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College Experiences and Learning Outcomes of Women of Color Engineering Students in the United States

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ABSTRACT
Framed by Crenshaw's concept of intersectionality, we examined how women of color students self-assess their learning outcomes, compared to white women, in engineering undergraduate programs at 18 research universities in the United States. We also examined if curricular, pedagogical, and co-curricular experiences moderate the relationship between the race/ethnicity and learning outcomes of women students. We analyzed 2,104 women students from the 2016 Student Experience in the Research University (SERU) survey. We found that Asian women self-assessed lower than white women in the learning outcomes measured, and their curricular experiences moderated the relationship between race and their self-assessments of critical thinking skills. We discussed implications for future research, institutional practices, and policies that could promote the academic success of women of color in the field of engineering.

KEYWORDS
Women of color; intersectionality; learning outcomes; curricular experiences; instructional experiences; high-impact practice participation

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INTRODUCTION

Many developed countries have invested to increase the gender diversity in their science, technology, engineering, and mathematics (STEM) workforce in order to promote economic development and global leadership (National Academy of Sciences, National Academy of Engineering, & Institute of Medicine, 2011; Organization for Economic Co-operation and Development [OECD], 2010). Policy makers and scholars alike have argued that the increasing demands being placed on the STEM workforce cannot be met without women and racial/ethnic minority scientists and engineers (Crawford, Johnson, Machin, & Vignoles, 2011; National Academy of Sciences, 2007; Smith, 2011). Yet despite this national-level priority and the long-term efforts being made, women of color are still underrepresented in STEM disciplines—both at student and professional levels. Within STEM, the underrepresentation of women and minorities is much more severe in engineering, which has traditionally been considered a white, male-dominated field (Riegle-Crumb & King, 2010; Seymour & Hewitt, 1997).

National statistics indicate that higher education institutions in the United States have failed to successfully diversify STEM education. The data from the National Center for Education Statistics (NCES) in the United States indicate that in the 2014–2015 academic year the percentage of Black (4%), Hispanic (9.3%), and American-Indian/Alaska Native (0.3%) students who earned a bachelor's degree in engineering was substantially lower compared to white (63.3%) students (NCES, 2016a). Compared to other STEM disciplines, such as biological science (in which more than half of the student body are women at the undergraduate level), engineering undergraduate programs only contained approximately 20% women in the 2014–2015 academic year (NCES, 2016b). Among this 20%, only 5% were Black, 10% were Hispanic, 0.4% American-Indian/Alaska Native, and 13.6% Asian/Pacific Islander. Although Asian Americans are not an underrepresented minority in engineering compared to the U.S. Asian-American population, literature looking at higher education indicates that they have experienced model minority stereotypes (Museus, Palmer, Davis, & Maramba, 2011).

Although a substantial body of research has addressed how to increase the number of women and students of color in STEM education and the wider STEM workforce, current literature examining STEM education includes several limitations. First, researchers tend to aggregate mathematics-based fields as STEM disciplines, even though the academic disciplines have their own curricular emphases, faculty culture, policies, and practices (Ferrini-Mundy & Güçler, 2009; Lattuca, Terenzini, & Volkwein, 2006). The recruitment and retention policies, course content, pedagogical approaches, faculty mentorship and advice received by students might vary across STEM fields. Furthermore, gender disparities vary across STEM fields. While engineering, physical science, computer science, and mathematics lack women students, social science (with the exception of economics) and biological science contain more women students in their undergraduate education in the United States (Chen & Weko, 2009) and other OECD countries (OECD, 2010). Thus, it is necessary to examine disciplines individually rather than as a single homogenized STEM field.

Second, with the exception of only a small number (Espinosa, 2011; Lord et al., 2009; Lord, Layton, & Ohland, 2011; Ro & Loya, 2015), many quantitative studies on underrepresented groups in STEM focus on gender or race/ethnicity separately. In a white, male-dominated field—in particular engineering—women of color students might be more vulnerable to tokenization and microaggression due to the intersections embodied by their gender and race/ethnicity (Espinosa, 2011; Lord et al., 2009). Unless both gender and race/ethnicity are considered simultaneously, policy makers, scholars, faculty, and administrators might overlook the challenges and difficulties faced by women of color students.

The purpose of this study is to examine the racial/ethnic differences in self-reported learning outcomes with a focus on critical thinking, research, communication, and professional skills among women students in engineering undergraduate programs at 18 research universities in the United States. We chose these four learning outcomes because they are directly connected to the learning outcomes required by the Accreditation Board for Engineering and Technology (ABET, 2008). We compared the learning outcomes between women of color students (Black and other racial/ethnic women, Latina women, and Asian women separately) and their white women peers. We also examined whether women students' curricular, instructional, and co-curricular experiences moderate the relationship between their race/ethnicity and self-reported learning outcomes. We adopted the theoretical framework of intersectionality (Crenshaw, 1989, 1991) and a college impact model developed by Terenzini and Reason (2005, 2014). We analyzed the 2016 Student Experience in the Research University (SERU) survey and employed ordinary least squares (OLS) regression with clustered robust standard errors because students were nested within universities. We discussed the implications for practices and policies to improve learning outcomes and academic success of women of color in the field of engineering.

LITERATURE REVIEW

In this section we reviewed existing literature that examines the learning outcomes expected of engineering students—outcomes that are expected to meet the requirements of both the ABET Commission (2008) and the engineering workforce. We also discussed current literature looking at how engineering and science students achieve the required learning outcomes through their curricular and course learning, pedagogical and instructional experiences, and co-curricular participation (e.g., undergraduate research or internship). Finally, we reviewed current literature on gender and racial/ethnic differences in learning outcomes through the lens of intersectionality.

Engineering Learning Outcomes and Gender Differences

An interest and competency in mathematics and science are crucial prerequisites if students are to gain access to, and persistence in, STEM majors. Research indicates that students who exhibit lower abilities in mathematics and science are less likely to choose and persist in STEM fields (Adelman, 1999, 2006). Women students, however, are not subject to these findings because women actually outperform men in mathematics in postsecondary education (Riegle-Crumb & King, 2010; Wang, Eccles, & Kenny, 2013). Performance in mathematics also differs by race (McGee & Martin, 2011). Research has shown that racial/ethnic minority students are less likely to choose STEM majors because of lower proficiencies in mathematics and science (Oakes, 2003). The mathematics and science abilities of these students appear to be influenced by the low quality of the schools they attend, a lack of direction and advice from teachers and school counselors in the fields of mathematics and science, as well as other—parental, economic, social, and cultural—factors (Harper, 2010; Oakes, 2003).

In addition to proficiency in mathematics and science, the critical thinking, problem-solving, and design skills of engineering students are also considered to be core learning outcomes. In engineering fields, design is a critical skill that builds upon a foundation of technical knowledge and skilled problem-solving (ABET, 2008). Researchers found that, after controlling for race, men students tend to report higher levels of critical thinking, problem-solving, and design skills than women in engineering undergraduate programs (Atman et al., 2010; Besterfield-Sacre, Moreno, Shuman, & Atman, 2001). Ro and Loya (2015) also found the negative impact of being a woman on self-reported design skills, but the negative impact of gender is greater for Black students than for their white counterparts.

Engineering education providers and the wider workforce emphasize the need for engineering students to possess professional skills, such as communicating effectively and working in teams. Engineering work often entails collaboration with colleagues who do not possess engineering or technical knowledge, and thus effective communication and team work are essential (Anderson, Courter, McGlamery, Nathans-Kelly, & Nicometo, 2010). In total, 1,622 engineering employers expressed the need for effective communication, teamwork, and professional ethics—along with foundational skills in mathematics and science, and problem-solving skills—as the most important skills looked for in job applicants (Lattuca et al., 2006). In other studies measuring students' own perception of the "importance" of such professional skills, researchers found gender differences. Analyzing 1,723 engineering students, Besterfield-Sacre et al. (2001) found that women reported a higher value for communication skills and the importance of interpersonal sources for information gathering than men—a finding further supported in a study conducted by Atman et al. (2010). Analyzing 5,400 engineering students from 21 institutions, Atman et al. (2010) found that women students attached greater importance to professional and interpersonal skills than men. Ro and Loya (2015) found a similar pattern, with women self-reporting higher than men regarding communication, teamwork, and leadership skills, although they found that Black women self-assessed lower in communication skills than white men and white women.

College Experiences and Gender Differences

Policy makers and scholars have argued for engineering programs to design and implement educational components—such as curricular content, instructional methods, and co-curricular activities—that are more attractive to, and supportive of, women students. Researchers have found empirical evidence to support this argument. For instance, curricular emphasis was the most significant factor related to engineering major choice (Zafar, 2009) and learning outcomes (Ro & Knight, 2016) for women. Women students seem to be more attracted by, and persist in, industrial and general engineering programs because their curricula incorporate broader societal contexts and issues (Brawner, Camacho, Lord, Long, & Ohland, 2012; Knight et al., 2012). Furthermore, Fuselier and Jackson (2010) concluded that the science curriculum should be more gender inclusive by incorporating social science and humanities perspectives.

In addition to the course content and emphasis, Pascarella and Terenzini's (2005) comprehensive summary of higher education literature indicates that instructional approaches work differently for men and women. Among a variety of learning and teaching methods (e.g., collaborative/cooperative learning, problem-, project-based learning from Prince & Felder, 2006), in this section we focused on active (Felder, Brent, & Prince, 2011; Prince & Felder, 2006) and inclusive instructional methods, and how such methods affect learning outcomes differently for women and men. In comparison to large lecture classes, student-centered learning appears to work for both men and women students. Indeed, some studies show that student-centered pedagogies increase women students' feelings of acceptance, positive expectations, and self-efficacy (Campbell, Jolly, Hoey, & Perlman, 2002; Johnson & Johnson, 1983; Pawley, 2004). Although the effects of student-centered and active learning pedagogies on the learning outcomes of engineering students has been well documented (Prince & Felder, 2006), inclusive pedagogies are relatively new in the engineering education field. While some researchers in higher education did not discuss engineering and science fields specifically (Quaye & Harper, 2007), they emphasized the accountability of all faculties when incorporating culturally inclusive curricula and pedagogies for students of color.

Engineering students not only learn in, but also beyond, the classroom. Among the many learning opportunities that exist outside of the classroom, we focus mainly on literature discussing the formal, structured co-curricular programs that engineering students often complete. The Association of American Colleges and Universities (AAC&U) published George Kuh's (2008) book, which addresses the use of high-impact practices (HIPs) as a means by which to enhance student engagement and learning. HIPs include first-year seminars and experiences, learning communities, writing-intensive courses, collaborative assignments and projects, undergraduate research, diversity/global learning, service, community-based learning, internships, capstone courses and projects (Kuh, 2008). Higher education researchers found considerable empirical evidence that supports the benefits of HIPs to the learning outcomes of college students. Benefits were seen in areas such as a grade point average (GPA), deep learning, gains in general education, practical competence, and personal/social development for minority students (Finley & McNair, 2013; Gipson & Mitchell, 2017; Kilgo, Sheets, & Pascarella, 2015).

The effect of HIP participation also appears to vary by race/ethnicity, socioeconomic status (SES), and gender. For example, Huber (2010) found that Latina/o and low SES students had greater improvements in timely graduation with increased HIP participation compared to those who did not participate in HIPs. In the engineering context, Ro and Knight (2016) found that regarding fundamental skills in mathematics and science, women self-reported lower than men, while there is no gender difference in contextual competence and communication skills. Contextual competence is an engineer's ability to appreciate the constraints and impacts of social, cultural, environmental, political, and other contexts on engineering solutions (Ro, Merson, Terenzini, & Lattuca, 2015). Ro and Knight (2016) found that women students who involved more actively in non-engineering clubs (e.g., student government, sororities) had higher self-assessments of fundamental skills, contextual competence, and communication skills than men.

Intersectionality between Gender and Race

A considerable amount of academic research and numerous policy studies have addressed the issue of gender disparity and equity in STEM education and the global STEM workforce (Chubin, May, & Babco, 2005; OECD, 2010). Drawing upon the feminist framework of intersectionality, we emphasize the importance of understanding the college experiences of women of color and their learning outcomes in engineering programs. The intersectional perspective is an extension of critical race theory and has also been referred to as critical race feminism (Delgado & Stefancic, 2017). Crenshaw (1989) used the term intersectionality to describe how Black women can experience discrimination in different ways from white women or men of color, because of the intersection of gender and race. By revealing disparities in college experiences and learning outcomes among women of color compared to white women, we recognize that social identity, gender, and race or ethnicity cannot be reduced to any single category. Rather, these categories mutually construct one another (Collins, 1986) and together reinforce the exclusions, microaggressions, and discriminations experienced by women of color students in engineering fields (Ong, Wright, Espinosa, & Orfield, 2011).

Most existing literature using quantitative data fails to explain the college experiences and learning outcomes of women of color students because of its focus on race or sex as "single, distinct factors" (Hankivsky, 2014, p. 2). Thus, this approach does not fully uncover the inequities that are "the outcome of intersections of different social locations, power relations and experiences" (Hankivsky, 2014, p. 2). Specifically, in the engineering context, Lord et al. (2009) contend that engineering education literature that focuses on either gender or race in isolation necessarily overgeneralizes their effects and thus make women of color invisible. Although the learning outcomes of engineering students in the United States have been well documented (Lattuca et al., 2006; Lattuca, Terenzini, Knight, & Ro, 2014), the literature often overlooks the potential racial/ethnic gaps in such learning outcomes among women engineering students. Women of color students might not self-assess their skillsets in the same way, even after accounting for other demographic and pre-college characteristics and college experiences. Furthermore, curricular, pedagogical, and co-curricular experiences might work differently between white women and women of color.

CONCEPTUAL FRAMEWORK

In order to better understand how being a woman of color relates to the self-assessment of learning outcomes compared to white women, this study draws upon two theoretical frameworks: Crenshaw's (1989, 1991) concept of intersectionality; and Terenzini and Reason's (2005, 2014) college impact model. This study also seeks to discover if college experiences, differentiated by race, influence women students' self-assessed learning outcomes.

Terenzini and Reason's (2005, 2014) model (see Figure 1) has been used to examine the learning outcomes of engineering students by incorporating their pre-college characteristics and college experiences, peer environment on campus, and institutional characteristics (Knight, 2014; Lattuca et al., 2014; Ro, Terenzini, & Yin, 2013). This study focuses on the relationship between the students' race and other pre-college characteristics, college experiences (curricular, pedagogical, and co-curricular), and learning outcomes (self-assessed critical thinking, communication, professional, and research skills). Figure 2 describes the conceptual framework of this study, drawing upon Terenzini and Reason's (2005, 2014) conceptual model.

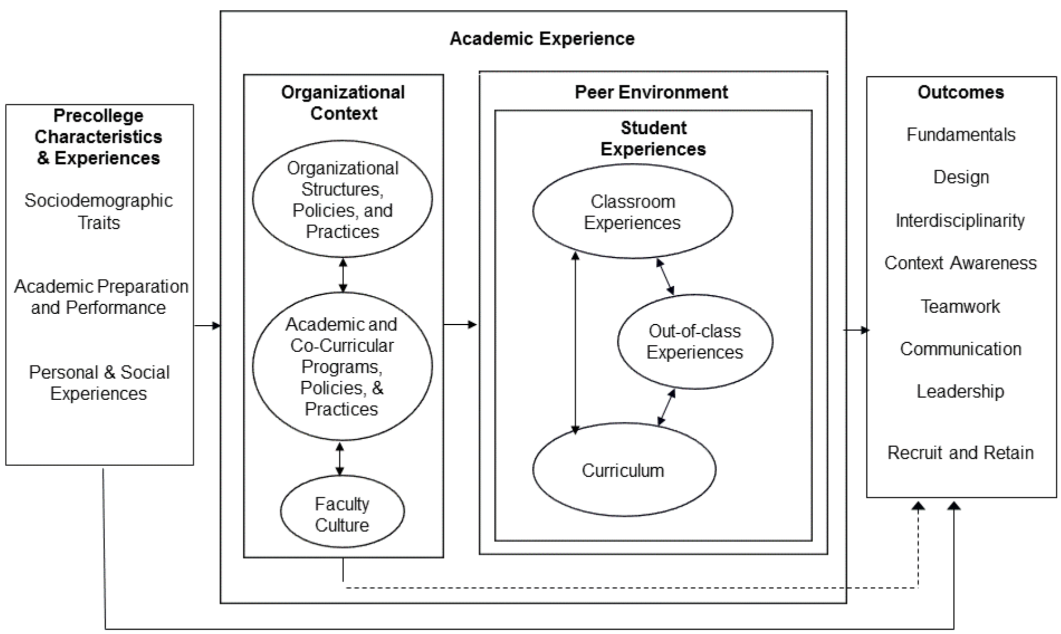

Figure 1. A comprehensive college impact model of influences on engineering student learning outcomes (revised from Terenzini & Reason, 2005, 2014).

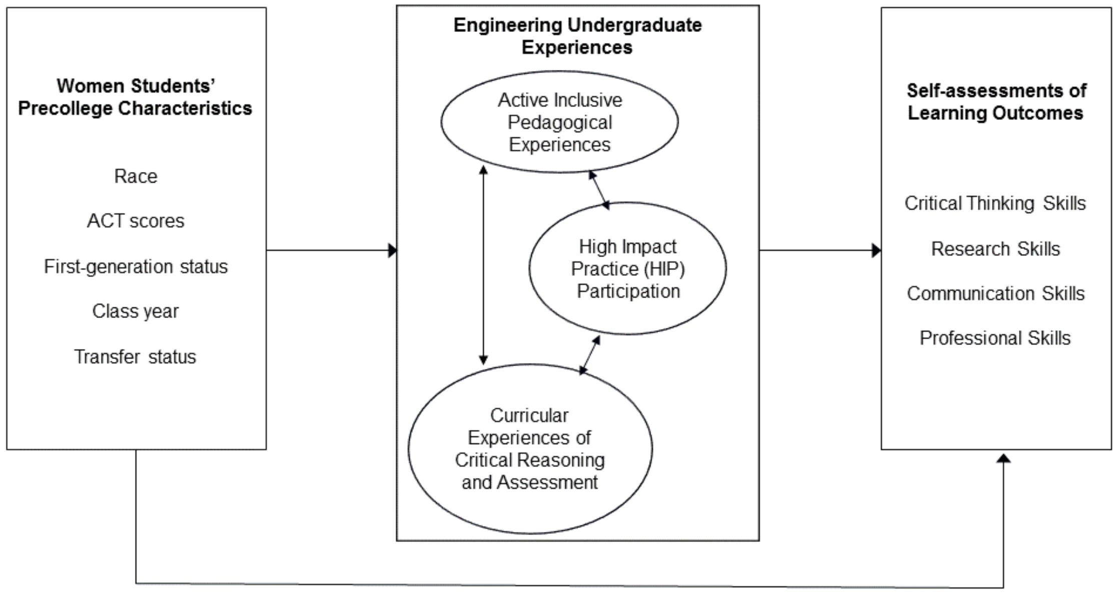

Figure 2. Conceptual framework of this study (adapted from Terenzini & Reason, 2005, 2014).

Terenzini and Reason (2005, 2014) provided a comprehensive framework via which to study the effect college has on students and to consider what students themselves bring to the college experience, such as gender and race. To this framework, the study adds a further angle of student social identity, namely the intersection of race and gender. This intersectional approach is critical to the study of engineering education, because women of color students, given their disadvantaged identities, could have different experiences and different learning outcomes compared to white men, white women, and men of color.

Using this intersectional approach, researchers have studied women of color students' identity as scientists (Carlone & Johnson, 2007; Ceglie, 2011), as well as their enrollment, persistence, and degree completion in the engineering and science field (Espinosa, 2011; Lord et al., 2009; Ohland et al., 2011). Furthermore, this approach has allowed researchers to assess their sense of belonging in the field of science and engineering (Johnson, 2007a, 2007b; Seymour & Hewitt, 1997). Yet only a few studies have examined the differences in learning outcomes between women of color and their white peers (Ro & Loya, 2015). Therefore, it is critical to examine if there are any racial/ethnic disparities in women students' self-reported learning outcomes, as well as how their college experiences might differently affect any such disparity, taking their race into account.

Research Questions
The research questions for this study are: (1) Do women of color engineering students self-assess lower or higher than their white women peers in learning outcomes? (2) To what extent do the curricular, instructional, and co-curricular experiences moderate the relationship between women students' race/ethnicity and self-reported learning outcomes?

METHODS

Data

In order to study the college experiences and learning outcomes of women of color engineering students, we used a multi-institutional data set, namely the 2016 Student Experience in the Research University (SERU) survey. The SERU survey consortium was formed in 2008 with a view to an academic and policy research collaboration with research-intensive universities based at the University of California-Berkeley in order to illustrate the experiences of undergraduates on campus and to promote a culture of institutional self-improvement. The SERU instrument measured academic and research engagement, academic and personal development, campus climate for diversity, and time allocation. The survey also asked students a range of questions concerning background and personal characteristics, their educational and occupational plans following graduation, and financial concerns. All degree-seeking undergraduates who enrolled in the 2015 autumn and 2016 spring terms are eligible to participate in the 2016 SERU survey. In the spring of 2016, the total number of responses captured by the data set was 101,280 students across 18 participating universities. The 2016 SERU study was conducted via an online survey and the institutional-level response rates varied from 9.4% to 33.1%.

Sample

The analytic sample consisted of 2,104 engineering women students who attended 18 research universities in 2016. The sample comprised 37% Asian women, 14% Latina women, and 9% Black and other racial/ethnic women (the other racial/ethnic category included American-Indian or Alaska Native, Native Hawaiian or Pacific Islander, and multiracial), and 40% white women. We combined Black and other racial/ethnic groups because the 2016 SERU data contained only a small number of Black and other racial/ethnic women students in engineering majors. Within this sample, 15% of the survey respondents were first-generation college students (neither parents attended any college), 3% were transfer students, 5% were first-year students, 15% were in their second year of study, 26% were in their third year, and 54% were in their fourth or subsequent years.

We employed listwise deletion for those respondents for whom there were missing values in the variables of interest. Listwise deletion yields (approximately) unbiased coefficient estimates even when data are not missing at random (Little, 1992). In the final models that used listwise deletion, the sample sizes were 2,104 students studying engineering majors at 18 research universities. Table 1 shows descriptive statistics for this sample.

Table 1. Descriptive statistics (N=2,104).

Race Variables	Mean	Standard Deviation	Minimum	Maximum
Race variables				
White	0.40	0.49	0.00	1.00
Latina	0.14	0.34	0.00	1.00
Asian	0.37	0.48	0.00	1.00
Black/Other	0.09	0.28	0.00	1.00
College experiences variables				
Active and inclusive pedagogies	0.05	1.00	-4.31	1.85
Curricular experiences of critical reasoning and assessment	0.00	0.99	-2.94	1.54
High-Impact Practices (HIPs)	0.20	0.96	-1.56	2.33
Outcomes				
Critical thinking skills	0.04	0.98	-4.14	1.84
Communication skills	0.04	1.00	-4.00	1.96
Professional skills	0.04	0.99	-3.73	1.71
Research skills	0.05	0.98	-3.45	2.02
Control Variables				
ACT scores	0.01	0.98	-3.31	1.72
First-generation student	0.15	0.36	0.00	1.00
First-year student	0.05	0.21	0.00	1.00
Second-year student	0.15	0.36	0.00	1.00
Junior	0.26	0.44	0.00	1.00
Senior	0.54	0.50	0.00	1.00
Transfer student	0.03	0.18	0.00	1.00
Low SES	0.28	0.45	0.00	1.00
Middle SES	0.41	0.49	0.00	1.00
High SES	0.31	0.46	0.00	1.00
Retrospective pretests				
Critical thinking skills	-0.05	0.98	-3.48	2.60
Communication skills	-0.04	0.98	-3.16	2.56
Professional skills	-0.04	0.98	-2.80	2.50
Research skills	-0.04	0.98	-2.53	2.86

Variables

Dependent variable

We chose four learning outcomes from the 2016 SERU survey instrument: (1) critical thinking skills (three items, Cronbach's α = .75); (2) research skills (two items, Cronbach's α = .65); (3) communication skills (three items, Cronbach's α = .75); and (4) professional skills (two items, Cronbach's α = .77). First, we created a standardized scale of *critical thinking skills*, using three items to represent students' self-reported gains in analytical and critical thinking skills, quantitative, mathematical, and statistical skills, and reading and comprehending academic materials. Second, we constructed a standardized scale of the self-assessment of their *research skills*, using two items to represent their ability to design, conduct, and evaluate research, as well as their library and online information research skills. Third, we created a standardized scale of self-assessment in terms of *communication skills* with the use of three items: their ability to be clear and effective when writing; oral communication skills; and their ability to prepare and make a presentation. Lastly, we created a standardized scale of *professional skills*, using two items to measure leadership skills and interpersonal and teamwork skills. All individual items have 6-point scales (ranging from 1 = very poor to 6 = excellent). The range of the correlations among the four learning outcomes are from 0.55 to 0.66. The SERU survey instrument adopts "a retrospective pretest and a current posttest (that is, a 'then' and 'now') design" (Douglass, Thomson, & Zhao, 2012, p. 324). The SERU survey asked students to assess their level of learning outcomes at two points—'when they started at the university' and 'now'. To measure these four learning outcomes, we used the students' self-reported learning outcomes as "now."

Independent variables

Our primary independent variable was the race/ethnicity of women students. All race/ethnicity variables are dummy coded, and the dummy-coded variables for white (*White*), Hispanic or Latino (*Latina*), Asian (*Asian*), and Black or African American and other race/ethnicities, including (*Black/Other*). Building upon our literature review and the theoretical framework of Terenzini and Reason (2005, 2014), we created three variables to assess students' college experiences in engineering. These variables are: *active and inclusive experiences of pedagogy*; *curricular experiences of critical reasoning and assessment*; and *HIP participation*. First, we created a standardized scale of *active and inclusive experiences of pedagogy* by using seven items (Cronbach's α = .86). Students reported how often they experienced: open channels of communication between faculty and student regarding student needs, concerns, and suggestions; students treated equitably and fairly by the faculty; clear explanation of what constitutes plagiarism; faculty providing prompt and useful feedback on student work; faculty maintaining respectful interactions in classes; opportunities for active participation in both lectures and discussion classes; and an instructor who increases your enthusiasm for the subject. The response scale for these items ranged from 1 = never to 6 = very often.

Second, we created a standardized scale to measure *curricular experiences of critical reasoning and assessment* using four items (Cronbach's α = .85). In the four questions, students were asked to answer how often they had done the following in their course within their academic major: used facts and examples to support their viewpoint; incorporated ideas or concepts from different courses when completing assignments; examined how others gathered and interpreted data, and assessed the soundness of their conclusions; and reconsidered their own position on a topic after assessing the arguments of others. The SERU research team developed the items to reflect Bloom's (1956) taxonomy of educational objectives. The four items asked students to report their course experiences in their academic majors to address higher-order thinking skills (Chatman, 2011). These items ranged from 1 = never to 6 = very often. Lastly, in order to measure the degree of HIP participation, we created a continuous variable by summing up the "yes" responses of the following eight categories: capstone or thesis projects; internship, practicum, or field experiences; first-year seminar; academic learning community; service learning; study abroad; undergraduate research; and intensive writing (minimum score = 0 maximum score = 8).

Control variables

The covariates were students' self-reported social class (dummy-coded variables for three categories with middle class as the reference group); first-generation college status (0 = non-first-generation college student, 1 = neither parents attended any college); class level (dummy-coded variables for four categories with senior as the referent group); and transfer status (0 = non-transfer student, 1 = transfer student). We included the retrospective pretest measures as covariates: (1) critical thinking skills (three items, Cronbach's α = .75); (2) research skills (two items, Cronbach's α = .68); (3) communication skills (three items, Cronbach's α = .75); and (4) professional skills (two items, Cronbach's α = .74). We further included students' self-reported American College Testing (ACT) scores to represent precollege academic achievement; we converted Scholastic Assessment Test (SAT) scores to ACT scores for students who took only the SAT, and the ACT scores were used for those who took both the ACT and SAT.

Analytical Methods

We ran a series of ordinary least squares (OLS) regressions in order to estimate the effect of women students' race/ethnicity and college experiences on the four continuous learning outcomes. We used clustered robust standard errors, because the students were nested within universities. We standardized all continuous measures with a mean of zero and a standard deviation of one to facilitate interpretation of effect sizes.

Some intersectional studies use a within-group design, for example, studying Black women only, whereas other intersectional studies use a between-groups design by comparing Black women to other women or Black men (Else-Quest & Hyde, 2016). While within-group focus allows for an intersectional approach to a phenomenon by specifying a particular interactional category, group, or location, such designs are less informative when attempting to compare intersecting categories because of the exclusion of other relevant social categories (Else-Quest & Hyde, 2016). Rather than choosing only a racial/ethnic group or analyzing each racial/ethnic group separately, we chose a between-groups design in order to test racial/ethnic group comparisons among women engineering students.

Limitations

The potential limitations in the use of the SERU data need to be addressed. First, the analysis only included students attending research-intensive universities in the United States, and thus findings should not be generalized to other U.S. higher education institutions. Second, we acknowledged the argument of using students' self-reported measures as indicators of students' learning and its potential limitations in terms of validity (Bowman, 2010; Porter, 2011). Given that the SERU study uses the retrospective posttest design, we at least controlled for the pretest measure of the learning outcomes.

Third, we combined Black women students and other racial/ethnic minority groups because of the small sample size of Black students (Black = 46, American-Indian or Alaska Native = 5, Native Hawaiian or Pacific Islander = 8, and Multiracial = 125). We acknowledged that different groups of racial/ethnic minority women students self-assess their learning experiences and outcomes differently. Thus, interpretations of the Black/Other group of students need to be made with caution.

Fourth, we acknowledged the limitation of the continuous variable that simply sums up the number of HIPs in which the student participated. The differences in the aggregate-level of HIPs do not indicate which specific programs include more racial/ethnic minority students, first-generation, or transfer students, given that "while research shows that participation benefits all students, not all students take part" (Kinzie, 2012, para. 9). Analyzing the National Survey of Student Engagement data, Kinzie (2012) reported that African-American and Latino/a students participated in internships less frequently than white students. We addressed future research areas on disaggregation by race/ethnicity in the HIP participation in the discussion.

FINDINGS

Main Effects

The results for students' race/ethnicity and college experiences predicting students' self-reported learning outcomes appear in Table 2 (*Critical Thinking Skills*); Table 3 (*Communication Skills*); Table 4 (*Professional Skills*); and Table 5 (*Research Skills*).

Critical thinking skills

Table 2 indicates that Asian and Black/Other women students self-reported critical thinking skills lower than white women, even after controlling for their ACT scores and other covariates. Being an Asian woman in engineering, net of other control variables, is associated with 0.41 standard deviation decrease in their self-assessed critical thinking skills. Three college experience measures have significant and positive effects on women engineering students' critical thinking skills regardless of race/ethnicity.

Table 2. The effects of race and college experiences on students' self-assessment in critical thinking skill (N=2,104).

	Model 1	Model 2	Model 3	Model 4
Race (vs. White)				
Hispanic	-0.018	-0.012	-0.016	-0.009
	(0.05)	(0.05)	(0.05)	(0.05)
Asian	-0.414***	-0.412***	-0.413***	-0.406***
	(0.04)	(0.04)	(0.04)	(0.04)
Black/Other	-0.193*	-0.187*	-0.191*	-0.164
	(0.08)	(0.07)	(0.07)	(0.09)
College experiences				
Active and inclusive pedagogies	0.197***	0.212***	0.197***	0.198***
	(0.02)	(0.03)	(0.02)	(0.02)
Curricular experiences of critical reasoning and assessment	0.162***	0.163***	0.216***	0.162***
	(0.03)	(0.03)	(0.03)	(0.03)
HIP participation	0.082**	0.081**	0.082**	0.106**
	(0.02)	(0.02)	(0.02)	(0.03)
Interaction terms between race and curriculum				
Hispanic * Active and inclusive pedagogies		0.040		
		(0.05)		
Asian * Active and inclusive pedagogies		-0.036		
		(0.05)		
Black/Other * Active and inclusive pedagogies		-0.069		
		(0.05)		
Hispanic * Curricular experiences of critical reasoning and assessment			-0.064	
			(0.06)	
Asian * Curricular experiences of critical reasoning and assessment			-0.090*	
			(0.04)	
Black/Other * Curricular experiences of critical reasoning and assessment			-0.087	
			(0.08)	
Hispanic * HIP participation				-0.063
				(0.04)
Asian * HIP participation				-0.016
				(0.03)

Black/Other * HIP participation				-0.094
				(0.08)
Intercept	0.349***	0.345***	0.346***	0.339***
	(0.05)	(0.05)	(0.05)	(0.05)
R-squared	0.424	0.425	0.426	0.425

Note: Ordinary least squares (OLS) regression analyses were used to predict the students' self-assessment of critical thinking skills. All other continuous variables were standardized with a mean of zero and a standard deviation of one. Control variables were students' self-reported social class, ACT scores, first-generation college status, transfer status, class level, and retrospective pretest of critical thinking skills. * p<.10. ** p<.05. *** p<.01.

Furthermore, the extent to which being an Asian woman affects self-assessment of critical thinking skills is dependent upon the curricular experiences of critical reasoning and assessment. Each unit increase in the curricular experiences of critical reasoning and assessment on average leads to 0.09 lower self-assessment of critical thinking for Asian women students than it does for white women. While the slope for white women is 0.22, the slope for Asian women is 0.13 (the sum of 0.22 and –0.09). Figure 3 indicates that white women reported greater critical thinking skills than Asian women when they increased their exposure to curricula offering critical reasoning and assessment.

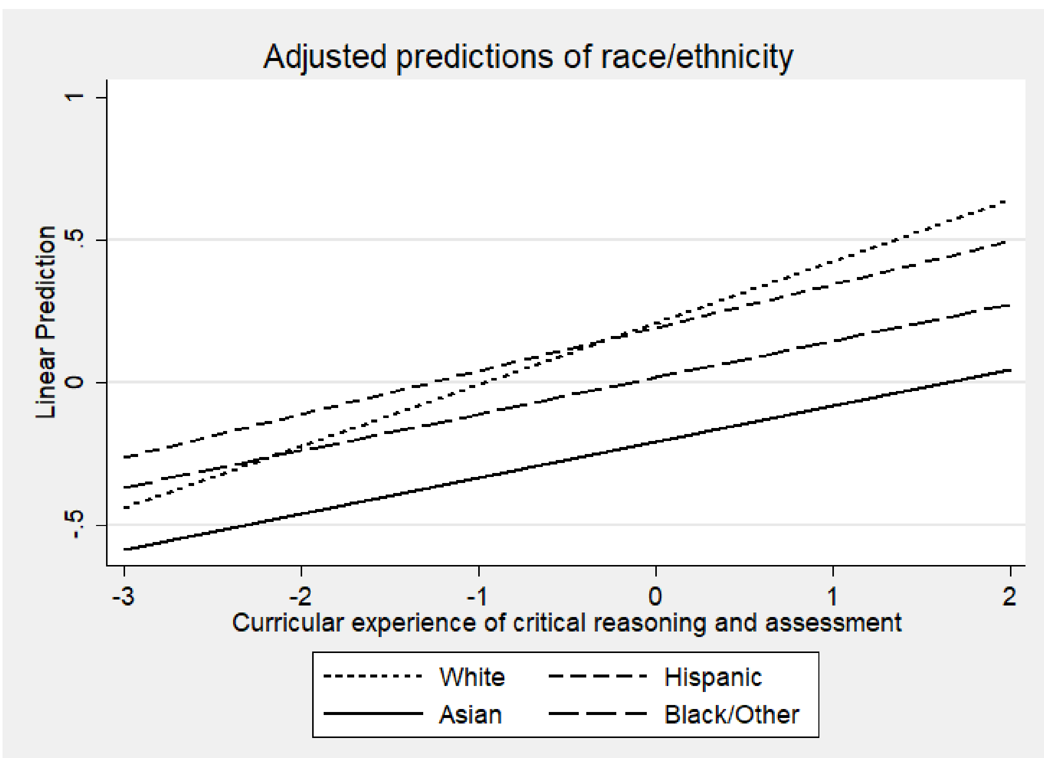

Figure 3. Predicted values between students' race/ethnicity and critical thinking skills by curricular experiences.

Research skills
Asian women engineering students self-reported lower than white women regarding their research skills (Table 3), their college experiences having significant positive effects on their self-reported research skills after controlling for other variables in the regression model.

Table 3. The effects of race and college experiences on students' self-assessment in research skills (N=2,104).

	Model 1	Model 2	Model 3	Model 4
Race (vs. White)				
Hispanic	-0.025	-0.014	-0.023	-0.023
	(0.07)	(0.07)	(0.07)	(0.07)
Asian	-0.131*	-0.122*	-0.132*	-0.125*
	(0.05)	(0.05)	(0.05)	(0.05)
Black and Other	-0.031	-0.015	-0.03	-0.001
	(0.06)	(0.05)	(0.06)	(0.06)
College experiences				
Active and inclusive pedagogies	0.130***	0.174***	0.130***	0.130***
	(0.02)	(0.03)	(0.02)	(0.02)
Curricular experiences of critical reasoning and assessment	0.176***	0.177***	0.197***	0.176***
	(0.02)	(0.02)	(0.03)	(0.02)
HIP participation	0.132***	0.132***	0.131***	0.146***
	(0.02)	(0.02)	(0.02)	(0.02)
Interaction terms between race and curriculum				
Hispanic * Active and inclusive pedagogies		-0.048		
		(0.05)		
Asian * Active and inclusive pedagogies		-0.059		
		(0.04)		
Black and Other * Active and inclusive pedagogies		-0.159**		
		(0.05)		
Hispanic * Curricular experiences of critical reasoning and assessment			0.030	
			(0.06)	
Asian * Curricular experiences of critical reasoning and assessment			-0.049	
			(0.04)	
Black and Other * Curricular experiences of critical reasoning and assessment			-0.055	
			(0.07)	

Hispanic * HIP participation				0.036
				(0.05)
Asian * HIP participation				-0.025
				(0.03)
Black and Other * HIP participation				-0.1
				(0.06)
Intercept	0.262***	0.251**	0.262***	0.256**
	(0.06)	(0.06)	(0.06)	(0.07)
R-squared	0.455	0.457	0.456	0.456

Note: OLS regression analyses were used to predict the students' self-assessment of research skills. All other continuous variables were standardized with a mean of zero and a standard deviation of one. Control variables were students' self-reported social class, ACT scores, first-generation college status, transfer status, class level, and retrospective pretest of research skills. * p<.10. ** p<.05. *** p<.01.

Interestingly, in self-reported assessment of research skills, as shown in Figure 4, the effect of active and inclusive pedagogies appears to be contingent on the students' race/ethnicity, particularly for Black/Other students. The figure shows that each unit increase in active and inclusive pedagogies on average leads to a 0.16 lower result in the self-assessment of research skills for Black/Other women students than it does for white women students. Although the result is statistically significant, we acknowledge that the slope of Black/Other women students' active and inclusive pedagogies is almost zero (Figure 4).

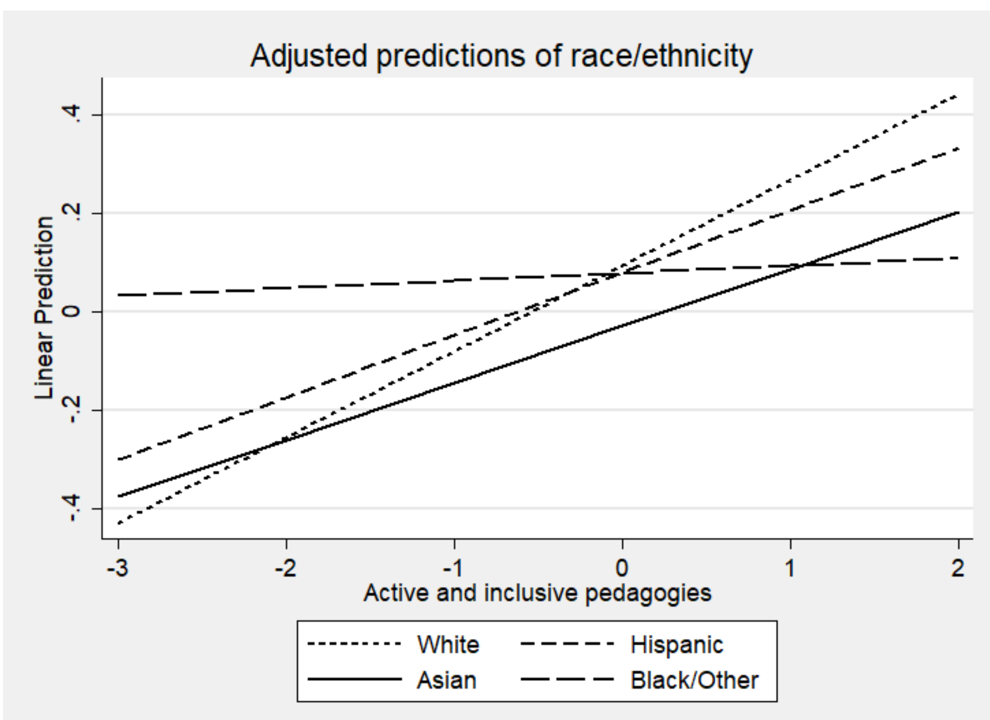

Figure 4. Predicted values between students' race/ethnicity and research skills by active and inclusive pedagogies.

Communication skills and professional skills
After controlling for the covariates, Asian women engineering students self-reported lower than white women with regard to their self-reported communication skills (Table 4) and professional skills (Table 5). The three college experiences have significant and positive effects on their self-reported communication skills and professional skills even after controlling for the students' race, retrospective pretests of learning, and pre-college characteristics. We did not find any interaction effects between race/ethnicity and college experiences in self-reported communication skills and professional skills.

Table 4. The effects of race and college experiences on students' self-assessment in communication skills (N=2,104).

	Model 1	Model 2	Model 3	Model 4
Race (vs. White)				
Hispanic	0.072	0.079	0.072	0.066
	(0.04)	(0.04)	(0.04)	(0.04)
Asian	-0.211***	-0.209***	-0.214***	-0.218***
	(0.04)	(0.04)	(0.04)	(0.04)
Black and Other	0.025	0.031	0.025	0.03
	(0.05)	(0.05)	(0.05)	(0.06)
College experiences				
Active and inclusive pedagogies	0.153***	0.172***	0.153***	0.152***
	(0.02)	(0.03)	(0.02)	(0.02)
Curricular experiences of critical reasoning and assessment	0.171***	0.171***	0.165***	0.170***
	(0.02)	(0.02)	(0.03)	(0.02)
HIP participation	0.129***	0.129***	0.129***	0.117***
	(0.02)	(0.01)	(0.01)	(0.03)
Interaction terms between race and curriculum				
Hispanic * Active and inclusive pedagogies		0.030		
		(0.05)		
Asian * Active and inclusive pedagogies		-0.050		
		(0.04)		
Black and Other * Active and inclusive pedagogies		-0.041		
		(0.05)		
Hispanic * Curricular experiences of critical reasoning and assessment			0.086	

			(0.05)	
Asian * Curricular experiences of critical reasoning and assessment			-0.02	
			(0.03)	
Black and Other * Curricular experiences of critical reasoning and assessment			0.019	
			(0.06)	
Hispanic * HIP participation				0.035
				(0.04)
Asian * HIP participation				0.027
				(0.04)
Black and Other * HIP participation				-0.018
				(0.03)
Intercept	0.242***	0.237***	0.245***	0.247***
	(0.04)	(0.04)	(0.04)	(0.04)
R-squared	0.449	0.450	0.450	0.449

Note: OLS regression analyses were used to predict the students' self-assessment of communication skills. All other continuous variables were standardized with a mean of zero and a standard deviation of one. Control variables were students' self-reported social class, ACT scores, first-generation college status, transfer status, class level, and retrospective pretest of communication skills. * p<.10. ** p<.05. *** p<.01.

Table 5. The effects of race and college experiences on students' self-assessment in professional skills (N=2,104).

	Model 1	Model 2	Model 3	Model 4
Race (vs. White)				
Hispanic	0.009	0.012	0.01	0.001
	(0.05)	(0.05)	(0.05)	(0.05)
Asian	-0.180***	-0.178***	-0.180***	-0.188***
	(0.03)	(0.03)	(0.03)	(0.03)
Black/Other	-0.082	-0.079	-0.082	-0.087
	(0.06)	(0.06)	(0.06)	(0.06)
College experiences				
Active and inclusive pedagogies	0.084***	0.098***	0.084***	0.084***
	(0.02)	(0.02)	(0.02)	(0.02)
Curricular experiences of critical reasoning and assessment	0.156***	0.156***	0.162***	0.156***

	(0.02)	(0.02)	(0.03)	(0.02)
HIP participation	0.151***	0.151***	0.150***	0.132***
	(0.02)	(0.02)	(0.02)	(0.03)
Interaction terms between race and curriculum				
Hispanic * Active and inclusive pedagogies		-0.018		
		(0.06)		
Asian * Active and inclusive pedagogies		-0.022		
		(0.03)		
Black/Other * Active and inclusive pedagogies		-0.024		
		(0.05)		
Hispanic * Curricular experiences of critical reasoning and assessment			0.008	
			(0.04)	
Asian * Curricular experiences of critical reasoning and assessment			-0.008	
			(0.03)	
Black/Other * Curricular experiences of critical reasoning and assessment			-0.039	
			(0.04)	
Hispanic * HIP participation				0.065
				(0.04)
Asian * HIP participation				0.022
				(0.03)
Black/Other * HIP participation				0.012
				(0.040)
Intercept	0.214***	0.211***	0.214***	0.222***
	(0.04)	(0.04)	(0.04)	(0.04)
R-squared	0.397	0.397	0.397	0.397

Note: OLS regression analyses were used to predict the students' self-assessment of professional skills. All other continuous variables were standardized with a mean of zero and a standard deviation of one. Control variables were students' self-reported social class, ACT scores, first-generation college status, transfer status, class level, and retrospective pretest of professional skills. * p<.10. ** p<.05. *** p<.01.

DISCUSSION AND IMPLICATIONS

This discussion is structured by the two research questions that were examined. First, we asked if women of color engineering students report lower or higher in their learning outcomes than white women. We found that the self-assessments of learning outcomes vary with race among women students in engineering undergraduate programs at 18 research universities from the SERU data. Asian women students reported lower than white women across the four learning outcomes. Given that Asian students are not an underrepresented minority in the engineering field, they are often excluded in studies focusing on racial inequalities in STEM (Museus et al., 2011). Asian women's experiences in STEM fields should be studied, regarding them also as "outsiders" at the advanced levels of leadership in STEM academia, industry, and government (Ong et al., 2011). Most studies on Asian students in STEM fields reveal experiences of microaggressions, biases, and model minority stereotypes (McGee, Thakore, & LaBlance, 2017). However, researchers pay less attention to the gap in self-assessed learning outcomes between Asian and other racial groups. As Ro and Loya (2015) found, Asian men students reported several of their learning outcomes lower than white men. In this current study, we also revealed Asian women's lower self-assessments of learning outcomes even after controlling for their pre-college academic achievement (e.g., ACT scores and high school GPAs) compared to white women. More research is needed to better understand how and why Asian women engineering students estimate their skills, knowledge, and learning outcomes lower than their white counterparts, and how administrators and faculties can increase their self-assessment levels.

While we hypothesized that Black/Other and Latina students report lower than white women considering the lack of gender compositional diversity and their intersectional identities in engineering, we found no significant relationship between Latina women and white women in their self-assessments of learning outcomes. Black/Other women reported lower than white women in critical thinking skills, but not the other three learning outcomes. Existing literature demonstrated that Latina and Black women's academic preparedness (particularly in mathematics and science) is lower due to a lack of resources (McGee & Martin, 2011). However, Latina or Black/Other women students' self-assessments of learning outcomes do not differ from white women when they persist in engineering programs. More qualitative research needs to be conducted in order to investigate the more nuanced processes at work—how Latina, Black, and other racial/ethnic minority women develop their self-assessments of learning outcomes through college experiences.

Furthermore, as we discussed in the section on limitations, more national studies oversampling racial and ethnic minorities are required. Researchers can then examine Black women or other racial/ethnic minority women students' college experiences and learning outcomes separately. When research institutes or policymakers collect their data, they could include more Historically Black Colleges and Universities (HBCUs), Minority Serving Institutions (MSIs), and Hispanic-Serving Institutions (HSIs). In this way, they could include more engineering students from racial/ethnic minorities. Without specific, focused efforts, Black, multiracial, or other racial/ethnic minority students' voices and experiences will continue to be overlooked in quantitative studies.

In addition to race, the main independent variables of this study were the three college experiences: active and inclusive learning pedagogies; curricular experiences of critical reasoning and assessment; and HIPs. The main effect model reveals that the three college experiences are positively related to the students' learning outcomes (Table 2). From the interaction effects (Table 3), we found that the positive effect of curricular experiences of critical reasoning and assessment is greater for white women than for Asian women in engineering programs. However, we did not discover any other interaction effects between college experiences and race in their learning outcomes. Espinosa (2011) suggests that Black and Latina women placed importance on group projects and tutoring other students to develop their academic self-concept. More research is needed in order to explore if other types of college experiences, such as student-faculty interaction, sense of belonging, and peer environments affect the learning outcomes of women engineering students differentiated by race.

We also offer several implications for future policies and practices based on the findings of this study. The U.S. engineering programs and workforce, ABET, and associations for engineering education should consider and incorporate intersectionality as a means by which to improve the learning outcomes of women of color. Policies that approach either women or racial/ethnic minorities separately might overlook the needs of women of color. For example, HIPs (e.g., internship, undergraduate research, or capstone) are known to work as effective practices to enhance students' learning outcomes. This study, however, found no significant interaction effect between HIPs and students' race on the four learning outcomes—perhaps because we combined the different types of HIPs as one continuous measure. We evaluated how many of the HIP programs women engineering students were involved in, rather than with which programs each racial/ethnic group of women engage. Latina women or Asian women engineering students may be attracted to certain HIP programs; thus, future research should look in greater detail at HIPs. Engineering faculties and administrators in higher education institutions should evaluate which racial/ethnic groups of students are included or excluded in certain HIPs and encourage them to experience the benefits of the programs.

We suggest that faculty staff and administrators review their teaching and learning methods in order to ascertain if they are attractive to women students. We did not find any interaction effects between race and active and inclusive pedagogies among women engineering students. However, the various pedagogies appear to be positively related to women engineering students' learning outcomes. STEM education research has shown that women are interested in learning engineering problems in broad and societal contexts (Knight et al., 2012). Incorporating cultural and historical contexts in engineering design and problem-solving may work better for women—particularly for women of color students. Furthermore, while active learning pedagogies are known as an effective teaching tool for both men and women students (Felder et al., 2011; Prince & Felder, 2006), this study confirms that the learning method positively contributes to women's learning outcomes regardless of their race. Engineering colleges and programs should continue to prioritize the recruitment and retention of women faculty and faculty of color since they are the driving forces towards incorporating active learning pedagogies (Johnson, 2007b). Applying more student-centered learning pedagogies should not be limited to women and URM faculties, but all faculties. We recommend that colleges of engineering need to offer professional development opportunities if engineering faculties are to develop more inclusive teaching and learning pedagogies.

CONCLUSIONS

As well as many other nations, the United States has committed itself to promoting a highly qualified and diverse workforce in STEM. Although women outnumber men in both undergraduate and graduate school enrollments in the nation overall (NCES, 2018), women are still underrepresented in STEM, particularly in the engineering education and wider workforce. This is an important matter of national concern, addressing and promoting economic development and gender equity in the United States. In this study, drawing upon Crenshaw's (1989, 1991) intersectional approach and Terezini and Reason's (2005, 2014) college impact model, we found that women of color (particularly, Asian women) tend to report lower learning outcomes than white women. While we focused on the racial/ethnic differences among women students in engineering, the intersectionality framework can help engineering education providers and researchers to encompass other marginalized students, such as LGBTQI students. We suggest that policy makers, scholars, administrators, and faculties provide educational programs and services that enable women of color to improve their learning outcomes and promote their academic success in engineering programs.

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