Pipelines and Pathways: Women of Color in Undergraduate STEM Majors and the College Experiences That Contribute to Persistence

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Supporting undergraduate achievement in science, technology, engineering, and mathematics (STEM) disciplines is paramount to ensuring our nation's continued scientific and technological advancement. In this quantitative study, Lorelle Espinosa examines the effect of precollege characteristics, college experiences, and institutional setting on the persistence of undergraduate women of color in STEM majors and also investigates how this pathway might differ for women of color in comparison to their White peers. She utilized hierarchical generalized linear modeling (HGLM) to examine the experiences of 1,250 women of color and 891 White women attending 135 institutions nationwide. Results revealed the paramount role of women's college experiences. Women of color who persisted in STEM frequently engaged with peers to discuss course content, joined STEM-related student organizations, participated in undergraduate research programs, had altruistic ambitions, attended private colleges, and attended institutions with a robust community of STEM students. Negative predictors of persistence include attending a highly selective institution.

As a nation that relies on scientific and technological innovation for the health of our economy and well-being of our citizenry, it is imperative that both U.S. educators and education policy makers foster learning pathways for those interested and capable of pursuing education and careers in science, technology, engineering, and mathematics (STEM). For years, the scientific community has witnessed wide gaps in STEM degree completion and the successive jeopardy of lost talent, which has broad economic and intellectual ramifications. Contributing to this trend is a U.S. education system that has failed to adequately prepare students interested in and capable of pursuing STEM

Harvard Educational Review Vol. 81 No. 2 Summer 2011

fields (National Academies Press, 2010). In higher education, this failure has disproportionally affected historically underrepresented groups, particularly people of color, women, and women of color. Yet, despite the vast body of postsecondary literature that has emerged from the civil rights and feminist movements, scholarly work on the intersection of gender and race/ethnicity in STEM fields is surprisingly slim in both quantity and empirical rigor.

Women of color—African American, Asian American, Latina,[1] Native American, and Pacific Islander—represented 20 percent of the nation's populace aged 15–24 years in 2010 (U.S. Census Bureau, 2009). This figure encompasses a large proportion of the precollege and college-going population and stands in stark contrast to the 12 percent of total STEM bachelor of science degrees conferred to women of color in 2006 (NSF, 2009). The percentage of White women who received degrees was twice this number, standing at 25 percent in 2006, illustrating the relationship between gender and race/ethnicity in STEM fields. Women of color are even further underrepresented in select scientific fields, earning less than 4 percent of undergraduate physics degrees, 7 percent of engineering degrees, and less than 10 percent of BS degrees in computer science.

Even in the biological sciences and other undergraduate STEM majors where women have achieved parity with men, women nonetheless fail to pursue STEM careers, as evidenced by their low numbers in top industry positions and academe (NRC, 2006). Studying women, particularly women of color, at the undergraduate level is critical to understanding and replicating in practice those experiences and interventions that contribute to their persistence in STEM majors and scientific careers. This study primarily focuses on the experiences of women who persist in STEM through their fourth year of undergraduate study, with a distinct examination of those factors that influence the persistence of women of color in comparison to the factors that influence the persistence of White women.

Such inquiry has its roots in several disciplinary streams within the social science literature, including early works on women in science. This subdiscipline of the second-wave feminist movement (early 1960s to late 1970s) depicted an intellectual environment that was hostile to women given its historical jurisdiction by White men and documented an androcentric, ethnocentric, and absolutist culture that adversely affected women seeking membership in the scientific community (Bleier, 1986; Cartwright, 1983; Haraway, 1991; Harding, 1991; Jordanova, 1993; Traweek, 1988). These early works on women in science set the stage for the development of a rich literature base on the education of women in STEM. This was followed by a steady stream of work on underrepresented minority students in scientific disciplines and, most recently, a number of dissertations and other studies addressing the unique position of women of color in these fields. Unlike the literature on women in general, this last body of work is remarkably slim, representing just 116 published and unpublished empirical papers between the years 1970 and 2009 (Ong, Wright, Espinosa, &

Orfield, 2011). Of this number, 80 percent of studies examine the undergraduate years, and 25 percent utilize quantitative, quasi-experimental, or experimental research designs drawn from twenty-five original sets of data. Only a limited number of studies utilize longitudinal and comparative analyses.

This study is timely for its contribution to a scant body of work on a population deemed critical to our nation's scientific and technological advancement. Yet, as a community of educators, our reasons for studying underserved populations—like women of color in STEM—must not solely rest on the need to fill a gap in the literature. Nor must we rely on arguments of equity alone. While the argument for gender and racial/ethnic equity is strong among social scientists, it carries far less weight among others in the scientific community, within present-day policy circles, and with the American public at large. An additional, poignant argument is the need for diverse experiences and perspectives in the STEM laboratory, which speaks to a scientific community in search of broad-based solutions to an array of global health-care, environmental, and infrastructure challenges. Moreover, the need to build a robust STEM workforce for national and regional economic development and job creation holds the attention of policy makers and the American people alike.

Of distinct importance is the argument for STEM college faculty that resemble our nation's increasingly diverse student body. Faculty perspectives and research trajectories have long-lasting effects on the nature of scientific inquiry and on the learning experiences of students across the entire higher education landscape. The educational benefits of a diverse faculty body are evident in the literature (Hurtado, Milem, Clayton-Pedersen, & Allen, 1999; Milem, 2003). Findings that relate positive faculty-student interactions to the persistence of women and minority students in undergraduate STEM majors support the argument for faculty diversity (Alfred, Atkins, Lopez, Chavez, Avila, & Paolini, 2005; Maton, Hrabowski, & Schmitt, 2000; NRC, 2006; Santovec, 1999; Seymour & Hewitt, 1997). Given the dearth of racial and ethnic minorities in the STEM professoriate, students often seek out faculty mentors who are themselves not racial or ethnic minorities (Ellington, 2006; Justin-Johnson, 2004) and find great benefit in doing so (Shain, 2002). While this link between the ethnic origin of STEM faculty and student persistence is not fully known, Sonnert, Fox, and Adkins (2007) have found strong association between the percentage of women among the STEM professoriate and the persistence of undergraduate women in these majors.

The concept of intersectionality—namely, among gender, race, ethnicity, and academic field—is the driving force behind the current study, which builds on and utilizes three literature streams within higher education scholarship: women in science, women and minorities in STEM, and women of color in STEM. Through a methodological design that examines both individual experiences and institutional environment (as well as other normative contexts), this study explores the active integration of women of color into the collegiate STEM environment. If women of color are not actively integrated into the undergraduate STEM experience, then institutions need evidence from which to make critical decisions that will improve policy and practice.

Research Literature and Theoretical Framework for the Study

Pioneering work by feminist scholars on women in science (see Bleier, 1986; Cartwright, 1983; Haraway, 1991; Harding, 1991; Hollis & Lukes; 1982; Jordanova, 1993; Keller, 1985; Traweek, 1988) and intersectionality (Chow, 1987; Collins, 2000; García, 1997; Maher & Tetreault, 1994) have contributed to the empirical and theoretical understanding of the unique psychosocial position held by women of color in STEM fields. In this section, I offer a frame in which the women of this study can be situated, a frame that joins several historically marginalized groups—women in STEM, people of color in STEM, and women and people of color in both higher education and society at large.

Women of color in STEM confront a myriad of systemic barriers resulting from an academic culture reinforced by elite, White men as authoritative, determinist, and with pretense to objectivity and neutrality, among other "damaging and self-defeating features" (Bleier, 1986, p. 1). Women of color in undergraduate STEM programs have experienced gender and ethnic microaggressions in predominantly male and White classrooms (Sosnowski, 2002). Others have felt unwelcomed, unsupported (Varma, Prasad, & Kapur, 2006), or invisible (Ong, 2005) due to how their gender and ethnic status affect the nature of their relationships with peers and faculty (Justin-Johnson, 2004; Ong, 2005).

These and other negative outcomes as experienced by women of color in STEM have been well documented in the literature and most often reference the intersection of gender, race/ethnicity, and scientific discipline—the lived experiences of women of color that encompass multiple forms of marginality (Ong et al., 2011). This psychosocial navigation by women of color in STEM fields influences their personal identity development, which is a powerful notion when one considers the socialization that young students already experience within the undergraduate collegiate environment (Hurtado, 2007). It is with these two salient perspectives in mind—the identity development and undergraduate socialization of women of color in STEM—that I chose the conceptual frames for this study.

The first frame is Carlone and Johnson's (2007) science identity model, developed from a six-year ethnographic study on women of color who persisted in science fields at a large, predominantly White research university. The model places strict focus on the undergraduate experience of women and how they developed their respective gender, racial/ethnic, and academic identities while traversing the path of an aspiring scientist. Relying in part on prior theories of identity and feminist frameworks, the model presents three overlapping dimensions of science identity—competence, performance, and recognition—as affected by one's own gender, racial, and ethnic identities. Competence refers to women's perceived grasp of scientific concepts and material; performance typically pertains to those scientific experiences that can be measured (e.g., research experience or an exam grade). Yet it is the recognition component that the authors found most salient to science identity, which refers to women being recognized as legitimate scientists by established members of the scientific community, such as faculty members. From these three dimensions of science identity, three independent trajectories emerged: research scientist, altruistic scientist, and disrupted science identity. Women with the research scientist identity focus on the prototypical aspects of science and display excitement for uncovering the natural world and scientific knowledge. Altruistic scientists gravitate toward health-related careers or preprofessional programs and pursue science as a "vehicle for altruistic ambitions" (Carlone & Johnson, 2007, p. 1199) and service to humanity. Disrupted scientists, as the name suggests, travel an unsatisfying road, persisting in the face of constant disruptions and instability. Although they may share the same motivations to pursue STEM as the other groups do, for disruptive scientists, experiences of being overlooked and unsupported shape their science identity more so than their desire to enter the STEM fields.

The second framework I utilize in this study is Weidman's (1989) theory of undergraduate socialization, a comprehensive model that depicts the integration of undergraduates into distinct university environments. Weidman presents a bidirectional relationship among students' background characteristics, parental socialization, collegiate experiences comprised of normative contexts and socialization processes, noncollege reference groups, and socialization outcomes. Relationships among students and their peers, faculty, and other individuals and groups on campus contribute to academic and social normative contexts and related normative pressures. Academic normative contexts are generated, among other things, by institutional setting. Settings are informed by, for example, educational mission and priorities at the institutional and departmental levels and by a series of behaviors of faculty who deliver the tools and rewards (e.g., curriculum, grades, guidance) that represent institutional priorities. Social normative contexts are often derived from extracurricular offerings, on-campus activities, and living group structures. Layered amongst these structures are three processes by which students become socialized into the campus environment: interpersonal interaction (i.e., the frequency and intensity of relationships, with an emphasis on relationships within the academic department); intrapersonal processes (i.e., individual perceptions of the environment including student satisfaction); and integration (i.e., the degree to which students find affiliation with the institution). In accordance with the theory, "academic integration refers to the extent to which students accept faculty expectations for their academic performance as legitimate" (Weidman, 1989, p. 310). In a STEM climate perceived as hostile by women of color—again, with specific attention to the departmental environment—it is conceivable that this integration is difficult for women of color to secure and maintain.

Weidman's concept of academic integration can be further applied to examine college math and science classrooms. Classroom experiences are vital to the persistence of women in STEM majors and can differ according to educational setting, including institution type (e.g., liberal arts, research). In addition to the pedagogy utilized by STEM faculty (Seymour & Hewitt, 1997), student-faculty relationships inside and outside of the classroom—an often-cited touch point for student connectivity to STEM subject matter and related long-term academic goals—are also important (see Alfred et al., 2005). Yet, for some women, their gender, race, and ethnicity become major barriers to being perceived by professors as serious science students (Carlone & Johnson, 2007; Seymour & Hewitt, 1997; Vogt, 2005; Wightman Brown, 2000). Other obstacles include the attitudes and behaviors of STEM faculty within the classroom. Johnson (2007) relates how her observations in science classrooms revealed that faculty members "tended to center their relationships with students around learning science, rather than around the students" (p. 11). Women who placed a high value on relationships therefore felt discouraged and unsatisfied—one of the "unintended consequences" of the ways science professors treat women of color (p. 1). Beyond relationships, course content and science exposure and experiences (e.g., undergraduate research) that speak to present-day, real-world scientific scenarios, and the challenges that exist in students' home communities have been linked to positive academic outcomes for diverse learners (Hurtado, Han, Saenz, Espinosa, Cabrera, & Cerna, 2007; Jones Eaton, 2004).

A final consideration in the success of undergraduate women of color pursuing STEM majors centers on the overall institutional setting. The predominantly White, large public research institutions have received much criticism in the literature. Common criticisms include impersonal, large classrooms; unapproachable professors; and competitive grading practices resultant from a system that actively attempts to "weed" students out of STEM majors (Seymour & Hewitt, 1997). Not only is a competitive atmosphere considered threatening to women for its conflict with collaboration and interpersonal relationship-building (Seymour & Hewitt, 1997), but perceptions of a highly competitive environment compound the adjustment that minority students must make in transitioning to the science environment in their first year of study (Hurtado et al., 2007).

Selectivity based on SAT scores and overall academic profiles of incoming freshmen is another aspect of institutional climate that might affect persistence. Rogers Elliott and colleagues (1996) assessed the role of ethnicity in students' decisions to enroll and persist in science majors at highly selective institutions, finding a significant negative effect on persistence for African American students; similar findings have been echoed by Bonous-Hammarth (2000) and Chang, Cerna, Han, and Sáenz (2008). While scholars acknowledge precollege choices and experiences as likely partial explanations of student nonpersistence at selective schools, they also point to the negative effect of hostile subenvironments of selective campuses. Addressing the ethnic and gender gaps in engineering, Campbell (1996) states that "failure to solve the attrition problem stems, in part, from an overemphasis on the student deficit model and underemphasis on institutional deficiencies" (p. 10).

Conceptual Approach to Studying Women of Color in STEM

Given the identity, socialization, and environmental frameworks and supporting literature just described, the current study's conceptual model (figure 1) depicts a relationship among these variables: persisting in STEM and background characteristics, college experiences, parental socialization, and institutional measures for women of color. As indicated by the dotted lines, both the effects of precollege characteristics and institutional characteristics on STEM persistence are mediated by college experiences.

While the STEM education literature at large shows a strong relationship between precollege measures (e.g., high school GPA) and persistence in college STEM majors (Bonous-Hammarth, 2000; Ethington & Wolfle, 1988), recent studies have revealed the effect of the college environment as particularly meaningful to educational trajectories in STEM (Carlone & Johnson, 2007; Eagan, Garcia, Herrera, Garibay, Hurtado, & Chang, 2010; Eagan & Newman, 2010; Zhang, 2005). As such, the present study is particularly concerned with the conditional effects of women's college experiences and environments on STEM persistence through the fourth year of undergraduate study. I pose the following research questions:

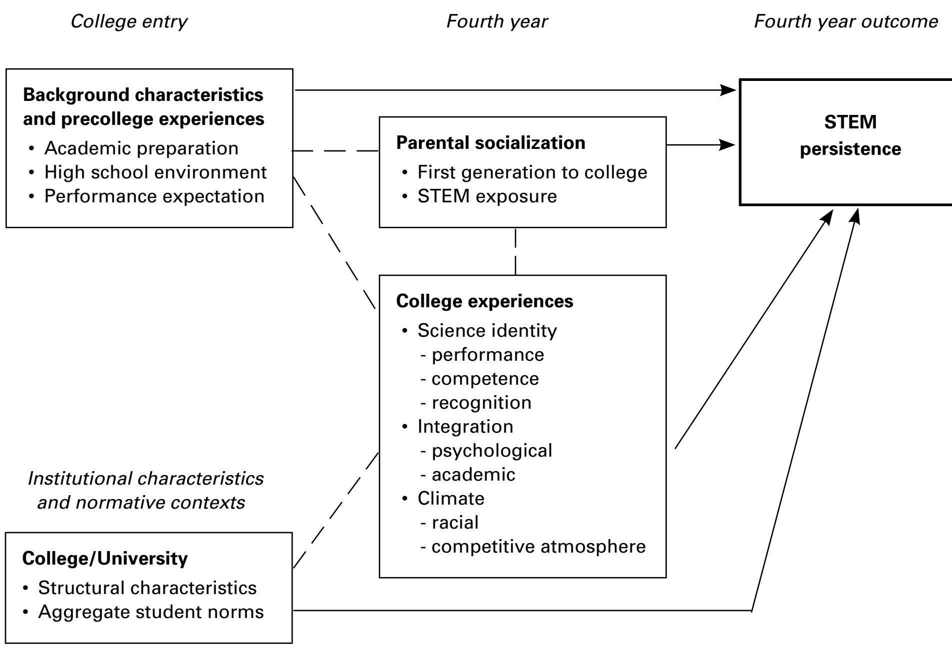
1. Are there differences in STEM persistence for women across types of higher education institutions?
2. If differences exist, what are the key predictors of persistence?
3. Does STEM persistence, as measured by such predictors, look different for women of color as compared to White women?

Methodology

Data Source and Sample

This study draws on longitudinal survey data from the Higher Education Research Institute (HERI) Cooperative Institutional Research Program (CIRP) at the University of California, Los Angeles. Established in 1966, CIRP is the oldest and largest empirical source of student and institutional trend data in higher education. The CIRP Student Information Form (SIF) accounts for students' backgrounds (e.g., high school experiences) and collegiate and career aspirations, while the College Senior Survey (CSS) prompts students to reflect on their four years of study and postbaccalaureate goals. Both surveys

FIGURE 1 *Conceptual model*



are largely concerned with students' academic, social, and personal development and the influence of family, peers, faculty, and other meaningful players in students' lives and long-term trajectories.

HERI staff collected survey data at two time points: college entry in fall 2004 and the fourth year of study in spring 2008. Survey participants completed the SIF during the summer before entry or during orientation activities of their freshman year. A subset of this group then completed the CSS during their fourth year of undergraduate study.[2] A multiyear research project on underrepresented minorities in STEM directed by HERI allowed for the specialized selection, recruitment, and subsidization of target institutions, resulting in a nationally representative sample of four-year colleges and universities with a reputation of graduating large numbers of underrepresented students in STEM.[2]

For purposes of comparison, I constructed two overall samples: one comprised of 1,250 women of color (37% Latina; 33% African American; 21% Asian American; 3.3% Native Hawaiian/Pacific Islander; and, 5.8% American Indian/Alaska Native)[3] at 96 institutions and the other of 891 White women at 123 institutions.[4] Women in both samples completed the 2004 SIF and 2008 CSS at the same institution where they began as first-time, full-time students and indicated intent to major in STEM on the SIF. I limited the samples to students holding U.S. citizenship or permanent residency.

Measures

The outcome of this study (STEM major, a binary dependent measure) was whether or not a student indicated that she was majoring in a STEM field in 2008. Those students with a dependent measure value of 1 persisted in STEM through their fourth year of study and are presumed to be on the path to a STEM bachelor's degree, while those with a value of 0 switched out of STEM and into a non-STEM discipline (but were still enrolled in a degree-granting program). It is important to note that this study is concerned with women who switched out of STEM and into non-STEM majors; women who switched majors *within* STEM are considered successful persisters.

Individual-level predictors are grouped into three categories: precollege characteristics, parental socialization, and college experiences. Student-level (level 1) predictor variables examine background characteristics and precollege and college experiences as derived from a number of measures on the SIF and CSS surveys that further corresponds with the study's conceptual framework and driving theoretical frames (Carlone & Johnson, 2007; Weidman, 1989). The study's women of color model includes several independent race/ethnicity predictors, which, despite being part of an aggregate sample, allows for the examination of between-group differences in STEM persistence. I included math and science course work in high school as a precollege experience measure given the research that shows such preparation as vital to undergraduate success in STEM while also serving as a contributor to students' academic self-assessment in college (Russell & Atwater, 2005; Trusty, 2002). Another high school measure is the type of school women attended (e.g., public or charter), a consideration that is virtually absent in the higher education literature despite the gatekeeping role of teachers and guidance counselors across various high school environments (Oakes, 2005). I also considered early STEM exposure and one's performance expectation in college. Such self-perceptions have been shown to affect academic performance (Gonzalez, Blanton, & Williams, 2002) and persistence (Espinosa, 2008; Huang & Brainard, 2001) for women and women of color in STEM, respectively.

While certainly important, the emphasis of this study rests not with high school preparation but, rather, with the influence of the collegiate experience on women's persistence in STEM over four years. The chosen college experience variables test Carlone and Johnson's (2007) model of STEM persistence for women of color while also addressing key components of Weidman's (1989) undergraduate socialization model, namely, academic and social environments, interpersonal integration, and socialization outcomes. The important performance, competence, and recognition domains of Carlone and Johnson's science identity model are measured by undergraduate research experiences and major grade point average (performance); changes in one's academic self-concept and analytical, problem-solving, and critical thinking skills (competence); and the frequency with which faculty provide support and guidance (recognition).

The final set of individual-level variables provides insight into the psychosocial and academic integration of women over their four years of college. These include pre- and post-test measures of sense of belonging and the frequency with which women engage with peers in academic settings. Both correspond to the integration component of Weidman's (1989) model, as does the measure of perceived campus racial climate. A final measure tests the relationship between women's intent to major in engineering and their overall persistence in STEM given a push by engineering departments to integrate innovative pedagogies that incorporate collaborative environments (Smith, Sheppard, Johnson, & Johnson, 2005).

Institutional-level variables (level 2) measure the academic and normative contexts of Weidman's (1989) model, which are hypothesized to vary between institutions. Institutional type, selectivity, and percent of undergraduates enrolled in STEM majors correspond to the influence of such predictors on STEM persistence as found in previous studies (Bonous-Hammarth, 2000; Chang et al., 2008; Chubin & Babco, 2003; Rogers Elliott, Strenta, Adair, Matier, & Scott, 1996). I also included perceived campus racial climate, satisfaction with science and math course work, and the frequency of faculty interaction—all in the aggregate and based on responses from women in each sample (per institution).

To augment institutional-level measures, I merged student enrollment data from the 2006 Integrated Postsecondary Education Data System database, which contains characteristics on American colleges and universities, including the percent of students on a given campus enrolled in STEM majors. Table 1 shows how each set of variables maps onto the two guiding theoretical frameworks.

Data Analysis

Given the chosen outcome measure explored in this study—whether or not women who remain enrolled in college persist in STEM between the freshman and senior years—I employed hierarchical generalized linear modeling (HGLM), a type of hierarchical linear modeling (HLM) that allows for a binary (0–1) outcome variable. Multilevel modeling techniques are ideal for research questions that seek to understand between-institution differences, allowing for the analysis of individuals as "nested" within differing environments (Raudenbush & Bryk, 2002; Seltzer, 1995). In the case of this study, HGLM allows for the examination of those predictors that promote the persistence of women in STEM majors relative to their distinct college or university environments. Since the STEM experience for women of color has been explicated in the literature as distinct across institutional settings (e.g., Historically Black Colleges and Universities [HCBU] versus predominantly White institutions), the ability to examine women's persistence in a way that allows for statistical differentiation between institutional environments is critical.

TABLE 1 *Description of variables and measures*

Items	*Scale and range*
Fourth-year outcome: STEM persistence	
STEM major	0 = no; 1 = yes
Ethnic subgroups: Women of color model	
Chicana/Latina	0 = no; 1 = yes (reference group)
African American	0 = no; 1 = yes
Asian American	0 = no; 1 = yes
Pacific Islander	0 = no; 1 = yes
American Indian	0 = no; 1 = yes
College entry: Background characteristics & precollege experiences	
Academic preparation:	
Years of mathematics in high school	Five-point scale: 0 = less than 1; 5 = four or more
Years of biological science	Five-point scale: 0 = less than 1; 5 = four or more
Years of physical science	Five-point scale: 0 = less than 1; 5 = four or more
High school GPA	Five-point scale: 0 = less than 1; 5 = four or more
High school environment:	
High school type: public (not charter or magnet)	0 = no; 1 = yes (reference group)
High school type: public charter	0 = no; 1 = yes
High school type: public magnet	0 = no; 1 = yes
High school type: private religious/parochial	0 = no; 1 = yes
High school type: private independent college prep	0 = no; 1 = yes
Performance expectation: Chances of making at least a "B" average	Three-point scale: 1 = no chance; 3 = some/good chance
Parental socialization	
First generation to college:	
Highest level of formal education obtained by father: less than college degree	0 = no; 1 = yes
Highest level of formal education obtained by mother: less than college degree	0 = no; 1 = yes
Concern about the ability to finance college education	Three-point scale: 1 = none; 3 = major
STEM exposure:	
Mother in STEM career	0 = no; 1 = yes
Father in STEM career	0 = no; 1 = yes

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TABLE 1 *Description of variables and measures (continued)*

Items	*Scale and range*
Fourth year: College experiences	
Science identity—performance:	
Participated in an undergraduate research program	0 = no; 1 = yes
Major GPA	Eight-point scale: 1 = D; 8 = A or A+
Science identity—competence:	
Academic self-concept	Five-item factor that measures the way students see themselves relative to someone their own age on the following characteristics: academic ability (0.81), drive to achieve (0.71), mathematical ability (0.57), intellectual self-confidence (0.75), writing ability (0.57) Five-point scale: 1 = lowest 10%; 5 = highest 10% Cronbach's Alpha: 0.71
Analytical/problem-solving/critical thinking skills	Two-item factor that asks students to compare when they first entered college: analytical and problem solving skills (0.93) and ability to think critically (0.93) Four-point scale: much weaker; much stronger Cronbach's Alpha: 0.85
Science identity—recognition:	
Meaningful other:	
Faculty interaction	Four-item factor that asks students to rate the level of frequency by which faculty provided the following: feedback on academic work outside of grades (0.80), advice/guidance on educational program (0.83), encouragement to pursue graduate/professional study (0.79), an opportunity to discuss course work outside of class (0.77) Three-point scale: 1 = not at all; 3 = frequently Cronbach's Alpha: 0.81
Self:	
Value commitment: personal importance of making a theoretical contribution to science	Four-point scale: 1 = not important; 4 = essential
Value commitment: working to find a cure to a health problem	Four-point scale: 1 = not important; 4 = essential
Integration—psychological	
Sense of belonging	Three-item factor asking students the extent to which they agree/disagree: I see myself as part of the campus community (0.87); I feel I am a member of this college (0.91); I feel I have a sense of belonging to this campus (0.91) Cronbach's Alpha: 0.88
Integration—academic	
Discussed course content with students outside of class	Three-point scale: 1 = not at all; 3 = frequently

Items	*Scale and range*
Tutored another college student	Three-point scale: 1 = not at all; 3 = frequently
2004 STEM major: engineering	0 = no; 1 = yes
Satisfaction with science and math course work	Five-point scale: 2 = very dissatisfied; 6 = very satisfied
Satisfaction with relevance of course work to everyday life	Five-point scale: 1 = very dissatisfied; 4 = very satisfied
Joined a club or organization related to major	0 = no; 1 = yes
Climate—racial	
There is a lot of racial tension on this campus	Four-point scale: 1 = strongly disagree; 4 = strongly agree
Faculty have expressed stereotypes about racial/ethnic groups in class	Four-point scale: 1 = strongly disagree; 4 = strongly agree
Climate—competitive atmosphere	
Strong competition among most of the students for high grades	Four-point scale: 1 = strongly disagree; 4 = strongly agree
Institutional characteristics and normative contexts	
Structural characteristics	
Control: public	0 = no; 1 = yes (reference group)
Control: private	0 = no; 1 = yes
Type: university	0 = no; 1 = yes (reference group)
Type: four-year college (public, nonsectarian, Catholic, other religious)	0 = no; 1 = yes
Institutional selectivity: Highly selective	Mean SAT > 1155
% students in STEM	% range: 0.01 to 0.69
Aggregate student norms	
There is a lot of racial tension on campus	Four-point scale: 1 = strongly disagree; 4 = strongly agree
Faculty interaction	Four-item factor (same as individual-level faculty interaction factor) that asks students to rate the level of frequency by which faculty provided the following: feedback on academic work (outside of grades), advice/guidance on educational program, encouragement to pursue graduate/professional study, an opportunity to discuss course work outside of class Three-point scale: 1 = not at all; 3 = frequently
Satisfaction with science/math course work	Four-point scale: 1 = dissatisfied; 4 = very satisfied

Note: Factors were explored through principle components analysis.

Longitudinal research studies on college student development have historically employed ordinary least squares (OLS) regression analysis, wherein random errors (i.e., unsystematic, unpredictable variation) are independent, normally distributed, and have constant variance. Yet, we can hypothesize that the random errors associated with individual-level predictors in this study are in fact dependent on the unique effects of the institution that women attend; random errors are thus not normally distributed and have unequal variance, since student-level predictors vary across institutions and across students themselves. Utilizing a nonmultilevel technique like OLS would further result in underestimated standard errors (i.e., reliability measures) and thus the likelihood of falsely concluding that a given independent measure is statistically significant and therefore contributing to STEM persistence (Raudenbush & Bryk, 2002).

The HGLM Model

The reason for employing HGLM (as opposed to HLM) is that one of the assumptions of HLM—the normal distribution of random effects at level 1—cannot be satisfied. The HGLM model instead provides estimates of how independent predictors contribute to the probability of a dichotomous outcome. As a first step to running an HGLM model (Raudenbush & Bryk, 2002), I constructed a null model (i.e., one with no predictors) to ascertain across-institution difference in STEM persistence as represented by the following level 1 and level 2 models (given a Bernoulli sampling model and logit link function):

$$\eta_{ij} = \beta_{0j} \tag{1}$$

$$\beta_{0j} = \gamma_{00} + u_{0j} \qquad u_{0j} = N(0, \tau_{00}) \tag{2}$$

where: η_{ij} represents the log-odds of individual STEM persistence; γ_{00} is the average log-odds of persistence between institutions; τ_{00} is the variance between institutions in log-odds of persistence; i is the individual student; and j is the institution.

Once I ran this model for each sample (women of color and White women) and found differences in persistence across institutions, I constructed the full HGLM model. The grand mean centered student-level structured model is represented by the following equation:

$$\text{Log}\left[\frac{\Phi_{ij}}{1-\Phi_{ij}}\right] = \beta_{0j} + \beta_{1j}^{*}\ (\text{race/ethnicity})_{ij} + \beta_{2j}\ (\text{background characteristics and precollege experiences})_{ij} + \beta_{2j}\ (\text{parental socialization})_{ij} + \beta_{2j}\ (\text{college experiences})_{ij} + \mu_{ij} \tag{3}$$

The grand-mean centered institution-level predictors modeled in the intercept term (β_{0j}) of equation (2) are represented by:

$$B_{0j} = \gamma_{00} + \gamma_{01}^{*}\ (\text{institutional characteristics})_{j} + \gamma_{02}^{*}\ (\text{normative contexts})_{j} \tag{4}$$

HGLM presents results through the use of odds ratios, or the log-odds of success (i.e., STEM persistence). Odds ratios greater than one suggest an increase in the likelihood that women will persist in STEM fields; values less than one indicate a reduced likelihood of this persistence (Hedeker & Gibbons, 2006). For ease of interpretation, the study's results are also presented in terms of the delta-*P* statistic, or the difference in probability resulting from a one-unit change in a given categorical or continuous predictor when holding all other predictors constant (Peng, So, Stage, & St. John, 2002). The delta-*P* statistic is particularly useful when interpreting dummy variables, in which case the measure represents an independent predictor's percent impact on the outcome.

Limitations

A first limitation of this study concerns survey nonresponse bias, or the potential differences between those women who responded to the 2008 CSS versus those who did not. For both the women of color and White women samples, I conducted an independent samples t-test to assess key indicators of academic exposure (e.g., years of math in high school), ability (as measured by high school GPA), perceived competence, aspirations, and behaviors as measured on the SIF. Women who responded to the CSS displayed higher ability and academic self-concept, appeared to have been more academically engaged in high school, and came from families with more college educated parents. The inherent bias that this presents should be considered a limitation given the lack of population generalizability. Another limitation of this study is its use of an aggregate sample of women of color, which assumes that women from varying racial/ethnic backgrounds experience college in similar enough ways that they can be placed into one overarching group for analysis. Although each race/ethnicity represents a distinct independent variable in the model examining women of color, the sample sizes of each group were too small to allow for discrete analysis. A final limitation is that the women in this study enrolled as freshmen and attended college full-time. That is, they do not represent part-time or transfer students, a common profile of underrepresented STEM undergraduates.

Results

Descriptive Statistics

Table 2 provides level 1 and level 2 descriptive statistics for both the women of color and White women samples. The overall STEM persistence rate of both samples—women of color and White women—was 57 percent, although differences by race/ethnicity occurred within the women of color sample: Latina, 52 percent (n = 463); African American, 54 percent (n = 413); Asian American, 70 percent (n = 260); Native Hawaiian/Pacific Islander, 68 percent (n = 41); and American Indian/Alaska Native, 41 percent (n = 73). True to the

TABLE 2 *Descriptive statistics*

Variable	*Women of color (n = 1,250)*			*White women (n = 891)*		
Dependent variable	*Mean (SD)*	*Min*	*Max*	*Mean (SD)*	*Min*	*Max*
Persisted in STEM	0.57 (0.50)	0.00	1.00	0.57 (0.49)	0.00	1.00
Level 1 variables						
Chicana/Latina	0.37 (0.48)	0.00	1.00	--	--	--
Asian American	0.21 (0.41)	0.00	1.00	--	--	--
Pacific Islander	0.03 (0.18)	0.00	1.00	--	--	--
American Indian	0.06 (0.23)	0.00	1.00	--	--	--
African American	0.33 (0.47)	0.00	1.00	--	--	--
Years of math in high school	3.98 (0.57)	0.00	5.00	3.97 (0.56)	0.00	5.00
Years of physical science in high school	1.83 (1.16)	0.00	5.00	2.01 (1.17)	0.00	5.00
Years of biological science in high school	1.80 (1.06)	0.00	5.00	1.89 (0.98)	0.00	5.00
High school GPA	6.85 (1.22)	2.00	8.00	7.29 (0.92)	2.00	8.00
Public high school	0.71 (0.45)	0.00	1.00	0.77 (0.42)	0.00	1.00
Charter/Magnet high school	0.11 (0.32)	0.00	1.00	0.04 (0.20)	0.00	1.00
Private religious high school	0.12 (0.33)	0.00	1.00	0.12 (0.32)	0.00	1.00
Private independent high school	0.05 (0.22)	0.00	1.00	0.06 (0.23)	0.00	1.00
Expect to make a B average	3.61 (0.55)	1.00	4.16	3.67 (0.51)		
Less than college degree: Father	0.52 (0.50)	0.00	1.00	0.36 (0.48)	0.00	1.00
Less than college degree: Mother	0.50 (0.50)	0.00	1.00	0.34 (0.48)	0.00	1.00
Father STEM career	0.17 (0.38)	0.00	1.00	0.23 (0.42)	0.00	1.00

Variable	*Women of color (n = 1,250)*			*White women (n = 891)*		
Dependent variable	*Mean (SD)*	*Min*	*Max*	*Mean (SD)*	*Min*	*Max*
Mother STEM career	0.05 (0.22)	0.00	1.00	0.06 (0.23)	0.00	1.00
Financial concern	2.01 (0.63)	1.00	3.00	1.83 (0.63)	1.00	3.00
Undergraduate research program	0.18 (0.39)	0.00	1.00	0.19 (0.39)	0.00	1.00
Major GPA	5.59 (1.71)	1.00	8.00	6.43 (1.46)	1.00	8.00
Academic self-concept	18.94 (2.76)	9.00	25.00	19.37 (2.60)	9.00	25.00
Critical thinking skills	8.79 (1.18)	2.00	10.00	8.71 (1.15)	2.00	10.00
Faculty interaction	10.72 (2.64)	4.00	12.00	11.18 (2.57)	4.00	12.00
Make theoretical contribution to science	2.15 (0.97)	1.00	4.00	1.99 (0.92)	1.00	4.00
Work to find health cure	2.74 (1.03)	1.00	4.00	2.48 (1.04)	1.00	4.00
Sense of belonging	9.23 (1.73)	3.00	12.00	9.44 (1.78)	3.00	12.00
Discussed course content w/ other students	2.66 (0.51)	1.00	3.00	2.73 (0.46)	1.00	3.00
Tutored another student	1.67 (0.68)	1.00	3.00	1.64 (0.67)	1.00	3.00
Engineering major	0.13 (0.33)	0.00	1.00	0.11 (0.31)	0.00	1.00
Satisfaction with math/science courses	4.85 (0.94)	2.00	6.00	5.00 (0.95)	2.00	6.00
Relevance of course work to everyday life	3.70 (0.88)	1.00	5.00	3.72 (0.88)	1.00	5.00
Joined club related to major	0.59 (0.49)	0.00	1.00	0.64 (0.48)	0.00	1.00
Racial tension on campus	2.02 (0.75)	1.00	4.00	1.92 (0.70)	1.00	4.00
Faculty have expressed stereotypes	3.70 (0.88)	1.00	4.00	1.98 (0.74)	1.00	4.00
Strong competition w/other students	2.97 (0.80)	1.00	4.00	2.80 (0.77)	1.00	4.00

continued on next page

TABLE 2 *Descriptive statistics (continued)*

Variable	*Women of color (n = 1,250)*			*White women (n = 891)*		
Dependent variable	*Mean (SD)*	*Min*	*Max*	*Mean (SD)*	*Min*	*Max*
Level 2 variables (n = 96)						
Type: University	0.54 (0.50)	0.00	1.00	0.51 (0.50)	0.00	1.00
Type: Four year	0.46 (0.50)	0.00	1.00	0.49 (0.50)	0.00	1.00
Control: Public	0.49 (0.50)	0.00	1.00	0.47 (0.50)	0.00	1.00
Control: Private	0.51 (0.50)	0.00	1.00	0.53 (0.50)	0.00	1.00
Highly selective	0.49 (0.50)	0.00	1.00	0.50 (0.50)	0.00	1.00
Percent students in STEM	0.18 (0.13)	0.01	0.69	0.16 (0.12)	0.01	0.69
High racial tension	1.95 (0.34)	1.11	2.90	1.98 (0.32)	1.11	3.00
Faculty interaction	8.99 (0.91)	7.09	12.00	11.45 (1.40)	7.00	15.00
Satisfaction w/math and science courses	4.94 (0.32)	4.14	5.75	4.96 (0.34)	4.00	5.75

aforementioned observation that both the women of color and White samples are made up of high-ability women, the descriptive statistics reveal women who took approximately four years of math, two years of physical science, and nearly two years of biological science at mostly (70%) public high schools. The high school GPAs are also similar across groups, with White women having a slightly higher average.

The two groups experienced college in relatively similar ways, according to the descriptive statistics, but with a few exceptions. White women, for example, have higher major GPAs, appear to have more interaction with faculty outside the classroom, and have experienced far fewer instances of faculty expressing racial or ethnic stereotypes in class.

Table 3 displays the characteristics of institutions attended by the full sample, organized by racial/ethnic group. Every group, except Pacific Islander women, attended public institutions, including 74 percent of American Indian women. Of the 260 Asian American women in the study, 80 percent attended universities and 64 percent attended highly selective institutions. The latter statistic is in contrast to the 42 percent of African American and 42 percent of American Indian women who attended selective schools.

TABLE 3 *Characteristics of institutions attended by race/ethnicity*

		Institutional characteristics (n = 135)				
		Public	*Private*	*Institu-tional type: University*	*Institutional type: 4-year college*	*Highly selective*
Full student sample (n = 2,141)	White (n = 891)	57%	43%	63%	37%	56%
	Chicana/Latina (n = 463)	55%	45%	63%	37%	56%
	African American (n = 413)	50%	50%	50%	50%	42%
	Asian American (n = 260)	59%	41%	80%	20%	64%
	Pacific Islander (n = 41)	44%	56%	44%	56%	32%
	American Indian (n = 73)	74%	26%	71%	29%	42%

Note: Percentages represent the number of women from racial/ethnic subgroups that fall within each cell.

Findings: Key Predictors of STEM Persistence

Table 4 displays the results of the HGLM analysis for women of color and White women, showing each predictor and the corresponding simple correlation (*r*), log-odds coefficient (C), standard error (SE), and delta-*P* statistic (Δ-*P*). The final models explained 27 percent and 17 percent of the variance in the outcome for the women of color and White women samples, respectively. True to previous findings that illustrate the importance of high school academic achievement on college performance, high school GPA emerged highly significant for both samples ($p<0.001$). Surprising, however, is that high school GPA was the only precollege variable to remain statistically significant for both women of color and White women once all measures were included in the model. Although father's education (less than college) and financial concern (college affordability) were significant for White women, none of the parental socialization measures proved significant for women of color. It may well be that parental ties are mediated by other powerful interpersonal relationship predictors, including the relationships that women of color construct with peers and other members of the campus community once at college and away from their immediate family.

Of the eleven student-level predictors that proved statistically significant in the final model for women of color, eight are categorized under college experiences and cut across several areas of the study's guiding theoretical frameworks. The strongest effects reveal the importance of science identity devel-

TABLE 4 *HGLM model predicting STEM persistence*

Independent variables	*Final model: Women of color* $R^2 = 0.27$				*Final model: White women* $R^2 = 0.17$			
	r	*C*	*SE*	Δ-P	*r*	*C*	*SE*	Δ-P
Intercept	—	0.37***	0.09	8.74	--	0.47***	0.09	10.96
Ethnic subgroups								
African American (Chicana/Latina)	–0.03	–0.20	0.16	4.82	—	—	—	—
Asian American (Chicana/Latina)	0.14**	0.72***	0.18	16.14	—	—	—	—
Pacific Islander (Chicana/Latina)	0.04	0.58	0.54	13.30	—	—	—	—
American Indian/Alaskan Native (Chicana/Latina)	–0.08**	–0.61	0.34	–13.93	—	—	—	—
Precollege								
Years of math in high school	0.07*	0.13	0.12	2.91	0.12*	0.25	0.14	5.99
Years of physical science in high school	0.01	–0.06	0.07	–1.46	0.06	–0.02	0.07	–0.49
Years of biological science in high school	0.02	0.00	0.06	0.00	0.04	0.10	0.09	0.49
High school GPA	0.13**	0.31***	0.08	7.38	0.15**	0.37***	0.09	8.74
Charter/Magnet (public)	0.02	–0.01	0.25	–0.24	–0.03	–0.17	0.39	9.19
Private religious (public)	–0.03	–0.24	0.24	–5.76	0.04	0.25	0.25	5.99
Private independent (public)	–0.00	–0.37	0.34	–8.74	–0.00	–0.05	0.35	–1.22
Expect to make B average	0.06*	0.15	0.13	3.63	0.03	0.12	0.12	2.91
Parental socialization								
Less than college degree: Father	–0.06*	–0.23	0.16	–5.52	–0.08*	–0.51*	0.21	–11.82
Less than college degree: Mother	–0.06*	–0.15	0.15	–3.63	–0.04	0.21	0.35	5.05
Father STEM career	0.10**	0.29	0.18	6.92	0.10	–0.16	0.21	–3.87
Mother STEM career	0.22	–0.05	0.31	–1.22	0.22	0.36	0.31	8.52
Financial concern	0.14	0.18	0.11	4.35	0.14	–0.34*	0.71	–3.39

College experiences								
Undergrad research program	0.15**	0.50*	0.23	11.61	0.11**	–0.04	0.23	–0.98
Academic self–concept	0.09**	0.02	0.03	0.49	0.13**	0.02	0.04	0.49
Critical thinking skills	–0.01	–0.11	0.07	–2.67	0.07*	0.02	0.07	0.49
Faculty interaction	–0.01	0.02	0.22	0.49	0.02	0.01	0.04	0.24
Make theoretical contribution	0.28**	0.44***	0.09	10.30	0.33**	0.75***	0.11	16.73
Work to find health cure	0.21**	0.30***	0.08	7.15	0.25**	0.36***	0.09	8.52
Sense of belonging	0.06*	0.07	0.06	1.71	0.05	–0.10	0.05	–0.49
Discussed course content	0.11**	0.46***	0.13	10.74	0.10**	0.17	0.20	9.19
Tutored another student	0.08**	0.09	0.11	2.19	0.14**	0.36*	0.13	8.52
Engineering	0.09**	0.86***	0.24	18.80	0.15**	1.31***	0.35	26.09
Satisfaction with science/math courses	0.26**	0.61***	0.07	13.93	0.32**	0.84***	0.10	18.43
Relevance of course work	–0.10**	–0.47***	0.12	–10.96	0.00	–0.26*	0.12	–6.22
Joined club related to major	0.11**	0.31*	0.14	7.38	0.04	–0.02	0.17	–0.49
Racial tension on campus	–0.07**	–0.0	0.12	0.00	–0.07**	–0.00	0.13	0.00
Faculty expressed stereotypes	–0.05	–0.12	0.09	–2.91	–0.06	–0.15	0.13	–3.63
Competition w/students	0.05	–0.07	0.08	–1.71	–0.07*	–0.02	0.10	–0.49
Major GPA	–0.12**	–0.32***	0.05	–7.61	–0.11**	–0.30***	0.07	–7.15
Institutional characteristics								
Control: Private (public)	0.03	0.40*	0.19	9.42	0.10**	0.30	0.25	7.15
Type: Four year (university)	0.01	0.01	0.22	0.24	0.04	0.29	0.21	6.92
Highly selective	–0.04	–0.62**	0.21	–14.13	–0.08*	–0.32	0.24	–7.61
Percent students in STEM	0.11**	1.38*	0.67	27.05	0.08*	1.08	0.90	22.61
Normative contexts								
High racial tension	–0.09**	–0.50	0.39	–11.61	0.05	0.45	0.44	10.52
Faculty interaction	0.01	–0.11	0.21	–2.67	0.03	–0.12	0.10	–2.91
Satisfaction w/science and math courses	0.12**	0.11	0.23	2.67	0.12**	0.30	0.42	7.15

Notes: *p<0.05 **p<0.01 ***p<0.001 reference groups are in parentheses.

opment, intrapersonal processes, and academic integration. Two key findings tie directly to the identity framework emergent from Carlone and Johnson's (2007) ethnographic study on women of color in STEM. For every one unit increase (e.g., from "somewhat important" to "very important" on the survey measure) in personal importance of the following goals—making a theoretical contribution to science (Δ-*P* = 10.30***) or finding a cure to a health problem (Δ-*P* = 7.15***)—women are ten and seven percentage points more likely to persist in STEM through the fourth year of college.

Also statistically significant were two satisfaction measures representative of the intrapersonal process within Weidman's (1989) undergraduate socialization model (i.e., processes that occur in conjunction with the formal and informal normative contexts of a given institution). First, women of color who find satisfaction with their institution's science and math curriculum are more likely to persist—for every increase in satisfaction score (e.g., "neutral" to "satisfied"), there is a nearly fourteen percentage point greater likelihood of STEM persistence (Δ-*P* = 13.93***), a finding that supports the link between instructional quality and the retention of racial minority women in STEM majors (Hilton, Hsia, Cheng, & Miller, 1995). Also predictive of STEM persistence is satisfaction with the relevance of course work to everyday life (Δ-*P* = –10.96***). An unexpected negative relationship between this satisfaction measure and the outcome might suggest that women found such satisfaction only after switching to non-STEM majors.

Two measures of academic peer group interaction were statistically significant for women of color and map onto Weidman's (1989) dimension of academic integration in addition to showing aspects of the interpersonal processes dimension through the frequent sharing of ideas and values with fellow students. First, women who engage in peer discussion (on course content) outside the classroom are more likely to persist in STEM (Δ-*P* = 10.74***), which affirms theories of learning specific to women that espouse the importance of interpersonal relationships in and around academic settings (Baxter Magolda, 1992; Belenky, Clinchy, Goldberg, & Tarule, 1986). Second, women of color who join a major-related club are 7.38 percentage points ($p<0.05$) more likely to persist in STEM than those who do not join this type of club. Another prominent integration predictor shows that women who enter college with the intent of majoring in engineering are nearly nineteen percentage points more likely to persist in STEM on the whole (whether in or outside of engineering disciplines) than women who aspired to other STEM majors (Δ-*P* = 18.80***).

In support of the performance aspect of Carlone and Johnson's (2007) model, women of color who participated in research programs are nearly twelve percentage points (Δ-*P* = 11.61*) more likely to persist in STEM. The second performance measure, major GPA (Δ-*P* = –7.61**), is negative in its relationship with the outcome, indicating that women who switch out of STEM receive higher grades in their major discipline, perhaps an unsurprising fact given the differences in norms around grading in scientific courses (i.e., the propensity to grade on a curve and to "weed" students out of STEM majors).

Three of the seven institution-level variables utilized in the model significantly predicted STEM persistence for women of color. Those attending highly selective colleges and universities are over fourteen percentage points more likely to switch out of STEM by the fourth year of college (Δ-*P* = –14.13**) than those who do not attend such institutions. This finding adds to a growing body of literature that depicts environments at highly selective colleges as less supportive of STEM students from underrepresented backgrounds (Bonous-Hammarth, 2000; Chang et al., 2008; Cole & Barber, 2003). Furthermore, attending a private institution and the percentage of the student body majoring in STEM were positive predictors of persistence in STEM. Women who attend a private college are nearly ten percentage points more likely to persist in STEM (Δ-*P* = 9.42*); perhaps this can be attributed to the resource-rich environments that private institutions are able to construct for their students. Similar to the student-level predictors (e.g., joining a major-related club and discussing course content outside of class), peer environment contributes to persistence at the institutional level. For each percent increase in the number of students majoring in STEM at a given institution, women of color are thirty percentage points more likely to persist to year four.

In extending these findings, comparisons between women of color and White women are important. Focusing on college experiences, a key point of difference concerns the relationship between joining a major-related club/organization and STEM persistence—a significant and positive finding for women of color but not for White women, despite the two groups having joined at comparable rates (60% for women of color and 64% for White women). This points to the importance of a STEM peer group for women of color, driving home the importance of peer relationships (i.e., integration) as espoused by Weidman (1989) and the importance of peer support overall, as evidenced in the literature on women of color in STEM (Meiners & Fuller, 2004; Shain, 2002; Valenzuela, 2006).

Yet the most salient differences across measures that predict STEM persistence for women of color versus White women are found at the institutional level. As stated, there is a negative relationship between highly selective institutions and the fourth-year persistence of women of color and a positive relationship between persistence and attendance of a private institution and the percentage of STEM majors. Neither of these measures proved statistically significant for White women, despite significant correlation between these same predictors and the outcome for the White sample.

Discussion and Implications

Among the major conceptual factors that contribute to the persistence of women of color in STEM fields, the college experience and college environment prove paramount relative to high school performance and family background characteristics. Women of color who actively engage in the academic community and who exhibit behaviors and participate in activities that make STEM an accessible career path ultimately persist in STEM through their fourth year of college. Another major takeaway is the importance of engagement in co-curricular experiences and the integrative influence of scientific performance—both of which may help women of color see beyond a STEM culture that is fraught with barriers. What is unclear, however, is whether the institutional environment cultivated this engagement or if the women in this study would have otherwise displayed integrative behaviors—a limitation that could be addressed with qualitative or mixed-methods designs. Nonetheless, those who were successful in STEM frequently engaged with peers outside the classroom to discuss course content, joined STEM-related clubs and organizations, and participated in undergraduate research programs.

As a contributing factor to persistence, academic peer relationships—as opposed to strictly social ones—may be especially important, since women of color in STEM often find themselves challenged to form meaningful relationships in courses where the majority of students are White and/or male (Justin-Johnson, 2004; Ortiz, 1988). Similarly, participation in STEM-related clubs may help women of color feel more connected to the STEM community at large. Academic organizations in science and engineering that place emphasis on racial/ethnic diversity, like the National Society of Black Engineers (NSBE), Advancing Hispanics/Chicanos and Native Americans in Science (SACNAS), and the American Indian Science and Engineering Society (AISES), are growing in their popularity and have a strong national presence. It is not known if women in this study joined these types of organizations, but their presence supports the notion that such co-curricular offerings are sought after by minority students and provide a brand of academic and social support that students may not find elsewhere.

Given a national emphasis on providing undergraduates with research exposure—and the related funding streams coming out of the National Science Foundation (NSF), National Institutes of Health (NIH), NASA, and other federal agencies supporting women and minority populations—it is encouraging that research program involvement has a significant impact on persistence for women of color. Through the performance of scientific practice and community recognition, program involvement may reinforce the confidence that women have in their abilities (Carlone & Johnson, 2007); this confidence in turn may bolster their chances of persisting in the major. Moreover, research programs often monitor and facilitate positive interactions for students in the STEM laboratory and provide role models and avenues for continued science performance such as opportunities to publish and present at research conferences. It is, of course, also probable that women who participate in such programs are intrinsically more motivated than those who do not. However, we also know from the literature that such programs have an incredible impact on the goals and trajectories of minority women in STEM (Ellington, 2006; Espinosa, 2008; Ong, 2002), whatever their reasons for choosing to participate. Engagement in structured programs may further allow women to become more active members in their academic environment, offsetting the obscurity and subsequent silence that marks the behavior of women of color in the STEM classroom due to gendered and racialized treatment by peers and professors (Johnson, 2007; Ortiz, 1988). Exposure to scientific concepts in a research setting may further reinforce the accessibility of STEM careers by providing opportunities for women of color to make theoretical contributions to science and to work to find health cures. Since involvement in formal research programs often comes with a programmatic structure that supports participants' interests—as well as program staff and faculty devoted to seeing students pursue STEM careers (Brown, 2000; Ellington, 2006)—this type of environment could be very motivating for women who seek to utilize their education to further scientific progress.

All women, regardless of their race, leave STEM in part because of the inability of professors to make science accessible and aligned with their goals of contributing to society, including the relevance of course work to women's everyday lives. If women are finding other disciplines and related course content more relevant to their day-to-day life and worldview, they are likely to switch majors, marking an incredible lost opportunity for STEM disciplines. Yet despite this negative relationship, women of color who stay in STEM are in fact more likely to indicate overall satisfaction with science and math course work. Satisfaction with STEM course work aligns with instructional quality (Seymour & Hewitt, 1997) and speaks volumes to the importance of pedagogy in the science and engineering classroom. Simply stated, pedagogy matters. Attention to improved pedagogical practices in STEM have been taking shape for decades but have gained increased importance in recent years given the desire of educators to increase the numbers of women and minority students in STEM. Much of this work follows practices set forth by feminist scholars and theories of learning specific to women: encouraging students to question the role of power in the creation of scientific knowledge, aligning theoretical concepts with real-world scientific problems, and increasing interpersonal collaboration among students inside and outside the classroom (Mayberry, 1998). Proponents of these methods are quick to point out that innovative pedagogies benefit all students, not just women.

A final measure of academic integration for all women concerns the positive impact of intending to major in engineering. The literature is clear on the gendered environment found in engineering classrooms, departments, and laboratories for women of all backgrounds, in part due to the lack of progress in enrolling women over the last several decades (Felder, Felder, Mauney, Hamrin, & Dietz, 1995; NSF, 2009). So why the positive relationship between engineering and STEM retention? This can be answered in part, I believe, by the characteristics of aspiring engineers—women intent on pursuing engineering had more math course work in high school, which is also evidenced in the literature (Adelman, 1999; Anderson & Kim, 2006; Ethington & Wolfle, 1988; Seymour & Hewitt, 1997). Furthermore, of all STEM disciplines, engineering is perhaps one of the least defined fields for secondary school students, given its absence in the curriculum and a lack of understanding of what it is that engineers do. It is plausible that women who enter college with engineering aspirations either have engineering role models, have stronger academic backgrounds, are perhaps more oriented toward science, and are thus more likely to switch into other scientific fields before leaving STEM altogether.

Perhaps the most important finding on the factors that steer women of color away from STEM is the impact of institutional selectivity. While there is an impressive body of research concerning the positive impact of selective institutions on the academic outcomes of minority students (Alon & Tienda, 2005; Bowen & Bok, 1998; Bowen, Chingos, & McPherson, 2009; Trent, Owens-Nicholson, Eatman, Burke, Daugherty, & Norman, 2003), the study of selectivity on minority students *in science fields* does not paint an equally rosy picture (Astin & Astin, 1992; Bonous-Hammarth, 2000; Chang et al., 2008; Rogers Elliot et al., 1996; Smyth & McArdle, 2004). Despite their reputation of providing substantial academic and human resources to support students, elite campuses—including large tier-one research institutions—may engage in academic practices that discourage students from staying in STEM. For example, students may be adversely affected by an institutional culture that values research over teaching and actively discourages students from STEM through competitive grading practices. The latter activity is particularly counter to talent development in favor of sorting students into two categories—STEM or non-STEM. In these selective institutions, students have already been sorted through a strict admissions process, only to be sorted once more. The fact that these very institutions are some of the most equipped in the country to train future scientists and engineers, and prepare students for advanced study in these fields means an incredible loss of talent. The magnitude of such opportunity loss is tragic given the barriers that minority women must overcome to enroll in STEM in college, only to be potentially turned away from these fields due to an inhospitable academic climate.

While in my findings, there were both similarities and differences between the women of color and the White women, the difference in the effect of institutional selectivity was quite noteworthy. What is it about selective institutions that disproportionately affects women of color? It may first be a lack of ethnic diversity on selective college campuses, leaving women of color to experience both gender and racial/ethnic isolation in the STEM classroom, laboratory, and department (Dickey, 1996; Justin-Johnson, 2004; Varma et al., 2006). Second, the isolation that women of color perceive on selective campuses may be further heightened by the lack of role models given the low numbers of women, minority, and women of color faculty employed on these campuses, with even lower numbers in STEM departments.

However, attending private institutions, and those with high numbers of students studying STEM fields, has a positive relationship with STEM persistence for women of color. It may be that private institutions—often armed with an array of resources aimed at supporting students academically, socially, and personally—do a better job of creating a warm climate for women of color pursuing STEM degrees. More than half of the women of color in this study attended private, four-year colleges (as opposed to private research universities), perhaps indicating the importance of an emphasis on teaching in addition to research that four-year settings place on undergraduate education. Also encouraging is the relationship between the number of students studying STEM and the relative likelihood of women of color to persist in scientific majors through the fourth year of undergraduate study. This normative context in fact supports the notion of community that women of color may form through joining a major-related club, participating in undergraduate research, and seeking academic peer relationships outside of class—all of which also predict persistence in STEM.

Conclusion

The findings I present in this study illustrate the need for federal and state policy makers to direct new and existing resources toward institutional programs that directly serve women, overall. Perhaps most important is the need for colleges and universities—particularly selective institutions—to create learning environments that promote peer-to-peer interaction, co-curricular involvement, and access to undergraduate research opportunities. Emphasis should also be placed on providing tangible support to assess and improve the quality of STEM curriculum. Instead of solely focusing on the delivery of content, deans and faculty would be wise to create departmental environments that continuously examine how course content translates to those problems most relevant to the twenty-first-century student.

Brickhouse (2001) contends that "in order to understand learning in science, we need to know much more than whether students have acquired particular scientific understandings. We need to know how students engage in science and how this is related to who they are and who they want to be" (p. 186). This includes understanding social structures, their inherent systems of power, and the influence of social institutions on women's intellectual development and access to scientific material. Support for cross-disciplinary research and training—among departments of education, science, engineering, and gender and ethnic studies—is not only warranted, but it is a lost opportunity if institutional leadership fails to forge and promote such connections.

It is vital that institutions explore the gender and racial climates within science and engineering schools and remove systemic barriers that adversely affect women of color, while employing evidence-based practices that help women of all backgrounds succeed. Retention of women of color attending selective institutions is critical given the relationship between such attendance and one's long-term career trajectory. Competitive admission to top STEM doctoral programs is dependent on several elements of a given student's education portfolio, not least of which is where she received her undergraduate degree (Eide, Brewer, & Ehrenberg, 1998; Lang, 1987; Zhang, 2005). If women of color cannot access and complete competitive undergraduate STEM programs, they will essentially be shut out of attending these same universities at the doctoral level and kept from joining the faculty.

The Obama administration's commitment to both scientific advancement and postsecondary completion for youth and adult student populations is an enormous opportunity for the STEM community to advance innovation as well as widen the educational and career STEM pipeline. As educators, we must demand commitment to diversity in full by keeping underrepresented populations at the center of related discussions taking place in Washington, statehouses, and chancellors' offices alike. This requires creative fiscal management and a challenge to the status quo of institutional practice. Pushing the established boundaries of education institutions for the purpose of inclusion is at the core of the very feminist discourse that helped frame this study. And push we must—for the sake of diverse scientific inquiry and for the sake of those who will shape the future of our scientific and technological world.

Notes

1. For the purposes of this article, the terms *Hispanic* and *Latina* are used interchangeably.
2. Most of the women who completed the 2008 CSS survey did so under the guidance of their campus (i.e., campus officials administrated the survey). However, in some cases, women were directly contacted by HERI to complete the survey online as part of the institute's plan to ensure a representative sample of minority and nonminority respondents; NIH Grant Number 1 RO1 GMO71968-01; NSF Award Number 0757076; see http://www.gseis.ucla.edu/heri/research.php.
3. Given my desire to address the experience of Asian American and Pacific Islander women as distinct from other women of color and White women, I chose to allow the Asian American/Asian and Native Hawaiian/Pacific Islander categories to stand as mutually exclusive ethnic subcategories within the women of color sample. Also note that the terms *Native American* and *American Indian* are used interchangeably in this article.
4. The average number of women in the sample, per institution, was thirteen for women of color and seven for White women.

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