to 20, and Hispanic/Latina women faculty from 18 to 41. The proportion of WoC assistant professors only increased from 6.2% to 7.2% over the 14 years. The share of African American/Black and Hispanic/Latina women assistant professors decreased from 0.7% to 0.6% and from 1.3% to 1.2%, respectively. Among Hispanic/Latina women faculty in civil engineering, modest increases were primarily at the associate and full professor ranks. Overall, as illustrated in Figure 2 Panel 3, there have been small increases in the proportions of Asian/Asian American and Hispanic/Latina women faculty in civil engineering. Meanwhile, the proportions of African American/Black and Native American/Native Hawaiian have remained relatively stagnant in civil engineering.

Computer Science

Overall, the number and proportion of WoC faculty increased from 82 (4.1%) in 2005 to 203 (7.2%) in 2018. Compared to the other engineering disciplines in this study, computer science had the second-highest proportion of WoC faculty in 2018. However, the ASEE database did not report any women faculty identifying as Native American/Native Hawaiian in computer science in 2005 or in 2018. In 2018, of the 2,823 total faculty in computer sciences, 13 were African American/Black women and 12 were Hispanic/Latina women. The share of WoC faculty in assistant professor positions changed very little over this time period. There were larger gains in the proportion of WoC at the associate and full professor ranks, which are primarily driven by increases in the number of Asian/Asian American women faculty. As shown in Figure 2 Panel 4, there was very little change in the shares of African American/Black, Native American/Native Hawaiian, and Hispanic/Latina women faculty over the 14-year time period. In computer sciences, the proportion of African American/Black women faculty increased between 2005 and 2012 and then decreased between 2013 and 2018 (Figure 2 Panel 4).

Electrical/Computer Engineering

The share of WoC faculty in electrical/computer engineering was similarly low with 172 (3.2%) of the electrical/computer engineering faculty in 2005 and 316 (5.3%) of the electrical/computer engineering faculty in 2018. Like computer science, the ASEE database did not report any women faculty identifying as Native American/Native Hawaiian in electrical/computer engineering in 2005, but by 2018, the ASEE database reported two in associate professor positions. Figure 2 Panel 5 shows trends in the shares of women faculty by race/ethnicity in electrical/computer engineering. The proportion of Asian/Asian American women faculty increased between 2005 and 2018, with a faster rate between 2014 and 2018. Meanwhile, the shares of African American/Black and Hispanic/Latina women faculty remained relatively constant at levels below 0.5% from 2005 to 2018.

Industrial Engineering

Compared to the other engineering disciplines in this study, industrial engineering had the highest share of WoC faculty in 2018. Industrial engineering had 90 (7.5%) WoC faculty in 2018. Although the proportion of WoC identifying as assistant professors grew from 8.2% to 10.6% between 2005 and 2018, the trends were in the opposite among African American/Black and Hispanic/Latina assistant professors. The proportion of African American/Black assistant professors was 1.0% in 2005 and 0.8% in 2018, whereas the proportion of Hispanic/Latina assistant professors was 1.7% in 2005 and 0.3% in 2018. The representation of Hispanic/Latina faculty in industrial engineering is illustrated in Figure 2 Panel 6, which shows growth between 2005 and 2014, but subsequent decline thereafter. During this time period, the share of Asian/Asian American women faculty in industrial engineering increased.

Mechanical Engineering

Although the share of WoC in the mechanical engineering faculty was only 2.4% ($N = 102$) in 2005, this share increased to 4.8% ($N = 254$) by 2018. There were increases in the proportions of assistant, associate, and full professors, indicating that WoC were being hired and promoted across the ranks. However, examining by race/ethnicity, the shares of African American/Black and Hispanic/Latina women assistant professors decreased from 1.0% to 0.6% and from 0.9% to 0.5%, respectively. As one of the largest engineering disciplines, mechanical engineering had a total of 5,275 faculty in 2018. Of the 5,275 faculty members, only 23 were African American/Black women and 22 were Hispanic/Latina women. Figure 2 Panel 7 further illustrates that the proportions of African American/Black and Hispanic/Latina women faculty remained relatively constant between 2005 and 2018.

Discussion

The underrepresentation of WoC faculty across engineering disciplines continues to garner widespread concern. Our results illustrate the extent of this underrepresentation in engineering, highlighting trends by women faculty's race/ethnicity, professor rank, and engineering discipline. Although there have been changes in the prevalence of WoC faculty across engineering, overall, the magnitudes of these increases are relatively small. Investigating the trends at the intersection of gender and race/ethnicity using intersectionality theory shows that while women overall are underrepresented in engineering, the extent of this underrepresentation is more pronounced among Native American/Native Hawaiian, African American/Black, and Hispanic/Latina women faculty (Crenshaw, 1989; see also Collins, 1993; Ross et al., 2015). During the 2005–2018 time period, the numbers of Native American/Native Hawaiian women hovered between 3 and 14 across all engineering disciplines. Between 2005 and 2018, the shares of African American/Black women faculty across engineering disciplines changed little, from 0.3% (84) to 0.5% (153). Similarly, across all engineering disciplines, the shares of Hispanic/Latina women faculty increased from 0.4% to 0.7%, and the proportions of Asian/Asian American women faculty increased from 2.0% to 4.4%. The changes in the proportions of Hispanic/Latina, African American/Black, and Native American/Native Hawaiian women faculty disaggregated by rank and by engineering discipline are relatively small. While 2005 and 2018 are just two points and the relative changes can vary depending on which years are compared, the illustrative figures (Figures 1 and 2) show that WoC faculty are underrepresented across time and across a number of engineering disciplines.

We also examined the shares of WoC in assistant, associate, and full professor ranks across time. Albeit small, the increases in the representation of WoC in assistant, associate, and full professor ranks suggest that there have been improvements in the recruitment, retention, and promotion of WoC in engineering education. To further strengthen the representation of WoC in engineering, more WoC needs to be recruited at the assistant professor level. However, our findings show that the representation of WoC is also relatively low among engineering PhDs. It is critical to increase the number of WoC engineering PhDs if we are to increase the representation of WoC among engineering faculty. Among engineering PhDs who hold U.S. citizenships, only 3.8%, 0.4%, and 5.4% identified as African American, Native American/Native Hawaiian, and Hispanic/Latina, respectively. Thus, to expand WoC's representation among engineering faculty, more WoC need to be recruited and supported in engineering PhD programs. The relatively small pool from which to draw WoC engineering faculty contributes to challenges in increasing faculty diversity. In addition, the climate and culture of engineering education also deter many WoC engineering PhDs from pursuing faculty positions. Many WoC engineering faculty experience racism *and* sexism, as highlighted by intersectionality theory (Collins, 1993; Crenshaw, 1989; Ross et al., 2015), and WoC PhD students may be deterred from pursuing academic positions when they witness the negative experiences of WoC faculty. When discrimination is openly known and experienced within a field, WoC avoid entering those professions (DeCuir-Gunby et al., 2009; Evans & Herr, 1991). This is especially true for WoC graduate students, who may decide to leave engineering (Nelson & Rogers, 2003) or to not enter the professoriate at all because of their own negative experiences and/or the experiences of WoC faculty (National Academy of Sciences, National Academy of Engineering, Institute of Medicine, 2007; National Research Council, 2006). Furthermore, Nelson (2003) found that the WoC tenure-track faculty who do enter the academy are less likely than their counterparts to earn tenure and to ascend to the rank of full professor. This, coupled with the pressures and stresses of being the first or only WoC in their environments may further discourage WoC from entering academia across engineering disciplines (DeCuir-Gunby et al., 2009). Thus to enhance faculty diversity, academic institutions and engineering programs need to focus on recruitment efforts at both the PhD and faculty levels (e.g., the ADVANCE program; National Science Foundation, 2020). Future work should incorporate an investigation of which institutions are recruiting and supporting WoC faculty and how to share these best practices with academic institutions that aspire to hire and promote more WoC faculty.

Our results highlight the gap between the proportions of WoC engineering PhDs and the proportions of WoC engineering faculty, suggesting there are opportunities to further recruit, support, and retain WoC faculty in engineering. This gap is consistent with the evidence from the literature indicating that WoC faculty experience issues related to stereotype bias and unfriendly departmental culture and climate, and face barriers and systemic marginalization related to recruitment, persistence, and retention in engineering (Alfred et al., 2019; McGee & Bentley, 2017b; Ross et al., 2015; Wilkins, 2017). Kanter's theory of proportions suggests that the relative representation of a subgroup has important implications for the experiences of the members of that particular subgroup (Kanter, 1977). Because there are so few WoC faculty in engineering, African American/Black, Native American, Native Hawaiian, Hispanic/Latina, and Asian/Asian American women are often the "tokens" or "minorities" in their departments (Kanter, 1977; Wharton et al., 1992; Zucker, 1987). Studies have shown that WoC faculty experience marginalization, discrimination, lack of mentoring, and toxic work environments (e.g., Aquirre, 2000; Carroll, 2017; DeCuir-Gunby et al., 2009; Orelus, 2020; Settles et al., 2019). Yet, the participation of WoC in the engineering professoriate is critical to promoting diversity efforts because WoC are role models and mentors to WoC graduate and undergraduate students in engineering. Main, Tan, et al. (2020), for example, demonstrated that the prevalence of WoC faculty is associated with the prevalence of WoC undergraduate students in engineering. Consequently, the persistence of WoC faculty in engineering has important implications for the number of WoC students completing degrees in engineering and eventually pursuing faculty roles. Consistent with Main, Tan, et al. (2020), our results highlight the lack of WoC PhDs in engineering fields, suggesting that to increase

WoC faculty representation, there also needs to be greater effort and investment in the recruitment and retention of WoC PhD students.

Our findings reveal the dynamic that different groups of WoC enter and persist through various engineering disciplines at the PhD and faculty levels at different rates. Therefore, future research should focus on the recruitment and experiences of WoC in the engineering doctoral programs in which they are most underrepresented. Having cohorts of WoC enter the doctoral program together, guided by a racially conscious mentoring program, has shown some success (McGee & Robinson, 2019). There are ample calls in the diversity literature for faculty of Color to serve as role models and mentors to support students of Color. As another tension, we necessitate that WoC should not be viewed solely through the lens of service and as the gatekeepers of diversity, equity, and inclusion. WoC are disciplinary experts, knowledge-makers, theory builders, and counter storytellers. They add to the intellectual production and innovation of STEM fields. They should also be valued for their brain power and contributions to their intellectual and academic communities, as much as they are valued for their roles as community providers for students.

We also argue for incorporating critical theories that have resulted in novel solutions for diversifying STEM faculty—intersectionality, critical race theory, minority status stress, and structural racism—as these theories have great potential to translate into departments, identifying the conscious and unconscious biases and acting upon a shared understanding and explicit purpose for diversifying their faculty. From a theoretical perspective, while researchers often employ intersectionality (Charleston et al., 2014; Collins, 1998; Leggon, 2010), critical race theory (DeCuir-Gunby et al., 2009), standpoint theory (Rios & Stewart, 2015), and feminist theory (Beddoes & Borrego, 2011; Buzzanell et al., 2015; Foor & Shehab, 2009; Riley et al., 2009) as lenses to view research on women faculty of Color in engineering and STEM (e.g., Charleston et al., 2014; Ong et al., 2020), the frameworks used should expand to include other, related factors, especially with respect to socioeconomic class and environmental context (e.g., working in a minority-serving institution or a predominately White institution).

Conclusion and Recommendations for Research and Policy

African American/Black, Native American/Native Hawaiian, and Hispanic/Latina women faculty are consistently underrepresented across engineering disciplines. Our findings show that between 2005 and 2018 there was little to no gain in the shares of WoC engineering faculty. Similarly, the shares of African American/Black, Native American/Native Hawaiian, and Hispanic/Latina women PhDs in engineering are also similarly low. There are opportunities to increase diversity in the engineering professoriate with efforts and investments in promoting growth in the number of WoC PhDs in engineering.

Thus, we revisit the strategy for increasing engineering faculty diversity by improving the recruitment, support, and retention of WoC in engineering doctoral programs. This also requires improvements in the retention of WoC engineering undergraduates and inspiring them to pursue graduate education (Main, Tan, et al., 2020). This may also entail providing WoC engineering PhDs with multiple pathways to the professoriate, including supportive postdoctoral research positions (Main et al., 2021). In concert, it is critical to improve recruitment and hiring of WoC engineering faculty members using policy-based strategies such as those suggested by Liu et al. (2019). Recruitment is only the first step as it is also essential also to provide a supportive and culturally responsive academic environment to promote retention. This should include mentorship and support targeted to the stages of tenure and promotion (Terosky et al., 2014) and counteracting the potential barriers to promotion as described by the qualitative meta-analysis from Corneille et al. (2019).

Our work builds on prior scholarship in diversity and in engineering education to underscore the severity of underrepresentation of WoC at the faculty level. WoC in engineering matter because the intellectual vitality of engineering depends on their contributions as teachers, professors, researchers, scholars, and knowledge producers. Without scholarly products infused with the reality associated with being a person of Color, engineers will continue to craft innovations that do not include the population that they serve, risking further the United States' global competitiveness in STEM disciplines. However, focusing on recruiting diverse populations to increase product and technological innovations overlooks the moral imperative of advancing marginalized groups in engineering for social justice, fairness, and equity. Future work should continue to explore what WoC engineering faculty need and deserve in order to thrive in academic engineering environments.

Improving WoC faculty representation will be a long-term task but certainly one worth pursuing. Our research suggests that the strategy for increasing STEM faculty diversity will need to entail increasing the number of WoC PhDs, improving the culture and environment of academic careers to attract WoC to the professoriate, and then continuing to enhance the experiences and retention of WoC faculty members. Increasing the representation of WoC faculty in engineering is a complex process, requiring changes in education policy, improvements in academic culture and environments, and societal efforts in addressing many dimensions of the engineering education system.

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(*Appendix follows*)

Appendix

Supporting Data

Table A1

The Number of ASEE Membership Institutions With Available Data From 2005 to 2018

Year	*N*
2005	350
2006	353
2007	354
2008	355
2009	357
2010	362
2011	366
2012	372
2013	379
2014	368
2015	372
2016	366
2017	335
2018	319

Note. ASEE = American Society for Engineering Education.

Table A2

The Number of ASEE Membership Institutions With the Specified Engineering Discipline (2018)

Engineering discipline	*N*
Electrical/computer	267
Mechanical	258
Civil	218
Chemical	151
Computer science (within engineering)	142
Biomedical	127
Other engineering disciplines	121
Industrial/manufacturing/systems	93
Metallurgical and materials	67
Aerospace	42
Engineering (general)	37
Computer	33
Biological and agricultural	30
Engineering science and engineering physics	24
Engineering management	22
Environmental	16
Petroleum	16
Nuclear	13
Mining	12
Architectural	7
All institutions	319

Note. ASEE = American Society for Engineering Education.

(*Appendix continues*)

Table A3

Comparison of the ASEE and NSF Data Using 2017 Engineering Faculty Demographic Composition

Panel A: Number

		ASEE				NSF			
Gender	Race/ethnicity	Total (*N*)	Assistant professor	Associate professor	Full professor	Total (*N*)	Assistant professor	Associate professor	Full professor
Women	African American/Black	143	60	50	33	150	50	50	50
	Asian/Asian American	1,212	485	386	341	1,200	500	400	300
	Hispanic/Latina	236	78	88	70	150	50	50	50
	White	2,566	825	740	1,001	2,500	750	800	950
Men	African American/Black	496	123	161	212	650	200	200	250
	Asian/Asian American	6,444	1,748	1,639	3,057	6,900	2000	1,750	3,150
	Hispanic/Latino	851	202	247	402	1,050	300	350	400
	White	12,925	2,416	3,137	7,372	12,650	2,750	3,600	6,300

Panel B: Proportion

		ASEE				NSF			
Gender	Race/ethnicity	Total (%)	Assistant professor (%)	Associate professor (%)	Full professor (%)	Total (%)	Assistant professor (%)	Associate professor (%)	Full professor (%)
Women	African American/Black	0.5	0.8	0.7	0.2	0.6	0.8	0.7	0.4
	Asian/Asian American	4.2	6.6	5.2	2.4	4.8	7.6	5.6	2.6
	Hispanic/Latina	0.8	1.1	1.2	0.5	0.6	0.8	0.7	0.4
	White	8.8	11.2	10.0	7.0	9.9	11.4	11.1	8.3
Men	African American/Black	1.7	1.7	2.2	1.5	2.6	3.0	2.8	2.2
	Asian/Asian American	22.1	23.6	22.0	21.3	27.3	30.3	24.3	27.5
	Hispanic/Latino	2.9	2.7	3.3	2.8	4.2	4.6	4.9	3.5
	White	44.2	32.6	42.2	51.3	50.1	41.7	50.0	55.0

Note. ASEE = American Society for Engineering Education; NSF = National Science Foundation. The proportions are calculated over the total number of faculty.

Table A4

Proportion of Women Engineering Faculty Who Are U.S. Citizens by Year and Race/Ethnicity

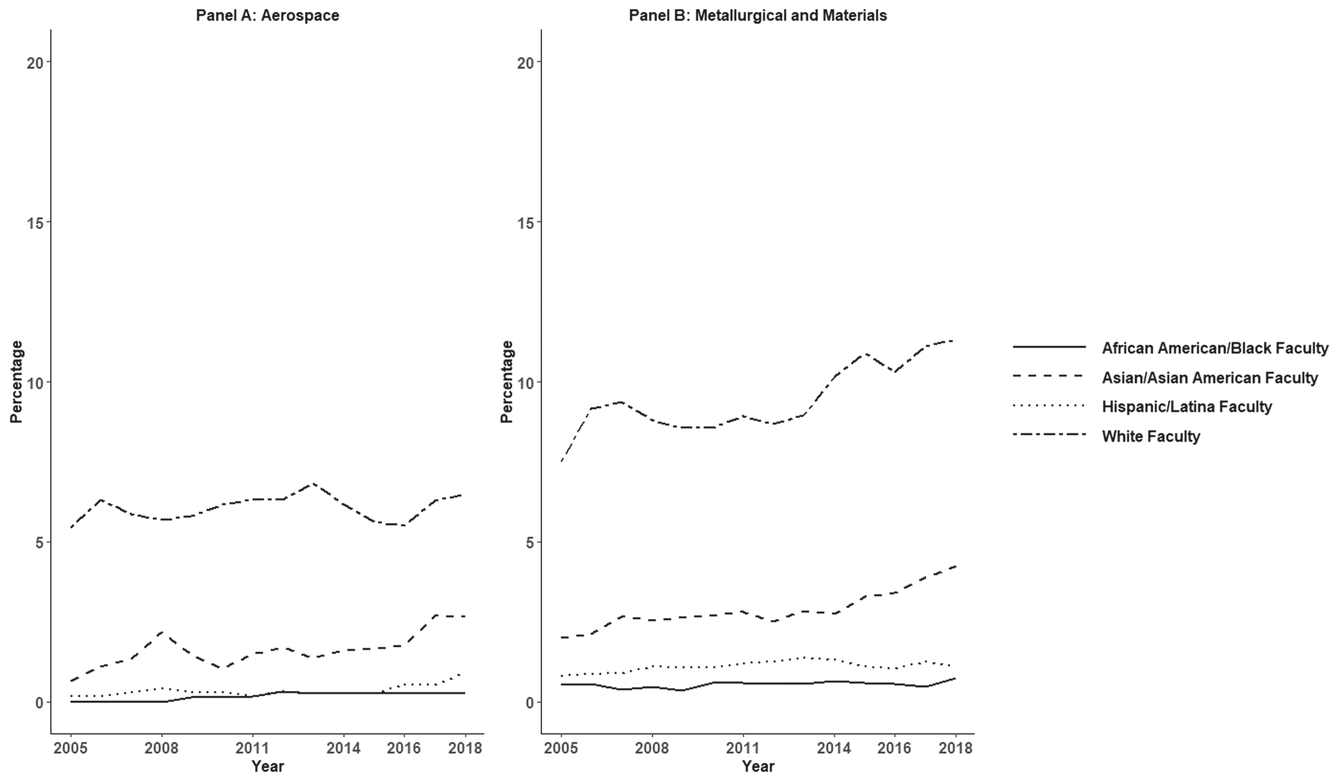
Year	African American/Black (%)	Asian/Asian American (%)	Hispanic/Latina (%)	White (%)
2006	91.9	48.7	74.6	91.8
2008	95.4	47.5	75.7	90.9
2010	92.1	47.0	66.1	91.9
2013	91.5	43.6	72.4	92.3
2015	77.8	49.9	78.0	91.5
2018	91.3	50.8	83.4	89.9

Note. Percentages calculated using final survey weights. Data from the Survey of Doctorate Recipients (National Science Foundation, 2019a).

(*Appendix continues*)

Figure A1

Trends in the Composition of Women Faculty in Aerospace and Metallurgical and Materials Engineering by Race/Ethnicity From 2005 Through 2018



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