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WHO'S PERSISTING IN ENGINEERING? A COMPARATIVE ANALYSIS OF FEMALE AND MALE ASIAN, BLACK, HISPANIC, NATIVE AMERICAN, AND WHITE STUDENTS

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Interest in increasing the number of engineering graduates in the United States and promoting gender equality and diversification of the profession has encouraged considerable research on women and minorities in engineering programs. Drawing on a framework of intersectionality theory, this study recognizes that women of different ethnic backgrounds warrant disaggregated analysis because they do not necessarily share a common experience in engineering education. Using a longitudinal, comprehensive dataset of more than 79,000 students who matriculated in engineering at nine universities, this research examines the question: How does the persistence of engineering students (measured as enrollment to the eighth semester) vary by disaggregated combinations of gender and race/ethnicity? Findings reveal that for Asian, Black, Hispanic, Native American, and White students, women who matriculate in engineering are most likely to persist in engineering compared to other eighth-semester destinations and, except for Native Americans, do so at rates comparable to those of men. Thus, contrary to considerable popular opinion that there is a gender gap in persistence, the low representation of women in the later years of engineering programs is primarily a reflection of their low representation at matriculation.

INTRODUCTION

The low participation of women and minorities in engineering is a well-known issue in higher education and has attracted attention not only because of the needs of a modern, technology-driven economy, but also because it calls into question issues of social justice, gender equity, and diversification of the profession (Watson & Froyd, 2007). With a national interest in increasing the number of engineering graduates (Jackson, 2004; Bureau of Labor Statistics, 2002; National Academy of Engineering [NAE], 2006), women have been identified as the greatest potential source of new engineering talent because they represent approximately 58% of all undergraduates (King, 2006) but only 17% of engineering students (National Science Foundation [NSF], 2005, tabb-10). Few studies, however, explore the persistence of engineering students disaggregated by race and gender. Whereas Seymour and Hewitt (1997) define persistence as "intending to graduate" (p. 14), for this research, persistence is defined as enrollment in an engineering program through the eighth semester.

This study capitalizes on an opportunity to conduct a multi-institutional and multivariate study of the persistence of women in undergraduate engineering programs to an extent never before possible. It focuses on the nine institutions of the former Southeastern

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University and College Coalition for Engineering Education, which account for one twelfth of the engineering bachelor's degrees awarded to women from 1987 to 2004. The Multiple-Institution Database for Investigating Engineering Longitudinal Development (MIDFIELD) is a longitudinal, comprehensive dataset that includes 79,417 first-time-in-college (nontransfer) students who matriculated in engineering (MIDFIELD, 2008; Ohland et al., 2008). This dataset is used to examine the research question: How does the persistence of engineering students to the eighth semester vary by disaggregated combinations of gender and race/ethnicity? Building on research in Critical Race Theory (Delgado & Stefancic, 2001), in this analysis race is not considered as a dichotomy (Black vs. White or majority vs. minority). Instead the analysis describes the persistence for all racial–ethnic groupings identified in institutional data, including Asian, Black, Hispanic, Native American, and White. Therefore, this is one of the few studies that recognize that persistence rates of women may look very different when examined through a critical race lens.

BACKGROUND

Persistence of Students in Engineering

Prior research using the MIDFIELD database has challenged the popular notion that engineering is a "weed-out" major, revealing that persistence rates of engineering students are actually higher than those of other groups of majors (Ohland et al., 2008). A preliminary analysis of the effects by race and gender indicated that persistence did "not vary much more than 5% by race/ethnicity or gender" (Ohland et al., 2008, p. 269). This research finding suggested the need for more extensive, in-depth analysis by race and gender. The study presented in this work disaggregates persistence by race and gender to explore this issue more fully.

Research on the retention of women in science, technology, engineering, and mathematics (STEM) disciplines in general and engineering in particular contains "conflicting evidence" regarding gender differences in persistence (Oakes, 1990, p. 23). Oakes (1990) focused on scientific majors, including engineering, and cites 10 studies from the 1970s and 1980s; 6 of these report men persisting at higher rates than women, and 4 report women persisting at the same or higher rates than men. Given that "the share of bachelor's degrees in engineering awarded to women increased by a factor of 12 from 1975 to 1985" and remained relatively constant since then (Oakes, 1990, p. 5), it would be inappropriate to compare studies before about 1980 with those conducted in subsequent years. Smaller sample sizes, different definitions of persistence (particularly in defining the starting point and ending point), and whether or not studies controlled for ability or prior experience (Oakes, 1990, p. 23) make persistence in undergraduate engineering education difficult to assess.

A variety of studies have reported that women matriculating in engineering majors persist at the same rates as men (Seymour & Hewitt, 1997, p. 21; Hartman & Hartman, 2006). Seymour and Hewitt's landmark work *Talking about Leaving*, demonstrated that women and men persist at comparables rates in engineering. Strenta, Elliott, Adair, Matier, & Scott (1994) found that although there is sparse evidence for STEM generally, in engineering women persist at rates of 56.77%, versus a rate of 64.69% for men. Also, "once science grades in the first two years were taken into account, gender was not a factor in persistence" (Strenta et al., 1994, p. 529) in engineering. Linden, Jagacinski, LeBold, & Shell (1985) found that "women (67%) were almost as likely as men (73%) to persist in their engineering studies." Hilton and Lee (1988) noted that although women are present in smaller proportions at each educational stage, they are more likely to persist in math, science, and engineering than are men.

Other studies found lower persistence for women in engineering. Using longitudinal data from multiple institutions, Astin and Astin (1992) found a slightly lower persistence of women as compared with men, noting that, "the net loss in the percentages of students pursuing science majors and careers during the undergraduate years are roughly proportionate for men and women, although women are slightly more likely to defect from engineering majors and careers" (p. 3). Adelman (1998) also found that overall there is a notable (20%) gender gap in engineering persistence—61.6% of men starting engineering study complete their degrees by age 29/30, compared to only 41.9% of women selected similarly. Among "high performing students," however, "the degree completion gap in engineering between men and women is negligible" (Adelman, 1998, p. 67). Adelman's unique use of a transcript-based "engineering threshold" (which was different for different populations within his study) eliminated from consideration a large number of students who would have been predicted to leave engineering, based on the work of Strenta et al. (1994). As a result, Adelman's analysis cannot easily be compared to earlier or later work. Finally, others have found gender and race to be inconclusive factors in determining persistence (Adair, 1991), or have used measures that do not allow precise comparisons of persistence (NSF, 1990).

Despite the sparse and sometimes contradictory evidence supporting the claim that there is a gender gap in engineering (or more generally STEM) persistence, there is a pervasive popular belief that women persist at lower rates than men. One source of this assumption is the inclusion of studies that measure persistence from precollege STEM intention rather than college matriculation. Starting at this earlier point reduces the overall persistence rate and conflates the gender gap in precollege choices regarding college STEM enrollment with the persistence after matriculation. The work of Xie and Shauman (2003, p. 87) indicated that the gender gap in STEM degree completion is accounted for primarily by gender gaps in (1) the expectation (in high school) of pursuing a STEM degree, (2) choosing to enroll in a STEM degree program after expecting (in high school) to do so, and (3) the choice to start college in a STEM degree program in spite of the (high school) expectation of pursuing a non-STEM degree program. Another likely reason for the belief in a gender gap in persistence is the severe gender gap in the enrollment–presence of women, which may be confused with the persistence of women. Overall, a careful investigation reveals that amidst some conflicting evidence, most research finds no significant difference in men's and women's STEM persistence rates, particularly for students with comparable academic preparation and achievement and specifically for engineering.

Disaggregating Women by Race/Ethnicity

Over the past two decades, feminist scholars of color have argued for a more nuanced and differentiated understanding of gender, asserting that "women" and "men" are not monolithic groups and that experiences by gender cannot be understood outside of a wider prism of difference that accounts for race, social class, nationality, sexual orientation, etc. (Andersen & Collins, 2007; Moraga & Anzaldua, 1984; di Leonardo, 1991; hooks, 2000). These multiple layers of difference are not mutually exclusive and, therefore, merit collaborative analysis (Leggon, 2006).

If the climate has been characterized as "chilly" for women in engineering education (Hall & Sandler, 1984), the terrain is "icy" for minority women. Recent work by Shehab et al. (2007) disaggregated the experience of various minority groups, revealing differences in the degree of isolation they experience. Although climate may explain observed differences, the purpose of this research is to characterize persistence.

In analyses of engineering persistence, failing to disaggregate data on women by race produces results that are not only erroneous and overgeneralized, but also counterproductive, rendering minority women "invisible." Women in engineering do not necessarily share common experiences of marginality. For example, women of color may experience both sexism and racism, compounding their experiences of exclusion. Failing to consider race in any analysis of gender ignores the intersectionality of both of these sociocultural constructs. The theory of intersectionality refers to the way in which gender operates together with race, not independently, and produces multiple, overlapping forms of discrimination and social inequality (Collins, 1990).

Minority women in STEM bear the burden of sexist as well as racial stereotypes that vary based on ethnic group. Some high-achieving women in STEM, particularly Asian women, are ascribed the stereotypical label of "model minority," suggesting they outperform other underrepresented minorities. Though seemingly "positive," this label is problematic, not only because it is equally discriminatory in its racial stereotyping, but it implies competition among minority group members. Further, it glosses over important intracultural differences among Asian American subgroups (Hanson & Meng, 2008).

There are two problems associated with the dearth of women of color in STEM: (1) With the overrepresentation of White men in STEM, women of color are vulnerable to tokenization, the perception that they are "representatives" of a larger social group to which they belong (Saenz, 1994). Women of color are marked outsiders both because of their gender and phenotype. The culture of exclusion or feelings of isolation that White women experience in engineering are different than those experienced by women of color because racial stereotyping compounds the experience of gender stereotyping. Thus, gender in engineering is experienced in socially different ways that vary by race. The theory of intersectionality considers such nuance important to understanding the overlapping factors that may produce differing social outcomes (Collins, 1990). In particular, this framework suggests the need to examine the conditions under which women of color persist in academia in spite of such obstacles. (2) The discipline of engineering itself is homogenous relative to other disciplines, composed primarily of White men. Studies have suggested the importance of diversifying the discipline by gender and ethnicity to promote the incorporation of a wider range of voices, with the goals of evolving as a discipline and adapting to a broader, more complex and globalized world (NAE, 2008; Watson & Froyd, 2007; Jackson, 2004). Women of color represent the largest void in engineering programs. The relationship between representation and persistence, however, has been understudied.

Reichert and Absher (1997) reported data on minority retention rates from the National Action Council for Minorities in Engineering (NACME), but they neither tracked individual students nor disaggregated by race or gender. May and Chubin's (2003) significant study for NACME spoke clearly to the issue of representation of underrepresented minorities disaggregated by race and gender but did not track individual students to address the issue of persistence. Cook and Córdova (2007) also disaggregated by race in their study of representation. Disaggregation by gender and race/ethnicity in the study of persistence in engineering has been called for (e.g., George, Neale, Van Horne, & Malcolm, 2001) but has not been undertaken on such a scale as is presented here.

Representation and Persistence of People of Color in Engineering

The vast majority of undergraduate engineering degrees in the United States are awarded to Whites. For example, in 2004, Whites received 65% of the engineering bachelor's degrees, Asians about 12%, Hispanics 7%, Blacks 5%, and Native Americans less than 1% (NSF, 2008, tabc-14). Except for Asians, each group received about the same proportion of nonengineering STEM degrees. In 2005 (NSF, 2008, figc-3), about one third of the bachelor's degrees for Whites, Blacks, Hispanics, and Native Americans were in science and engineering fields. By contrast, almost half of the Asian graduates earned bachelor's degrees in science and engineering. There is a wealth of literature on the experiences of people of color within science and engineering, yet much of this research aggregates science, math, and engineering (SME) and/or underrepresented minorities: Blacks, Hispanics, and Native Americans. For example, Seymour and Hewitt (1997) reported that "the relative graduation rate for students of color in engineering was about half (52%) that of White students" (p. 319).

The most comprehensive recent study (Anderson & Kim, 2006) found that Black and White students are as likely to select STEM fields of study and to persist for 3 years, but that differences accrued to graduation—62.5% of Blacks persisting for 3 years graduate within 6 years compared with 94.8% for Asian Americans and 86.7% for Whites. Yet these persistence issues may not be related to majoring in STEM disciplines alone. Rather, low minority persistence in STEM is a microcosm of low persistence in higher education. The same institutional and structural barriers that affect overall persistence in all majors affect engineering. More research on these issues is needed. The aggregation of engineering with other STEM majors obscures important differences. Ohland et al. (2008) found that a wide gap exists between the engineering persistence rate (57% persist to eight semesters) and the persistence rate in nonengineering STEM fields (41% persist to eight semesters).

Research by Elliott, Strenta, Adair, Matier, and Scott (1996) found that ethnicity was not a predictor of persistence beyond what could be explained by ability as measured by scholastic aptitude tests (SAT), math (SATM) scores, and achievement (high school grades). The SATM scores of Blacks and Hispanics are known to be substantially lower (1 and 0.75 standard deviations, respectively) than those of Whites (Suter, 1993). Large differences in persistence result when comparing high-performing Blacks (62% persistence per Hilton, Hsia, Solorzano, & Benton, 1989) to a broader cross-section of Black students (34% persistence per Elliott et al., 1996). Although Historically Black

Colleges and Universities (HBCUs) contribute substantially to the number of Black engineering graduates, there is no significant indication the HBCUs have higher or lower rates of persistence—they seem to show the same variability as nonminority institutions (Chubin, May, & Babco, 2005).

Asian students are unique among students of color in engineering because they are not underrepresented, and they demonstrate the highest persistence (Culotta & Gibbons, 1992, Fullilove & Treisman, 1990; Humphreys & Freeland, 1992; Simpson, 2001). They show the strongest predilection for engineering and the smallest proportionate losses in SME majors during their undergraduate years (Astin & Astin, 1992). Some researchers have questioned the "model minority" stereotype and have found a bimodal distribution in terms of educational attainment with Filipinos, Pacific Islands, and Southeast Asians having lower levels of attainment than Chinese, Japanese, and Korean (Gloria & Ho, 2003; Li, 2005). Smyth and McArdle (2004) reported a 63% graduation rate for Asians matriculating in SME, as compared to 55% for Whites and 38% for underrepresented minorities, including Black, American Indian, and Hispanic students (p. 371). Similarly, research by Bonous-Hammarth (2000) indicated that Whites and Asians had comparable attrition rates from SME majors (25% and 26%, respectively) considerably less than the 44% for African American, Hispanics, and Native Americans. Asians are often excluded in studies of minorities (Culotta, 1996) or combined with Whites in engineering persistence studies (National Center for Education Statistics [NCES], 2000; Hilton & Lee, 1988). Recent work (Shehab et al., 2007) revealed that Asian engineering students have distinct academic struggles and strategies for overcoming them. Such a finding indicates the need for more research with data disaggregated by race to understand the unique experiences of Asian students in SME majors, who have "been ignored, both in the literature, and by the institutions they attend" (Seymour & Hewitt, 1997, p. 322). Hanson and Meng (2008) provide a notable example of work that considers the complexities of the Asian experience including the "model minority" stereotype. The researchers used a status attainment framework to examine how race and gender influence choices of science major and degree for White and Asian students.

The Hispanic population (which is sometimes referred to as Latinos and is itself an aggregation of multiple national backgrounds) is the fastest growing minority group in the United States (Chapa & De La Rosa, 2006) and accounts for the largest increase of underrepresented minorities in public education enrollment from 1994 to the present (Rochin & Mello, 2007). Demographic predictions suggest that Hispanics may be poised to have the greatest effects on engineering education (Millett & Nettles, 2006). However, the educational gap between Hispanics and other groups continues to widen, especially in engineering (Johnson, 2007), possibly as a result of factors affecting Hispanics' participation in education generally, such as health care, nutrition, adequacy and stability of housing, neighborhood environments, and a lack of engineering role models (Gándara, 2006; Rochin & Mello, 2007).

Similar to women and Blacks, among Hispanics the proportion of bachelor's degrees awarded in engineering has only marginally increased between 1991 and the present (NACME, 2008). Of all engineering degrees earned in 2004, for example, only 6.9% were awarded to Hispanics (NSF, 2008, tabc-14). Nonetheless, there is room for the numbers of Hispanics to increase in the field of engineering because engineering is the third most popular destination (after social sciences and psychology) among Hispanic bachelor's degree recipients (NSF, 2008). Recent ethnographic research indicates that precollege experiences, socioeconomic background, age upon entering college, academic experiences of validation, and social support networks (both peer and faculty mentoring) all contribute to academic success and persistence among Hispanic undergraduate engineering majors (Vasquez, 2007; Vazquez-Barquet, 2004; Wightman Brown, 2002).

Native American women are much more likely to participate in higher education and to earn bachelor's degrees than Native American men. Yet, like all women, they are less likely to choose science and engineering fields as college majors. (Babco, 2000, 2003). In 2004, 333 Native American women received bachelor's degrees in engineering, accounting for about 0.5% of engineering students nationwide (NSF, 2008, tabc-14). From 1995 to 2005, Native American engineering students as a percentage of all undergraduate engineering students remained relatively steady at approximately 0.65% (NSF, 2008, figb-1). Of those Native American students receiving bachelor's degrees, approximately 4% were in engineering (NSF, 2008, figc-3). Because of their small numbers, Native Americans are frequently combined with Hispanics and Blacks in studies of engineering persistence (Bonous-Hammarth, 2000; Humphreys & Freeland, 1992). Specific references with details of the persistence of Native Americans in engineering could not be found.

METHODS

Population Definition

As noted earlier, the data source for this research is MIDFIELD, which is described in detail elsewhere (Ohland et al., 2008), and contains undergraduate student records for all students at nine public universities in the southeastern United States. These institutions have a larger-than-average percentage of engineering students. Black students are overrepresented because of regional demographics. Significant numbers of Black students in this dataset come from HBCUs as well as predominantly White institutions. The experience of MIDFIELD students is likely representative of the experience of a large fraction of U.S. engineering students attending large public institutions. A complete data dictionary is available (MIDFIELD, 2008). Note that MIDFIELD contains data for all matriculants in all majors. In this study, only first-time-in-college students (FTIC) are considered. Transfer students are excluded because their patterns of persistence follow a different educational trajectory and therefore merit independent analysis. The large and rich dataset permits using data to describe how students racially/ethnically identify, moving beyond dichotomous classifications and capturing a richer and fuller portrait of diversity in engineering to the extent possible, given institutional data collection practices. Appendix A provides details on the specific racial categories that are used by each MIDFIELD institution.

On the basis of each university's system of classification, the following descriptors for race are used throughout this research: Asian, Black, Hispanic, Native American, Nonresident Alien, White, and Missing. Given that the category of "Nonresident Alien" represents an aggregation of students from races, ethnicities, and countries all over the world, individuals assigned to this category would not be expected to behave as a group and are not included in further analysis. Similarly, the "Missing" category is aggregated such that it is not possible to draw conclusions from analysis of this group either. Although differences in curriculum and policy may certainly affect the persistence of students of various race–gender groups, the current study aggregates data for all institutions, and institutional differences are not addressed at this time. The results of this work therefore speak to the experience of students at this group of institutions, masking the experience of students at an individual institution. Although the MIDFIELD dataset is suited to studying variation by institution and time, this work does not explore those variables because of the need to pool data for low-frequency combinations of gender and race/ethnicity. Institutional differences will be explored in a later work.

Definitions of Variables

Throughout this work, "engineering" as a major includes all disciplines of engineering offered at any of the MIDFIELD institutions. Persistence is operationalized as matriculating in engineering and being enrolled or previously graduated in engineering at the eighth semester. By this definition, these eight semesters need not be consecutive, so students can "stop out" (take a temporary withdrawal from college) without consequence (U.S. Department of Education, 1990). Again, this dataset permits consideration of multiple definitions of success. Choosing eighth-semester persistence rather than 6-year graduation rate increases the population being examined, which decreases the sensitivity of the measurement to continuous enrollment and includes more recent cohorts. Yet, the eighth-semester measure is still sensitive to ethnic differentiation in patterns of persistence, given that some groups exhibit differing behaviors past the 3rd year. Other fields of study and destinations are referenced, as well. The acronym "TOLEDO" ("Trajectory of Leaving Education, Destination Obscure") is used to indicate the destination of students whose actual destination is unknown because they are no longer found in the database. Such students may have transferred to another institution (possibly continuing in engineering), dropped out, or stopped out without having returned yet and in this study are referred to as having "gone to TOLEDO." Computer Science is treated separately because it is in some ways similar to engineering and in other ways quite distinct (Ohland et al., 2008). "Other-STM" refers to other STM fields such as biology, chemistry, physics, geosciences, agriculture, and mathematics. "Social Science" (Soc Sci.) includes education, psychology, and sociology, and "Arts and Humanities" (A & H) includes majors such as English, foreign languages, and fine arts. "Other" includes majors such as health sciences, paralegals, human development, child care, textiles, library science, and technology. For the present group of MIDFIELD partners, technology majors are considered "Other" rather than "Other STM" because only one of the current MIDFIELD institutions offers engineering technology programs.

Analytical Procedures

Institutional data analysis was used to conduct this study. Because this is whole population data, inference is unnecessary; all reported differences are real for the population studied. Whereas earlier studies (including some using the same data source) have sought to predict the persistence of engineering students, precollege factors and even data collected after enrollment typically explain no more than 10% of the variation in whatever outcome variable is chosen (Zhang, Anderson, Ohland, Carter, & Thorndyke, 2004). Rather than continuing to engage in further study of variables with limited-effect sizes, this work identifies important findings using primarily descriptive statistics—findings that challenge conventional beliefs regarding the persistence of women in engineering. Definitions from the Integrated Postsecondary Education Data System (IPEDS) are used (U. S. Department of Education, 2007).

RESULTS

Who Matriculates in Engineering?

Figure 1 shows the numbers of native (nontransfer) students matriculating in three sets of majors at all MIDFIELD institutions from 1988 to 2000.[1] The three sets of majors are (1) Engineering, (2) Other STM, and (3) Arts & Humanities, Social Sciences, and Other (combined for this display because their matriculation patterns are similar). Three sets of majors are omitted from Figure 1 to reduce the complexity of this work: (a) Computer Science, because its matriculation pattern is similar to Engineering, (b) Business, and (c) Undecided, because their matriculation patterns are similar to Other STM. A closer look at individual groups of majors does reveal some interesting patterns of enrollment and persistence in other fields, but exploring that level of detail is beyond the scope of the present work. The panels in Figure 1 indicate the majors, the rows indicate the ethnicities, and the dots represent the numbers of females (filled circles) and males (open circles) matriculating in a particular category. The largest and smallest numbers of matriculants differ by nearly three orders of magnitude; therefore, a logarithmic scale is used. Thus, each scale division represents a factor of 10. The total number of females (n_F) and the total number of males (n_M) matriculating in each major are shown in the panel titles. Such "dot plots," as means of displaying categorical data, are presented in Cleveland (1993) and Robbins (2005).

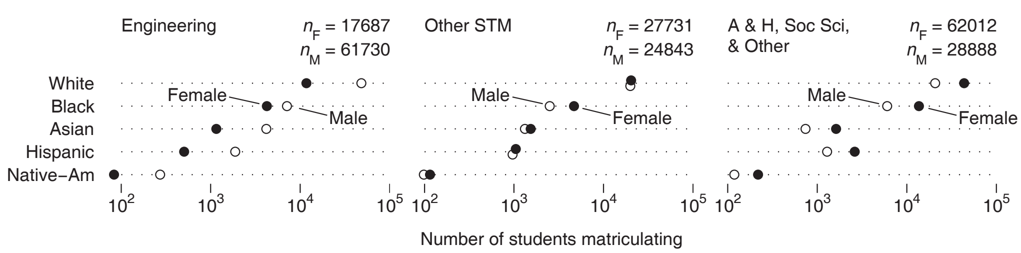

Figure 1. The numbers of students matriculating in three groups of majors. Females (filled circles) are underrepresented in Engineering majors, have parity or better in Other STM majors, and are overrepresented in Arts & Humanities, Social Sciences, and Other majors. This pattern holds for all ethnic groups.

[1]The data source for Figure 1 and all subsequent Figures is MIDFIELD, native (nontransfer) students matriculating from 1988–2000.

Defining "underrepresentation" to mean that fewer females than males of the same ethnicity matriculate in a major, females of every ethnicity are underrepresented in Engineering—only 22% of the total number of students matriculating in Engineering are female. No other major except Computer Science follows the same pattern. In all other majors, females of every ethnicity are either equally represented, as in Other STM, Business, and Undecided, or females outnumber males, as in Arts & Humanities, Social Sciences, and Other majors. The gender imbalance in engineering is not an effect of its being a scientific major; the second panel indicates that Other STM majors attract slightly more females than males of all ethnicities and, noticeably, more Black females than Black males. Other studies (American Council on Education [ACE], 2006; NCES, 2000) have shown that the underrepresentation of minorities is a problem shared by all majors. As seen in Figure 1, the underrepresentation of females is a problem unique to Engineering and Computer Science.

For the rest of this study, to focus on persistence, only students within MIDFIELD who matriculated in engineering are considered. The largest subpopulation, with 48,296 students, is White males. The smallest subpopulation, with 83 students, is Native American females. Thus, the subpopulations, even when disaggregated by race and gender, are larger than the typical thresholds for small cell sizes (Mehta & Patel, 1997). The subpopulations in the MIDFIELD dataset also provide more compelling and richer information compared to other studies because these subgroups are commonly neglected in science and engineering studies, or aggregated with other underrepresented minorities because of insufficient population size (Waite, 2000; Anderson & Kim, 2006).

Women of all ethnicities are underrepresented in engineering compared to their presence in the overall dataset. In this research, the "expected value" for a particular race–gender group is calculated as that group's population multiplied by the overall fraction of students matriculating in engineering. This expected value answers the question, "If this group matriculated in engineering at the same rate as all students combined, how many students from this group would have matriculated in engineering?" Examining the nuances of persistence among women and men through the lens of race elicits unique findings. In Engineering, Asian women most closely approximate proportional representation (76% of the number expected if they had enrolled in engineering at the same rate as all students in the population studied), whereas Hispanic women are the most underrepresented (34% of what would be expected). White women are the second lowest, with 45% of their expected representation. In the case of white women, because their population size is so much greater, greater representation in engineering would be expected. Asian men are present in engineering in greater numbers than would be expected for their population (about twice as many), whereas Hispanic men are present in engineering at rates typical of their overall enrollment. The enrollment of male students in Other STM is consistent with enrollment demographics, with the exception of Black males who only have about half their expected representation. As suggested by theorists of intersectionality and critical race theory, understandings of disparities among and between men and women in STEM are deepened with closer analysis of differences by ethnicity. In this case, differences by ethnic group emerge. Some women (e.g., Hispanics and Native Americans) are proportionally less represented compared with other women, and in the case of African Americans, women fare better than men. These data indicate that studies aggregating all minorities into one group (that dichotomously opposes the majority) blur important distinctions. Qualitative data are required to understand the conditions that contribute to these differences.

If Students Matriculate in Engineering, Where Do They Go?—Results for Women and Men

Figure 2 compares the eighth-semester destinations of all women and all men in this dataset who matriculated in engineering from 1988 to 2000.

The data symbols represent the percentage of women and men starting in engineering and arriving eight semesters later at the destination shown. For example, the "Computer Science" data point indicates that 1.4% of all women and 2.6% of all men matriculating in engineering migrate to computer science by the eighth semester. A logarithmic scale is used so that differences among small numbers are more clearly visible. The scales along the two axes indicate the values associated with each point that is plotted (Tufte, 1983, p. 133).

The line in Figure 2 indicates where the percentages of women and men are equal. Points on that line are destinations attracting equal percentages of men and women matriculating in engineering. Destinations to the right of the line are more common for women and destinations above the line are more common for men. Analysis suggests

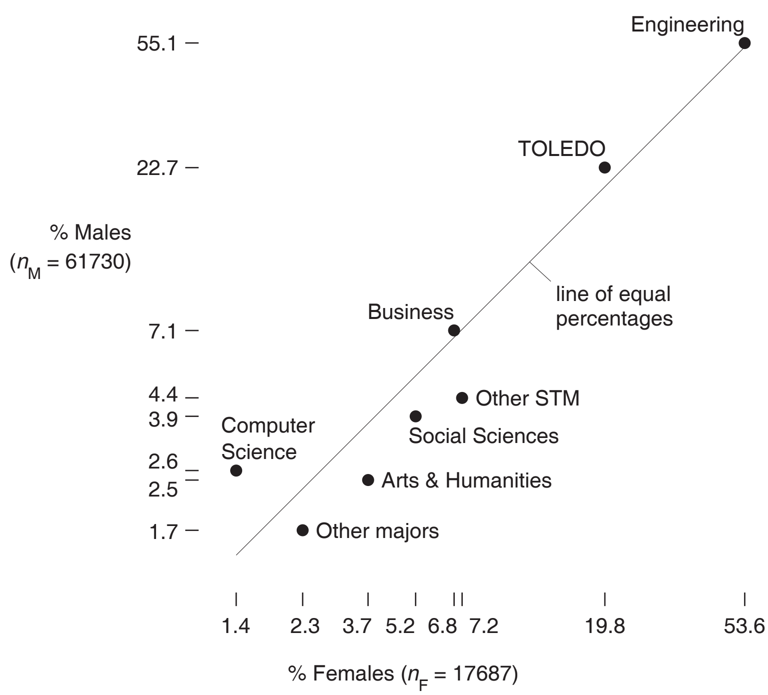

Figure 2. Comparison by gender of the eighth-semester destinations of Engineering matriculants. More than 50% persist in Engineering, and females and males persist at nearly the same rate. The same holds true for the nearly 30% who go to Business and TOLEDO (drop out or leave the dataset). Comparatively larger differences by gender appear in the smaller percentage destinations.

1. *Women persist in engineering to the eighth semester at the same rate as men.* Overall, women persist in engineering to the eighth semester at 54%, and men are at 55%.
2. *The eighth-semester persistence behaviors of the majority of men and the majority of women are more alike than different.* The top three eighth-semester destinations (Engineering, TOLEDO, and Business) attract men and women in about the same percentages, for a combined total of 80% of women and 85% of men who matriculated as engineers.
3. *Although many women and men follow similar pathways, there may be interesting stories in the narrower pathways.*
   a. Women migrate to "Other STM" at nearly twice the rate of men (7.2% to 4.4%).
   b. Men migrate to Computer Science at about twice the rate of women (2.6% vs. 1.4%).
   c. Women migrate more often to Social Sciences, Arts and Humanities, and Other majors than do men.

Results Disaggregated by Race and Gender

As argued throughout this article, disaggregating by race and gender can more accurately portray the experience of students. Table 1 includes the number and percentage of students who matriculated in engineering, as well as their eighth-semester destina-

Table 1. Number and Percent of Students by Race and Gender Matriculating in Engineering and Arriving at the Eighth-Semester Destinations Shown

ENGR matriculants…			…and their eighth-semester destinations					
	ENGR		ENGR		Switched		TOLEDO	
Ethnicity and gender	No.	% of total	No.	% of group	No.	% of group	No.	% of group
Asian male	4185	5.3	2641	**63.1**	772	18.4	772	18.4
Asian female	1159	1.5	710	**61.3**	281	24.2	168	14.5
White male	48296	60.8	26795	**55.5**	10875	22.5	10626	22.0
Hispanic male	1875	2.4	1024	**54.6**	396	21.1	455	24.3
White female	11704	14.7	6319	**54.0**	3216	27.5	2169	18.5
Hispanic female	506	0.6	260	**51.4**	144	28.5	102	20.2
Black female	4235	5.3	2163	**51.1**	1028	24.3	1044	24.7
Native-Am. male	272	0.3	138	**50.7**	70	25.7	64	23.5
Black male	7102	8.9	3439	**48.4**	1573	22.1	2090	29.4
Native-Am. female	83	0.1	34	**41.0**	23	27.7	26	31.3
All males	61730	77.7	34037	**55.1**	13686	22.2	14007	22.7
All females	17687	22.3	9486	**53.6**	4692	26.5	3509	19.8
All matriculants	79417	100	43523	**54.8**	18378	23.1	17516	22.1

Data source: MIDFIELD native 1988–2000 matriculants in engineering.
Note. The bold column highlights the variable used to sort the rows in order of decreasing magnitude.

tion: persisting in engineering, switched majors (aggregating all other destinations), or left the dataset (TOLEDO). Note that all engineering matriculants are accounted for by these three destinations; percentages of the particular gender–ethnicity for these eighth-semester destinations total 100%. For example, of the Black women who started in Engineering, Engineering was by far the top eighth-semester destination, with 51.1% compared to 24.7% leaving the dataset and 24.3% switching to another major.

Figure 3 displays the same information as Figure 2, but disaggregated by ethnicity, using a visualization technique called "small multiples." The small graphs, each with identical axes and scales, invite comparison and contrast, allowing the reader to "detect contrasts and correspondences at a glance—uninterrupted visual reasoning" (Tufte, 1997, p. 112). In this case, the small multiples illustrate a comparison between females and males of a particular ethnic group, as well as similarities and differences among the ethnic groups. For example, among Black students, the dots are closest to the line of equal percentages than in any other plot, indicating that Black females and males choose more similar destinations than do the females and males of any other ethnicity. TOLEDO is above the line in every case except for Native American, revealing that fewer females go to TOLEDO in every ethnicity except Native American. Other STM draws engineering females at a higher percentage than males in all ethnicities.

The small multiples, viewed in parallel with Figure 2, demonstrate that students who initially choose to study engineering are more likely to persist in engineering through the eighth semester than they are to choose any other pathway, regardless of race and gender. For all combinations of race and gender considered, the next-most-likely eighth-semester destination is leaving the university. The behaviors of students of different race and gender combinations are more alike than different. Approximately 76% of students, regardless of race and gender, have the same top two eighth-semester destinations:

- Persist in engineering (approximately 53% for all groups, range 41% to 63%)
- Missing from the database (TOLEDO, approximately 23% for all groups, range 14.5% to 31.3%)

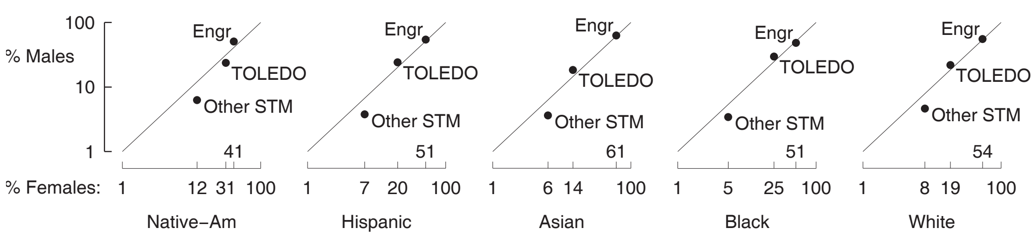

Figure 3. Disaggregating by ethnic group and gender the most popular eighth-semester destinations of Engineering matriculants. The two most common destinations are Engineering and TOLEDO (leaving the database). Other STM attracts higher percentages of females than males of all ethnic groups.

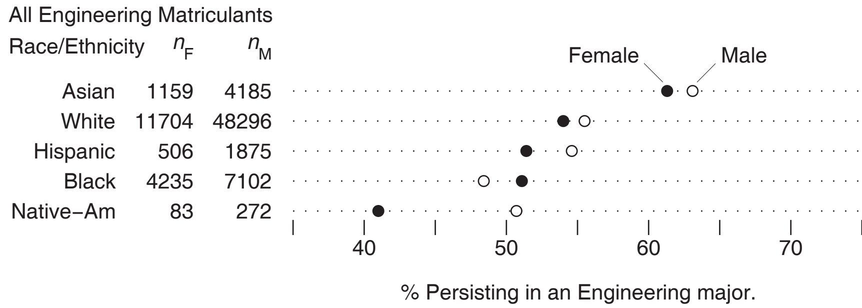

Figure 4. Percentages of Engineering matriculants persisting to the eighth-semester in Engineering. Black females persist at a higher rate than Black males, and Native American females persist at a much lower rate than Native American males. Female and male persistence rates in Engineering among other ethnicities are within 3% of each other. Asian students persist at higher rates than other groups.

After these two destinations, the population that migrates to any other specific group of majors is much smaller, each accounting for less than 12% of a given race–gender group. Business is the most popular third destination for all groups except Native American women and White women, who go to Other STM as their third destination.

To facilitate closer examination of the top destination, Figure 4 describes eighth-semester persistence in Engineering as a percentage of all students of a particular race–gender group who matriculate in engineering. Females are denoted by the filled circles and males by the open circles. For example, Asian women persist in engineering at 61.3%, and Asian men persist in engineering at 63.1%. Thus, an open circle to the right of a filled circle indicates that males persist at a higher rate than females; a filled circle to the left of an open circle indicates that males persist at a lower rate than females. The rows (or levels) of the plot are ordered by decreasing persistence of females in engineering. Figure 4 demonstrates that Black females are the only group persisting at a higher rate than males of the same race. The difference between female and male persistence in engineering is consistently low—less than 3.2%, except for Native Americans, where the difference is about 10%.

Gender and Performance in Lower-Division, University-Level STEM Coursework

A possible explanation for the lack of a gender gap in persistence in this study could be that the MIDFIELD women were more academically successful in their early curriculum. This would be consistent with research by Strenta et al. (1994), where differences in grades in early science courses explained an observed gender gap in persistence. To determine whether MIDFIELD women were faring better in early science courses than the women in Strenta et al.'s study, or if MIDFIELD women were able to persist in spite of lagging performance in those early science courses, the grades in such courses were examined. The distributions of female and male 4th-semester grade point averages (GPAs) in STEM courses appear to be the same when plotted as histograms. However, given the very different sizes of the two populations, to confirm that the data

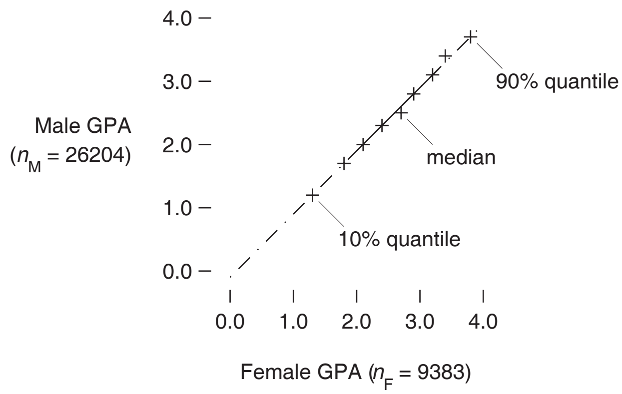

Figure 5. Comparison by gender (with all races aggregated) of the distribution of fourth-semester GPAs in STEM courses. The Male GPA quantiles are plotted as a function of the Female GPA quantiles. The points lie on a 45-degree line, confirming the same underlying distribution. Female GPA is equal to or slightly greater than Male GPA in every quantile. GPA = grade point average.

share a common distribution, a quantile-quantile (q-q) plot is displayed in Figure 5 (Engineering Statistics Handbook [NIST/SEMATECH]), with quantiles shown in 10% increments from 10% to 90%.

Note that a quantile represents the percentage of students having a GPA below the given value. For example, the median female GPA (2.7) and the median male GPA (2.6) are the 50% quantiles. Since the male and female GPA quantiles align on a 45-degree line, the similarity of the two distributions is confirmed. Female GPA is equal to or slightly greater than Male GPA in every quantile. These results demonstrate that MIDFIELD women in the aggregate perform as well as men in early science courses.

The average GPAs of males and females in the first four semesters disaggregated by ethnic group are shown in Table 2.

Table 2. GPA in Science and Engineering Courses in the First Four Semesters, Aggregated for Each Combination of Race and Gender

	STEM GPA		Difference
Ethnicity	Female	Male	Female–Male
Black	2.34	2.10	**0.24**
Native American	2.50	2.32	**0.18**
Asian	2.82	2.65	**0.17**
White	2.68	2.54	**0.14**
Hispanic	2.54	2.50	**0.04**
All	2.61	2.50	**0.11**

Data source: MIDFIELD native 1988–2000 matriculants in engineering.

Note. The bold column highlights the variable used to sort the rows in order of decreasing magnitude.

Females in general have higher STEM GPAs, with Black females showing the largest difference (0.24) compared to Black males and Hispanic females having the smallest difference (0.04) compared to Hispanic males. Thus, MIDFIELD women of all races perform as well as men in early science courses. Strenta et al. (1994) do not disaggregate by race, so more careful analysis is necessary to make meaningful comparisons regarding persistence and early science grades. The data in Table 2 show that the relationship is complex. For example, among Blacks, women perform much better than men in early science courses and have higher persistence. However, among Native Americans, women perform much better than men in early science courses but have lower persistence in engineering.

DISCUSSION

Contrary to popular assumptions that women fare poorly in engineering, the data indicate that women persist in engineering at approximately the same rates as men, even when disaggregated by race. The "conflicting evidence" presented in the literature review indicated that some debate lingers about whether or not women persist at different rates than men within engineering. Although this research project did not probe the micro-level challenges faced by female students (both White women and women of color) in predominantly male engineering educational environments, the quantitative analyses provide rich information. The methodological breadth allowed by the large MIDFIELD dataset suggests the possibility of putting to rest conflicts of evidence and definitively asserting that female matriculants to engineering are "educational-persisters." This is the case for every ethnic group examined here.

A more nuanced view of the structure of persistence rates by gender is provided by comparing the rates of different racial groups. Overall, the most distinctive rates are those of the 83 Native American women who comprise 0.1% of the students included in the study. Of all groups, Native American women are most likely to leave the university and least likely to persist in engineering. This is in sharp contrast to the pattern of the 1,159 Asian women who comprise 1.5% of the students included in the study. Of all groups, Asian women are the most likely to stay at the university. They persist in engineering at rates higher than all race–gender groups except Asian males. Consistent with the literature, Asians are the most likely to select and persist in engineering. This work indicates that this is true for Asian women as well as for Asian men. These findings do not account, however, for the heterogeneity of Asians because of the limited nature of the ethnicity data collected. Future research would do well to examine intracultural variability among U.S.-born Asian students, including factors such as ethnicity or generation.

For each racial group, women are more likely than men to switch from engineering to another major rather than leave the university. This is consistent with Seymour and Hewitt's (1997) finding that women were more likely to leave science, math, and engineering because of other educational interests. Other factors that might explain this phenomenon include chilly campus climate, lack of social support networks, or few role models (Seymour & Hewitt, 1997; Hanson, 1997).

The low persistence of Native American women, in general, and compared to Native American men, in particular, is troubling. Their lagging persistence rates compared to men cannot be explained in terms of their STEM GPA because Native American women have higher STEM GPA than do men. The small populations of these students complicate analysis. Nonetheless, the low persistence rates suggest that their small numbers may be due to the lack of what has been termed "critical mass."

The theory of "critical mass" states that numerical shifts in distribution have a profound effect on social interaction (Oliver, Marwell, & Teixeira, 1985). Empirical studies of "token" women in organizations tend to support that hiring women in clusters is needed to avoid the gender stereotyping that accompanies the presence of one or two women in a department (Kanter, 1977; Etzkowitz, Kemelgor, Neuschatz, & Uzzi, 1994a; Etzkowitz, Kemelgor, Neuschatz, Uzzi, & Alonzo, 1994b; Widnall, 2000). However, at least one study failed to verify this empirically, noting that critical mass assumes a collective experience that may not exist (McManus & Sproston, 2000). Research suggests that women place more emphasis on group affiliations, community, and collaboration than do men (Helgesen, 1995; Maier, 1999). The 83 Native American women in this dataset are spread over more than a decade at nine institutions. Thus, they could very well be the only Native American women in all of their classes. Although other ethnicities do not reach parity either, they may have enough women to mitigate the isolation, the end result being comparable persistence. For Native American women, however, this threshold is never reached, and the likelihood that they can somehow overcome the negative consequences of being subjected to racial and gender stereotyping will remain remote.

Black men and women behave more alike in their migration patterns than any other ethnic group. As shown in Figure 6, the 4,235 Black women who comprise 5.3% of the students included in the study have the highest percentage of women in engineering by race at matriculation and at the eighth semester; 39% of the Black engineers are women.

For all other racial groups, only about one fifth of their engineering population is female at the first and eighth semesters. This points again to the similarity in engineering persistence rates for women across all races. Although Black women matriculate in engineering at higher rates, their persistence rates are not the highest. Although no

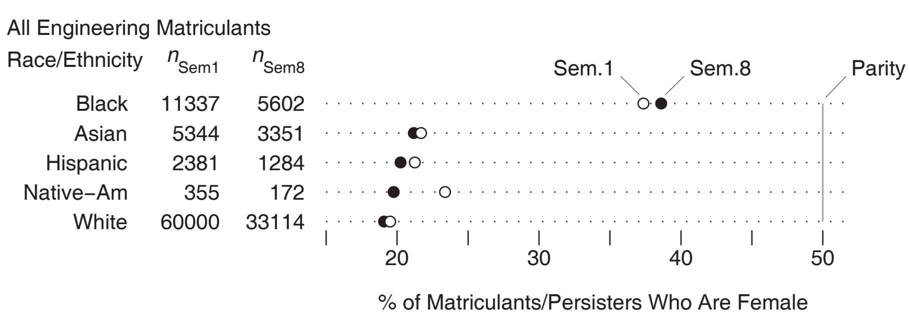

Figure 6. Underrepresentation of Females in Engineering by race at two points in time: percentage of Females matriculating in Engineering (open circles) and persisting to semester 8 (filled circles). Total population sizes are listed for both semesters. Black Females come closest to parity, with nearly 40% of the Black eighth-semester persisters being female, nearly double the representation of all other Females who are clustered around 20%. Female representation is fairly constant over time—the largest change (for Native American Females) is less than 4%.

racial group comes close to parity in gender representation, the smaller gender gap in the representation of Black undergraduates in engineering can be understood within the social context of dwindling persistence rates for Black men nationally (ACE, 2006). However, this can also be viewed as a pocket of success for Black women in engineering. Future research might explore the specific role of HBCUs in understanding such success. Qualitative research could also probe the heterogeneity of the Black population, exploring, for example, variations in persistence by social class.

Hispanics are a heterogeneous group comprised of Mexican, Puerto Rican, Cuban, Dominican, and Central and South American subgroups spread across the United States. In the case of the dataset used for this study, the majority of Hispanic students are at universities in Florida and Georgia. Greater variability might be found in the educational experiences of Hispanics if the universities in the southwestern United States were included, given the significance of a small group of Hispanic-Serving Institutions (HSIs) in the production of Hispanic engineering graduates (Rochin & Mello, 2007).[2] Universities in California, Florida, New Mexico, Texas, New York, New Jersey, and Puerto Rico graduate the highest number of Hispanic engineers. Community colleges, as a route toward engineering degrees, also play a vital role in advancing Hispanics in higher education (Chapa & De La Rosa, 2006; Rochin & Mello, 2007). However, for methodological consistency, transfer students were excluded from this study. Finally, other characteristics, such as nativity, length of time in the United States, generation, and socioeconomic status affect educational persistence among Hispanics. Although a disaggregated analysis of Hispanic students by subgroup would be most meaningful for examining educational differences in persistence, all MIDFIELD universities (and likely most other United States universities) aggregate "Hispanic" students, preventing such nuanced analysis. The proportion of Hispanic undergraduate students enrolling in engineering is gradually increasing. At the highest levels of engineering education, however, researchers claim that Hispanic status resembles less of a pipeline and more of a "pipette" (Chapa & De La Rosa, 2006, pp. 203–204).

CONCLUSIONS

The finding that women are nearly as likely to persist in engineering to the eighth semester as men in the same racial group is counter to conventional wisdom and has wide-ranging policy implications. It emphasizes the importance of recruiting more women and minorities to enroll in engineering programs. It further underscores the importance of the recent call by the National Academy of Engineering to improve the messages about what engineering is and the contributions it makes to bettering society in such a way as to appeal to young people, especially girls and underrepresented minorities (NAE, 2008).

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[2]The federal government defines Hispanic-Serving Institutions (HSIs) as accredited degree-granting public or private nonprofit institutions of higher education with a full-time equivalent enrollment of undergraduate students that comprises at least 25% Hispanic students, with no less than 50% of its Hispanic students being both low-income and first-generation college students and another 25% being either low-income or first-generation college students.

The disaggregation of race and gender reveals subtle differences among racial groups that are not apparent in most studies of engineering persistence. Small samples sizes and understandable limitations in acquiring robust datasets preclude most researchers from making empirical generalizations about how different racial/ethnic groups fare in undergraduate engineering. Aggregating all ethnic groups into a single category of "minorities" is problematic because there are differences by gender that merit critical evaluation.

The failure to recruit a diverse body of women to the subfields of engineering has previously been interpreted to mean that women are less likely to persist to graduation. Disaggregation of this large dataset by gender and racial/ethnic groups yields exciting information suggesting that a primary limitation for women is not in attrition rates; rather the largest obstacle is simply getting through the door. What has been framed as a problem of persistence is actually a problem of recruitment. Although women who matriculate in engineering are as successful in persisting as their male counterparts, they are still greatly underrepresented at all levels by any measure.

Whereas such a large quantitative dataset is very useful in understanding what is happening, qualitative follow-up work would be useful in understanding what causes these differences as well as the meanings students attach to their engineering education experience. How, for example, do Black men who matriculate in engineering navigate their educational trajectories, and how do these patterns differ from Black women? What social networks do Hispanic women in engineering rely upon, and how do these differ from those used by Asian women? What accounts for the paucity of Native American women in engineering and the relative success of Native American men compared to other men of color? How important are programs, such as First-Year Engineering or Learning Communities, in promoting retention among women, and what other structural mechanisms support women at a micro-level? Finally, future qualitative research could help elucidate institutional forms of racism and sexism, cultural stereotyping, and tokenism perceptible by those most affected by them.

Other factors that merit systematic analysis in future research include institutional variation and support networks. Persistence rates vary by institution, suggesting the need to examine qualitative differences at the institutional level of analysis. Support systems such as Women in Engineering programs and the Society of Women Engineers (SWE) play a vital role in maintaining an environment that facilitates the persistence of women in engineering. For example, in a study of female seniors in engineering by Wentling and Camacho (2008), the most frequently identified factor in assisting them in completing a degree in engineering was "involvement in campus student organizations (e.g., Women in Engineering, Society for Women in Engineering, Women in Math, Science and Engineering)" (p. 104). Such support systems also help women engineering students develop the skills and survival strategies needed to succeed in the profession as it is now, and serve as partners in improving the profession for all students. Future qualitative research could explore these factors and, in particular, look for variability by race, gender, and engineering subdisciplines.

The lens of intersectionality allows for a more comprehensive understanding of how women vary in their persistence in undergraduate engineering education. The data indicate that these issues merit greater exploration qualitatively to uncover the social conditions that promote persistence within each subgroup. Not all women or men persist equally; a critical race and gender approach allows for exploration of such nuance.

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APPENDIX A: RACIAL CLASSIFICATIONS OF MIDFIELD INSTITUTIONS

Defining racial classifications is complicated when dealing with such a rich dataset from multiple institutions. Many of the MIDFIELD institutions provided different choices for students to use when describing their race. The top row of Table A1 includes the terms that are used consistently in this research. Table A1 lists the specific choices available at each institution.

"International" or "Nonresident Aliens" are only counted as such if they have an F, M, or J visa type to visit the United States. They have (or should have) full intentions of returning to their home country after receiving a degree and are not assigned a race category in the federal Integrated Postsecondary Education Data System (IPEDS).

People with "Green Cards" are granted permanent residence in the United States. Therefore, these permanent residents are counted by IPEDS as noninternational students. Permanent residents self-select a race classification and are counted as some category other than "International" or "Nonresident Alien."

Table A1. Racial Classifications of MIDFIELD Institutions

	Asian	Black	Hispanic	Native American	Nonresident Alien	White	Missing
Florida A & M University	Asian or Pacific Islander	Black (not of Hispanic origin)	Hispanic	American Indian/ Alaskan native	Nonresident Alien	White (not of) Hispanic origin	No indication/ not reported
Florida State	Asian or Pacific Islander	Black (not of Hispanic origin)	Hispanic	American Indian/ Alaskan native	Nonresident Alien	White (not of Hispanic origin)	No indication/ not reported
University of Florida	Asian or Pacific Islander	Black (not of Hispanic origin)	Hispanic	American Indian/ Alaskan native	Nonresident Alien	White (not of Hispanic origin)	No indication/ not reported
NC State	Asian	Black	Hispanic	Native American	International	White	Missing
UNCC	Asian	American Black	Hispanic	American Indian	Nonresident Alien	Caucasian	Missing
NCAT	Asian	Black	Hispanic	Indian	Missing	White	Other
Ga Tech	Asian	African American	Hispanic	Native American	International	White	Other
Clemson	Asian/ Pacific Islander	African American	Hispanic	American Indian/ Alaskan native	Nonresident Alien	White	Unknown
Va Tech	Asian	African American	Hispanic	Native American	International	White	Missing