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Treating women as a homogeneous group obscures important racial and ethnic differences among women in STEM. This chapter focuses on the experiences of women of color in science and engineering and highlights the importance of addressing intersecting identities among women.

Women of Color in Science, Technology, Engineering, and Mathematics (STEM)

Dawn R. Johnson

Scholars have theorized and examined women's underrepresentation in science, technology, engineering and mathematics (STEM) fields for well over thirty years (Clewell and Campbell, 2002). However, much of this research has paid little attention to issues of racial and ethnic diversity among women, suggesting that all women have the same experiences in STEM (Clewell and Ginorio, 1996; Hanson, 2004). Women of color were excluded from research designs, or when they were included their numbers were too small for any meaningful analysis (Clewell and Ginorio, 1996). Some researchers did not describe the racial and ethnic composition of their samples, even if only to note that all of the participants were white women, or simply chose not to examine racial and ethnic differences in the design of the study (Atwater, 2000). Ignoring race and ethnicity obscures important dimensions of women's experiences in STEM and fosters the notion of a universal gender experience among women, without considering the differential experiences of women of color or the effects of racial privilege for white women (Atwater, 2000; Collins, 1999; Hanson, 2004). Women of color should not be further marginalized in a body of research that, in theory, is about transforming women's underrepresentation in male-dominated academic disciplines and career fields.

There are many calls for inclusion of women of color in STEM research and policy development in conferences and symposia (Malcom, Hall, and Brown, 1976; Ong, 2010), published literature reviews (Clewell and Anderson, 1991; Ong, Wright, Espinosa, and Orfield, 2011), and scholarly critiques (Atwater, 2000; Clewell and Ginorio, 1996; Collins,

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1999). A body of research on women of color in STEM has emerged to include research on African American (Hanson, 2009, 2004; Perna and others, 2009), Asian American (Chinn, 2002, 1999), and Latina (Brown, 2008) women, as well as women from other racial and ethnic groups (Carlone and Johnson, 2007; Ong, 2005; Trenor and others, 2008). Much of the published research used qualitative methods (Foor, Walden, and Trytten, 2007; Johnson, 2007; Tate and Linn, 2005), while others used quantitative analyses on large datasets (Brown, 1995; Espinosa, 2011; Hanson, 2009; Johnson, forthcoming; Nelson and Brammer, 2010) or employed a mixed-methods approach (Trenor and others, 2008). There were also several studies that included gender and race or ethnicity as variables to analyze the experiences of women of color (Bonous-Hammarth, 2000; Grandy, 1997, 1998; Huang, Taddese, Walter, and Peng, 2000; Leslie, McClure, and Oaxaca, 1998; Malone and Barabino, 2009; Smyth and McArdle, 2004). The majority of the research on women of color in STEM has focused on undergraduate women, with fewer studies examining graduate students or faculty (Ong, 2010).

In 2008, women of color accounted for 34 percent of all female undergraduate students and earned 26 percent of the bachelor's degrees awarded to women across all fields of study (National Science Foundation, 2011). These demographics suggest the need for inclusive scholarship on women in STEM because "it is no longer feasible, or appropriate, or just to conduct research solely on white subjects and use the findings of this research to make policy decisions for the entire populace" (Clewell and Ginorio, 1996, p. 216). To that end, this chapter provides an overview of how women of color are represented in higher education as undergraduate and graduate students and faculty. The unique challenges of race and ethnicity for women of color in STEM are discussed, as well as suggestions for institutional research practices that can build on the knowledge of women of color in STEM.

Definitions of STEM Fields and Women of Color

There are variations in the identification of particular academic disciplines as "STEM." For example, the National Science Foundation (NSF) uses the term *science and engineering* to include agricultural, biological, and computer sciences; atmospheric, earth, and ocean sciences; mathematics and statistics; astronomy; chemistry; physics; aerospace, chemical, civil, electrical, industrial, materials, and mechanical engineering; social sciences, and psychology (National Science Foundation, 2011). Using this definition, the NSF reported that women earned 50 percent of the bachelor's degrees in science and engineering fields in 2008; however, when the social science and psychology fields are excluded, the data show that women earned 39 percent of science and engineering bachelor degrees

(National Science Foundation, 2011). A report authored by Chen and Weko (2009) using data from the National Center of Education Statistics defines *STEM fields* as including the natural sciences (physical, biological, and agricultural sciences), engineering and engineering technologies, computer and information sciences, and mathematics. Chen and Weko (2009) noted their definition of STEM excludes social sciences and psychology because various state and federal legislative actions regarding STEM access and education do not include these fields. The STEM data from the NSF (2011) reported in this chapter do not include social science and psychology fields because these areas of study are heavily populated by women.

In discussing women of color in the context of STEM fields, most research and policy reports focus on black/African American, Latina/Hispanic, and Native American/American Indian women because these racial and ethnic groups are underrepresented in STEM fields relative to their representation in the overall population in the United States (Clewell and Anderson, 1991; Malcom, Hall, and Brown, 1976; National Science Foundation, 2011; Ong, Wright, Espinosa, and Orfield, 2011). Women from those racial and ethnic groups are referred to as "under-represented women" (Towns, 2010), "underrepresented minority women" (Nelson and Brammer, 2010), or "women from underrepresented groups" (Hill, Corbett, and St. Rose, 2010). Asian Pacific American women may be included in research on women of color in STEM (Carlone and Johnson, 2007; Ong, Wright, Espinosa, and Orfield, 2011), but more often they are excluded because they are not underrepresented in STEM fields relative to their representation in the U.S. population (National Science Foundation, 2011). However, this exclusion obscures the different rates and patterns of STEM participation among the ethnic groups designated as Asian Pacific American (Lee, 1997), and it does not account for the racial discrimination faced by Asian Pacific American women (Chinn, 2002, 1999) or for their earning fewer STEM degrees than their male counterparts (Hill, Corbett, and St. Rose, 2010). As the number of individuals identifying as multiracial increases, STEM policymakers must consider how to include this group of women (Ong, Wright, Espinosa, and Orfield, 2011) because scholars already include multiracial women in their research on women of color (Carlone and Johnson, 2007; Foor, Walden, and Trytten, 2007; Tate and Linn, 2005). This chapter defines *women of color* as black/African American, Latina/Hispanic, Native American/American Indian, Asian Pacific American, and multiracial women, recognizing that although women of color may share the common experience of racial oppression and discrimination, each racial and ethnic minority group also has unique social, economic, and political histories that contribute to their experiences of oppression and discrimination in the U.S. educational system (Andersen and Collins, 2001).

Patterns of Representation Among Students and Faculty

Data indicate that as undergraduate students, women of color expressed greater intention to major in STEM at the start of their freshman year of college than white women (National Science Foundation, 2011; Smyth and McArdle, 2004). In 2008, 13.4 percent of white female first-year students indicated their interest in majoring in STEM, compared to 29 percent of Asian Pacific American women and 16 percent of women from each of the underrepresented racial and ethnic groups (National Science Foundation, 2011). Enrollment data by undergraduate major are available only for engineering fields; these data indicate that women's enrollment in undergraduate engineering majors peaked at close to 20 percent in 1999 and hit a ten-year low in 2006 at 17 percent (National Science Foundation, 2009), with only a slight increase to 17.5 in 2008 (National Science Foundation, 2011). The racial and ethnic composition of women enrolled in engineering majors in 2008 (among all students) included 10.7 percent white, 2.2 percent Asian, 2 percent Hispanic, 1.4 percent black, 1 percent foreign national, and less than 1 percent Native American women (National Science Foundation, 2011). As highlighted in the first chapter of this volume, factors related to choosing a STEM major for women of color include high school math and science preparation, mother's level of education, expectations from parents of completing college, having a parent who works in a STEM field, and having a positive attitude toward science (Hanson, 2004; Huang, Taddese, Walter, and Peng, 2000; Leslie, McClure, and Oaxaca, 1999).

Women earned 38 percent of the STEM baccalaureate degrees (excluding psychology and social science fields) in the United States in 2008, including 18 percent in engineering and computer science fields (National Science Foundation, 2011). Among all students earning bachelor's degrees in STEM in 2008, women of color from underrepresented groups earned 6.1 percent, Asian Pacific American women earned 4.8 percent, white women earned 23.5 percent, women identified as "other" or race unknown earned 2 percent, and women identified as temporary residents earned 1.4 percent (National Science Foundation, 2011). Women from underrepresented groups had the lowest rate of STEM persistence among all students in STEM (Bonous-Hammarth, 2000; Grandy, 1998; Smyth and McArdle, 2004). Factors related to STEM persistence for women of color include SAT math scores, grades from high school, parental level of education and employment in a STEM field, and having plans to attend graduate school in a STEM field (Bonous-Hammarth, 2000; Huang, Taddese, Walter, and Peng, 2000; Leslie, McClure, and Oaxaca, 1999; Smyth and McArdle, 2004).

At the graduate level, women made up 34.4 percent of the graduate students enrolled in STEM fields in 2008, with 14.8 percent white women,

1.6 percent black/African American women, 2.6 percent Asian Pacific Islander women, 1.5 percent Hispanic/Latina, and less than 1 percent American Indian women. Women with temporary resident status were 11.8 percent and women indicating their race as "other" or whose race or ethnicity was unknown were 2 percent of graduate students in STEM fields (National Science Foundation, 2011). Nearly 33 percent of master's degrees in STEM fields were earned by women in 2008; white women earned 13.6 percent, black/African American women earned 1.7 percent, Asian Pacific Islander women earned 3.4 percent, Hispanic/Latina earned 1.3 percent, American Indian women earned less than 1 percent, women identified as "other" or whose race or ethnicity was unknown earned 2.2 percent, and women with temporary resident status earned 10.4 percent (National Science Foundation, 2011). Among the doctorates conferred in STEM fields in 2008, 37.4 percent were earned by women; 25.6 percent were white, 4.7 percent were Asian Pacific Islander, 2.1 percent were black/African American, 1.8 were Hispanic/Latina, fewer than 1 percent were American Indian, and 3 percent were women identified as "other" (National Science Foundation, 2011).

An examination of women's representation among STEM faculty across discipline and rank indicates that women were well represented in life sciences fields, making up 32.3 percent of associate and assistant professors and 22 percent of full professors in 2008. Women were less represented in computer science, engineering, and the physical sciences, with engineering having the fewest women on faculty (17.5 percent associate and assistant professors and 5 percent of full professors in 2008; National Science Foundation, 2011). However, the portrait for women of color faculty in STEM is quite bleak. Nelson and Brammer's 2010 report on faculty diversity in science and engineering at research universities indicated that out of 14,400 tenured or tenure-track faculty in the top fifty departments in the United States, 1,678 faculty were women and 88 faculty were women from underrepresented racial or ethnic groups. Towns (2010) made a simple yet important observation: that increasing the number of women of color on STEM faculty requires supporting them at the undergraduate and graduate levels.

The "Double Bind" for Women of Color in STEM

In describing the experiences of women of color in STEM, Malcom, Hall, and Brown (1976) used the term *double bind* to convey the idea that women of color as scientists experience oppression and discrimination based on their race or ethnicity and gender, resulting in women of color being the least recognized and valued, and the most invisible and marginalized, among underrepresented groups in STEM (Malcom, Hall, and Brown, 1976). Evidence of the double bind exists in detailed accounts from women of color about numerous instances of racism and sexism

encountered in STEM educational environments (Foor, Walden, and Trytten, 2007; Johnson, 2007; Malone and Barabino, 2009; Ong, 2005; Ong, Wright, Espinosa, and Orfield, 2011). As a result of being in both the racial and ethnic and the gender minority groups, women of color experienced isolation from peers and a lack of support from faculty, while various sociocultural factors influenced the way women of color negotiated the culture, values, and practices in the sciences. However, even though some women of color paid the price for the double bind by leaving their STEM educations and aspirations, others found agency, resilience, and support in the midst of the racial and gender oppression (Brown, 2008; Johnson, 2005; Ong, 2005; Tate and Linn, 2005).

Exclusion, Isolation, and Lack of Belonging. Women of color in STEM reported feeling excluded in the academic environment when they were avoided by white students in choosing where to sit in a classroom, and selecting partners for group assignments, laboratory work, and informal study groups (Johnson, 2007; Malone and Barabino, 2009; Ong, 2005; Tate and Linn, 2005). Women of color were isolated as "the only one" in the classroom or laboratory (Malone and Barabino, 2009) and when they were not included in informal networking and socializing among students and faculty where useful information was shared about classroom and laboratory work, as well as scholarship and research opportunities (Foor, Walden, and Trytten, 2007; Malone and Barabino, 2009; Tate and Linn, 2005). The lack of racial and ethnic diversity in STEM meant that women of color from underrepresented groups had fewer racial and ethnic group peers to provide critical academic and social support (Tate and Linn, 2005). Less-than-positive perceptions of the broader racial climate on campus negatively contributed to overall sense of belonging for women of color in STEM (Johnson, forthcoming), and the extent to which women of color felt their institution was committed to racial and ethnic diversity on campus and in STEM fields (Malone and Barabino, 2009).

Because much of the work in STEM is done in teams, the isolation had a significant impact on the extent to which women of color experienced belonging to their STEM major or department (Foor, Walden, and Trytten, 2007). This sense of belonging affected how women of color developed and maintained their identity as scientists (Carlone and Johnson, 2007; Ong, 2005; Tate and Linn, 2005). Women of color who were recognized by peers and faculty for their contributions and expertise had positive identities as scientists; those whose work went unnoticed and unacknowledged had difficulty establishing their science identity within their academic communities (Carlone and Johnson, 2007; Malone and Barabino, 2009; Ong, 2005; Tate and Linn, 2005).

Lack of Faculty Support. STEM learning environments for undergraduate students typically feature large lecture classes at the introductory level in which students compete with each other during class for the attention and recognition of the instructor (Johnson, 2007; Seymour and

Hewitt, 1997). These learning environments were not supportive for many students (Seymour and Hewitt, 1997), especially for women of color, who were discouraged by faculty from continuing in their major when seeking help with difficult course material; faced with the racial stereotypes faculty had about their academic abilities; and ignored by faculty during classroom discussions, research meetings, or laboratory work (Brown, 2008; Foor, Walden, and Trytten, 2007; Malone and Barabino, 2009; Ong, 2005). Women of color were less likely to be highly recommended by faculty for fellowship opportunities (Brown, 1995) and received little guidance and support from faculty as they completed their research and looked for fellowship, grant, and internship opportunities (Malone and Barabino, 2009). Faculty in STEM often actively discouraged discussion of diversity issues in class, which left women of color feeling silenced and ignored (Johnson, 2007).

Social and Cultural Influences. Science culture is identified with notions of whiteness and masculinity, even though science is portrayed as being objective and neutral regarding issues of racial, ethnic, cultural, and gender differences (Johnson, 2007; Seymour and Hewitt, 1997). The culture of science is a meritocracy that is seen as competitive, difficult, and intellectually superior to other academic and professional fields because of the required technical and scientific expertise (Burack and Franks, 2006; Johnson, 2007; Seymour and Hewitt, 1997). These values stood in sharp contrast to the cultural values for women of color who strongly identified with their racial, ethnic and cultural backgrounds, and this made it difficult to navigate STEM environments. Cultural conflicts existed in performing laboratory procedures (for example, dissecting animals), asserting oneself in classroom and laboratory spaces, and competing with peers for grades, correct answers, and recognition from faculty (Carlone and Johnson, 2007; Foor, Walden, and Trytten, 2007; Johnson, 2007; Ong, 2005; Seymour and Hewitt, 1997).

Managing multiple demands from the role of student and from family responsibilities also shaped how women of color experienced STEM. Some Latinas described conflict between the expectations of fulfilling traditional gender roles within their families and the desire to pursue their college education and STEM major (Brown, 2008; Trenor and others, 2008). Asian Pacific American women also described meeting familial responsibilities and roles (Chinn, 2002) and family expectations of choosing a career in science and engineering (Trenor and others, 2008). The socioeconomic realities of many women of color necessitated working long hours to pay for college and support their families, and commuting from home rather than living on or near campus, which in turn affected their ability to participate in study groups, internships and other research experiences (Foor, Walden, and Trytten, 2007; Trenor and others, 2008).

Agency, Resilience, and Sources of Support. Even though women of color reported many challenges in their STEM experiences, agency and

resilience were found among those who persisted to degree completion. Campus resources, including support groups, learning communities, undergraduate research programs, and student organizations geared toward students of color or women, were helpful for women of color (Brown, 2008; Espinosa, 2011; Johnson, 2005; Tate and Linn, 2005; Trenor and others, 2008). Academic resources such as course-related enrichment seminars, tutoring, study skills courses, and academically supportive residence halls were also important for women of color (Brown, 2008; Johnson, 2005, forthcoming; Tate and Linn, 2005; Trenor and others, 2008). Family (Hanson, 2004, 2009; Foor, Walden, and Trytten, 2007; Trenor and others, 2008), racial and ethnic peer groups outside of STEM majors (Tate and Linn, 2005), and mentoring experiences from alumni, faculty, and upper-level students were important forms of social support for women of color (Brown, 2008; Johnson, 2005; Tate and Linn, 2005; Trenor and others, 2008).

A strong sense of racial or ethnic identity gave many women of color the resilience and agency to cope with the stereotypes and marginalization they experienced in STEM (Brown, 2008; Malone and Barabino, 2009; Tate and Linn, 2005). Some women of color used their racial or ethnic and gender identity to manipulate stereotypes and gain visibility and credibility among peers and faculty (Ong, 2005), while other women of color used culturally relevant and humanistic goals for pursuing a career in science (e.g., giving back to their community, being a role model for girls of color, helping their family, wanting to make a difference in society) as tools for persisting in STEM (Espinosa, 2011; Trenor and others, 2008) and creating their science identity (Carlone and Johnson, 2007).

Implications for Developing Inclusive Research Practices

Women of color account for a growing number of undergraduate students and bachelor's degree recipients supplying the pipeline for careers in STEM fields (National Science Foundation, 2011). Understanding access and retention for women of color in STEM is critical for the development of the diverse scientific workforce necessary for addressing national and global issues (Ong, Wright, Espinosa, and Orfield, 2011). Increasing knowledge about women of color in STEM areas requires inclusive research practices, such as developing research designs that examine racial and ethnic differences, describing the racial and ethnic composition of samples, and considering issues of race and ethnicity in interpretation and discussion of the results, along with acknowledgment of the limitations associated with racially homogeneous samples. In studying students of color in STEM, gender differences should be analyzed and discussed, and multiracial women should be included in research samples given their increased representation on many campuses. Finally, research practice can

incorporate multiple forms of data, such as using institutional records to augment data from individual interviews, focus groups, or surveys; and examining the experiences of women of color at the undergraduate, graduate, and faculty levels to gain multiple perspectives on the STEM environment and inform institutional policy development and practice.

Developing inclusive research practices also means addressing issues relevant to women of color in STEM. Further research is needed on the racial climate in STEM departments and classrooms and how this climate contributes to the decisions of women of color to stay or leave STEM fields at the undergraduate, graduate, and faculty levels. More understanding is needed about how women of color develop their racial and ethnic identities in STEM contexts and how these identities help women of color construct science identities and develop resilience in STEM. Finally, more research is needed about the teaching and advising practices of STEM faculty who have created supportive learning environments for women of color and how these pedagogies can be used to transform STEM educational practice. Taken together, these directions for inclusive research practices allow development of STEM educational policies and programs that take into account the needs of women of color, and bring complexity and depth to the scholarship on women in STEM by addressing the diversity of women's experiences in these fields.

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