Fall 2013

Minority Women in STEM: A Valuable Resource in the Global Economy

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Abstract

While there is an expected demographic shift of the ethnic minority population in the United States to become the majority population by 2020, few minority women successfully attain baccalaureate degrees in science, technology, engineering, and mathematical (STEM) fields. To address this gap, this article employs critical race feminism and narrative analysis methods to examine minority women's challenges while pursuing undergraduate STEM degrees. Findings suggest that limited access to the field, isolation and alienation, and affordability create barriers that result in many minority women leaving STEM majors. Implications for practice include targeted institutional efforts to increase recruitment and retention efforts towards degree attainment for minority women to achieve the national goal of increasing America's global preparedness.

The economic and technological growth of the United States in response to the rapidly changing global economy presents significant challenges for industry to seek out skilled and diverse workers, including minority women for the 21st Century competitive workforce (Committee on Underrepresented Groups and the Expansion of the Science and Engineering Workforce Pipeline et al., 2011). The increasing knowledge based economy requires a diversified workforce with highly technical educational skills, specifically in science, technology, engineering, and mathematical (STEM) fields in order to adequately meet the needs of industry and remain competitive in the global economy. While there is an expected demographic shift of the ethnic minority population in the United States to be the majority population by 2020 (Hobbs & Stoops, 2002), there are low representations of minorities and women in the STEM fields of study (Espinosa, 2011; D. Johnson, 2007; Malcom & Malcom, 2011; National Science Foundation, 2011, 2013).

Even though minority women[1] represent the largest increase in postsecondary access and degree attainment over the last decade (National Science Foundation, 2013), few minority women successfully attain baccalaureate degrees in the STEM majors. For instance, in college among the women of color who begin in a STEM major, few students remain after their freshman year (Bowen, Chingos, & McPherson, 2009; Espinosa, 2011; Malcom & Malcom, 2011; National Science Foundation, 2011, 2013; Ong, Wright, Espinosa, & Orfield, 2011). Thus, there is a glass ceiling[2] that women of color face as they try to pursue undergraduate degrees in STEM fields.

[1] In this manuscript the terms women of color and minority women are used interchangeably to refer to African American women, Latinas, and Native American and/or indigenous women.

[2] The glass ceiling refers to barriers that women face when trying to advance in their careers (Harris, Wright, & Msengi, 2011; Jones & Palmer, 2011). To shatter the glass, means to remove obstacles that women face while advancing into to leadership positions (Cech & Blair-Loy, 2010; Marina & Fonteneau, 2012). In this article, we expand the definition of glass ceiling to include the roadblocks that minority women face while pursuing STEM degrees.

Research indicates that women of color are likely to depart from STEM majors due to the lack of mentorship and lack of developing a STEM 'identity,' which is usually closely tied to the development of a close research relationship with a faculty member (Carlone & Johnson, 2007; Johnson, 2006; Ong, 2005). The low numbers of STEM graduates among women of color limits the talent pool of graduate and professional students and subsequently those in the STEM workforce (Committee on Underrepresented Groups and the Expansion of the Science and Engineering Workforce Pipeline et al., 2011). This presents a unique opportunity and challenge for higher education professionals and industry. More specifically, minority women represent a huge untapped resource for our country with the increased emphasis on global preparation in higher education and industry. However, the United States lags behind several underdeveloped countries in engineering degree conferral, moving from 2000 to 2010. Thus, the U.S. devoting additional resources to minority women in STEM is expected to increase our country's diversity in STEM fields, the workforce, and global preparedness.

Moreover, few scholars have focused on understanding minority women's experiences while pursuing STEM majors. Contemporary research shows that women of color face discrimination inside college science classrooms due to their race and/or gender (Carlone & Johnson, 2007; Ceglie, 2009; Marlone & Barbino, 2008; Ong, 2005; Ong, Wright, Espinosa, & Orfield, 2011). Those who remain in STEM majors have a sense of belonging and develop a STEM identity. So, the current study answers the following question: What are the barriers that minority women face while pursuing undergraduate STEM degrees?

This article investigates the challenges that minority women face both institutionally and individually while pursuing STEM majors at research intensive universities. It begins by reviewing the literature on women of color in STEM. A discussion of the critical race feminism framework follows. It then discusses the research methods, data analysis procedures, the results, conclusions, and implications for practice.

Literature Review on Women of Color in STEM Fields

Over the last few decades, among U.S. adults ages 21-35, minority women represent the largest increase of baccalaureate degree recipients (National Science Foundation, 2013). Yet, a plethora of research confirms that women of color continue to be underrepresented in STEM fields (Carlone & Johnson, 2007; Clewell & Anderson, 1991; Espinosa, 2011; D. Johnson, 2007; Malcom & Malcom, 2011; National Science Foundation, 2011, 2013; Ong, 2005; Seymour & Hewitt, 1997). In addition to gender, women of color have to deal with multiple identities of race and social class when navigating through STEM majors. When developing recruitment strategies and programs to attract women and minorities to the STEM fields of study, it is important to include institutional issues of race, class and gender. What follows is a discussion of the leading debates about issues surrounding why minority women leave from STEM fields.

Some explanations offered to explain why few women of color are in the STEM fields are based on (1) individual factors, (2) K-12 school factors, and (3) environmental factors, which might be due to *the glass ceiling effect*. First, an individual factor, self-perception of math and science ability explains why few women of color participate in

STEM fields. A barrier to girls of color and women of color participating in math and science revolves around their attitudes and perceptions cultivated in a negative context such as school and home (Clewell & Anderson, 1991; Clewell & Ginorio, 1996). Other individual factors that explain their departure from STEM fields include: stereotypes about gender roles and how the fields are dominated by boys and men (Hill, Corbett, & St. Rose, 2010). Similarly, when girls or women face barriers because of their gender, due to a perceived *glass ceiling*, then they are more likely to *leak out* of the STEM pipeline prior to baccalaureate degree completion. Additionally, perceptions about the utility of math and science in everyday experiences, self-confidence and self-concept influence whether or not they continue to pursue science or math. Those female students who believe math or science is less valuable or not relevant in their everyday lives, are more likely to leave STEM fields all together.

Second, school factors account for the departure of some girls of color and women of color from STEM fields. These include representation in textbooks, peers' participation in science and math, teachers' encouragement or discouragement (Clewell & Anderson, 1991; Clewell & Ginorio, 1996; Hill et al., 2010). The leaky pipeline is another school factor for women of color leaving hard science majors. The leaky pipeline image "suggests that girls and boys of all races begin school curious about the world around them–eager and ready to learn about science" (Johnson, 2006, p. 136). However, girls and women become disengaged in science and math and thus leak out of the pipeline in K-20 schools and careers (Blickenstaff, 2005). Limited access to advanced placement courses is another school factor that contributes to some girls of color departing from STEM fields. In high school, some girls of color are less likely to enroll in advanced science and math classes as well (Ceglie, 2009; Espinosa, 2011).

Third, the environment, namely the science culture (e.g., teaching, pedagogy) might account for fewer women of color pursuing degrees or careers in STEM fields, due to the *glass ceiling effect*. In college, women of color might feel discouraged to participate in science majors due to the large lecture style classes taught by professors, professors who are unavailable to assist them with the curriculum, and/or challenges on multiple choice exams (Espinosa, 2011; A. Johnson, 2007). Gendered racial microaggressions[3] also contribute to fewer women of color in science classrooms (Espinosa, 2011; Sonowski, 2002). As a result of the chilly departmental climates and non-supportive institutional climates, fewer women of color engage in STEM majors. Hence, it is understandable that fewer African American women and Latinas earned bachelors' degrees and advanced degrees, especially doctorates in STEM fields when compared to their white female counterparts (Bowen et al., 2009; Ong, 2005; Ong et al., 2011). To better understand the *lived experiences* of women of color who pursue undergraduate STEM majors, we employ critical race feminism as a framework for understanding minority women's challenges in STEM majors. This is discussed further in the next section.

[3] Microaggressions are "brief and commonplace daily verbal, behavioral, and environmental indignities, whether intentional or unintentional, that communicate hostile, derogatory, or negative racial, gender, sexual orientation, and religious slights and insults to the target person or group (Sue, 2010, p. 5). Microaggressions can be raced, classed, gendered. They can also be in the form of microinsults, microassualts, and microinvalidations.

Theoretical Framework: Critical Race Feminism

This section outlines critical race feminism to better understand the lived experiences of women of color. Critical race feminism draws from critical legal studies and critical race theory (Evans-Winters & Esposito, 2010; Wing, 1997, 2003). Critical legal studies centered on "postmodern critiques of individualism and hierarchy in modern Western society" (Wing, 1997, p. 2), but it omitted the narratives of people of color and women. Hence, critical race theory (CRT) emerged through critical legal studies in order to tell the stories of people of color (Taylor, Gillborn, & Ladson-Billings, 2009; Wing, 1997, 2003). CRT employs multiple academic perspectives, including women studies, legal studies, sociology, and history to examine an individual and/or or a group's past and current experiences with race and racism (Harris, 2002). CRT places race at the center of analysis when examining educational access and degree attainment within the context of society, education and the law (Dixson & Rousseau, 2006; Ladson-Billings & Tate, 2006; Parker & Lynn, 2002; Taylor, Gillborn, & Ladson-Billings, 2009). It also confronts mainstream viewpoints about race in society, such as colorblindness, meritocracy, and equal opportunity. The counternarratives or the *stories* of these communities and program recipients allows for us to understand intervention programs that emanate from educational policies intended to address educational inequities in underserved communities (Solórzano & Yosso, 2002). CRT researchers acknowledge that changes in educational policies to benefit minorities or underserved communities must align with the economic and self-interests of whites, better known as interest convergence process as well (Bell,1980; Delgado & Stefancic, 2000).

Absent from critical race theory is the focus on multiple identities to better understand the experiences of women of color within law and society (Evans-Winters & Esposito, 2010; Wing, 1997, 2003). Critical race feminism fills this gap by using an intersectional perspective that centers on women of color's multiple identities of race, gender, social class, and national origin. As a framework, intersectionality privileges women of color in their everyday lived experiences of oppression and/or discrimination due to their multiple identities (Balderama, Texeira, & Valdez, 2004; Collins, 2000; Crenshaw, 1995; Feagin & Yanick, 1998; Gutiérrez y Muhs, Neimann, Gonzalez, & Harris, 2013; Reynoso, 2004; Seo & Hinton, 2009). These experiences can occur at home, in health care settings, the work place, and even school. By applying critical race feminism as a framework, scholars privilege women of color's counterstories in legal studies, education, gender and women's studies, in the workplace, and in the global economy (Evans-Winters & Esposito, 2010; Wing, 1997, 2003)

When we examine the technical fields of study, which provides a trajectory to higher paying skilled jobs and upward social mobility there is a *glass ceiling*, where minority women might face challenges trying to obtain educational degrees and/or advance in their careers. Critical race feminism researchers can provide a framework for understanding the stories and 'voices' of minority women as the focal point of our study. For that reason, we provide personal narratives from real-life case examples as higher education practitioners as a way to identify raced, gendered, and classed experiences that minority women face during their undergraduate studies. Following is a discussion of the methods employed for this study.

Research Methods

Our research addresses the following question: What are the barriers that minority women face while pursuing undergraduate STEM degrees? In this article we employed the narrative analysis as a qualitative methodological approach, more specifically personal narratives to reveal undergraduate minority women's everyday experiences with race, class, and/or gender in STEM majors.

Narrative Analysis. Narrative analysis is an approach to gathering data that is useful for "oral, first-person accounts of experience" (Reissman, 1993, p. 69). Within narrative analysis researchers or practitioners can draw out personal narratives of their lived experiences and others (Ellis & Bochner, 2000). A personal narrative "refers to talk organized around consequential events. A teller in a conversation takes a listener into a past time or "world" and recapitulates what happened then to make a point, often a moral one" (Reissman, 1993, p. 3). This passage suggests that main point of personal narratives is not for generalization, but to get a better understanding of the storyteller's lived experiences. Ellis and Bochner (2000) add that personal narratives usually center on a "single case" that may elicit an emotional response to a traumatic experience (p. 744).

Data collection methods. Personal narratives are used by the authors to share and learn from our personal and practical experiences working with seven minority women students in STEM majors in selective postsecondary settings in the Midwest. According to the Carnegie Foundation (2013), these institutions can be described as public universities with high research activity in a suburban and/or urban context.

Data analysis procedures. We engage in the data analysis technique of open coding to organize and interpret our data. The opening coding allows us to examine recurrent themes from the written narratives (Ryan & Bernard, 2000). Then we placed the narratives into an analytic matrix to further analyze and interpret the data. The interpretive approach is appropriate for understanding the meaning of a storyteller's experiences (Reissman, 1993). Scholars suggest that the "interpretation of events can be judged against another but there is no standard by which to measure any narrative against the meaning of the events themselves" (Ellis & Bochner, 2000, p. 745). This quote suggests that the meaning of the person's story is subjected to the listener's interpretation of the events. Through personal narratives we show that meaningful patterns and trends can be found in the data, and these patterns and trends are presented below.

Findings on Minority Women in STEM

Minority women encounter barriers while pursuing undergraduate degrees in STEM majors due to limited access to the field, isolation and alienation, and affordability. Using a critical race feminism framework, we further uncover these roadblocks in this section.

Limited access to the field. By using a critical race feminism perspective, our practical experiences provide evidence that minority women have a limited understanding of the academic preparation needed to successfully attain STEM degrees. This is displayed in the narratives below.

As a first-generation, Latina college student, Sabrina is a biology major. She has aspirations of attending medical school. She attended a suburban college preparatory high school and received above average grades. She received credit for four AP courses including, Pre-Calculus, Calculus, Chemistry, and English. Given her strong academic background she enrolled in four heavy classes with 17 credit hours, including Chemistry, Chemistry Lab, Calculus, and Biology for the first semester. After her first term, she landed on academic probation and was at-risk of losing her scholarship. So, her family asked for her to leave school and to come home and get a job.

> A first-generation, African American female college student, Tara was having challenges transitioning from a two-year college to a four year college. She was failing her calculus class. She ultimately withdrew from that class and focused on her other classes. She worked part-time and was a full-time student. She wanted to stay in school instead of engaging in the street life (e.g., gangs, pregnancy) that many of her family members and peers belonged as a part of city life. She also wanted to be first person in her family to graduate from college with a degree in engineering. She retook the Calculus class the next term, but she failed it again. She attempted to register for the math class a third time, but was denied. She was then asked to leave the engineering major.
>
> Shondra was a second year biology major from an urban setting. This year, she took more a rigorous postsecondary curriculum. She failed a couple of the exams in her biology classes and informed her advisor that she would be *leaving the major*. Per the encouragement of her advisor, she continued to pursue biology. Her grades improved on the subsequent biology exams that term.

The above narratives suggest that the intersections of race, class, and gender might limit minority women's access to STEM curriculum, due to the lack of academic preparation, including study skills and prior math and/or science classes. Similar to prior research (Ceglie, 2009; Espinosa, 2011), academic preparation, financial challenges, and family pressures (as in the case of Sabrina) in turn creates a *glass ceiling* that results in some minority women departing from these fields. To date all of the women left STEM fields to pursue other majors at their respective undergraduate research intensive institutions.

Isolation and alienation. The critical race feminism framework allows for us to understand that minority women also faced isolation and/or alienation while pursuing STEM majors, as described in Cynthia and Maria's stories below.

> Cynthia was considered an exemplary student and tutored her peers in statistics and quantitative methods. Her instructor asked how she ended up in her third year majoring in a social science discipline. Cynthia began to describe her first memorable engineering experiences. She said that it was during the break from this large lecture and walking out and seeing very plainly the male restroom, while she hurriedly sought out the female restroom. After running down a flight of stairs and turning to see the few women from her lecture all standing in line for the *one woman* stall restroom located under the stairway and the size of a closet,

she was beginning to understand that she was not *welcome* in this discipline. She also talked about feelings of *isolation and alienation* even though four male friends from her high school also attended the same institution and were majoring in engineering. She talked about 'hanging out with them in private' and described their reliance on her almost 'in secret' for her keen math acuity but described feeling ignored by them when in public spaces in and around engineering. She began wondering out loud, "was it because they knew I was smarter than them, but I was a female?" Despite these feelings and experiences, she completed her first year in engineering and did well academically. However prior to her return to the university, she chose to identify a social science discipline and chose to use her math skills in research, where she experienced a more welcoming environment**.**

A Latina adult learner, and first-generation college student, Maria was in her second year pursuing engineering in college. She took a series of courses, including math, chemistry, and engineering. She informed her advisor that she faced challenges working with her male peers who doubted her abilities, yet they wanted her to complete her portion of the engineering group project *alone*. At that moment, she informed her advisor that she wanted to *leave engineering*, due to her isolation and alienation as a first-generation, Latina female in engineering. Her advisor encouraged her to stick with it and to delegate tasks. She successfully passed the engineering class with a C-.

The passages above suggest that isolation and alienation due to race, class, and/or gender create barriers for minority women pursuing STEM degrees. This is consistent with the literature on women of color who depart from STEM fields (Espinosa, 2011; Ong et al., 2011; Sonowski, 2002). Hence, STEM fields must create more welcoming environments in order to encourage minority women to remain in the STEM pipeline.

College affordability. Using the critical race feminism framework, we also found that affordability creates a *glass ceiling* for minority women pursuing STEM majors.

An African American female valedictorian, Alisa was from a low-income neighborhood in an urban setting. She planned to pursue business, more specifically finance as a major. She informed her academic advisor that her academic preparation from high school did not prepare her for college level curriculum. In high school, she *never had to study*. She also lacked her own books and materials for classes. So, she borrowed instructors' copies and used library copies. Despite the lack of resources, she made A's and B's on the majority of her assignments and quizzes. Sometimes she scored C's and D's. She sought support in office hours and during class for her economics and math classes. She made a 3.7 during the first semester. During the end of her freshman year, she was accepted into the College of Business at her respective institution.

> An African American woman from an urban setting, Theresa pursued engineering during her first semester of college. She failed chemistry and received an 'A' in math. She struggled to pay for her first term of college. So she dropped out of college during the second semester of college due to finances. A year later, she attempted to return to college to pursue the engineering major. However, the financial aid office denied her financial aid petition due to her lack of satisfactory academic progress.

These narratives point to the importance of college affordability and more specifically minority women's social class determining whether or not they continue to pursue STEM majors. While both African American women were from low-income backgrounds, Alisa continued to pursue her degree in finance. However, Theresa left college due to finances. Therefore, practitioners at postsecondary institutions may consider implementing re-entry or transition programs for minority women pursuing STEM, and include resources like funding for books, materials, and tuition along with academic resources such tutoring centers in order to increase the academic success of minority women.

Discussion, Conclusions, and Implications for Practice

This article sought to understand minority women's experiences in STEM that contributed to roadblocks that are consistent with the glass ceiling effect (Harris et al., 2011; Marina & Fonteneau, 2012). We found that limited access to the field, isolation and alienation, as well as affordability creates institutional barriers that result in some minority women leaving STEM fields.

These findings are consistent with prior scholarship that provides evidence that the lack of a sense of belonging in STEM fields, due to a chilly departmental climate, an unwelcoming institutional climate and/or academic preparation results in women of color leaving these fields (Ceglie, 2009; Espinosa et al., 2011; Hill et al., 2010; Ong et al., 2011; Sonowski, 2002). Our scholarship adds to theory on critical race feminism by understanding minority women's raced, classed, and/or gendered experiences in STEM fields (Evans-Winters & Esposito, 2010; Wing, 1997, 2003). It also contributes to STEM education debates and discussions on broadening the participation of underrepresented students by understanding the some of the challenges that minority women face while attempting to pursue STEM majors. It challenges institutions and organizations to collaborate to provide academic, financial and support resources in order to *shatter the glass ceiling* of barriers in postsecondary settings towards the goal of increasing the number of minority women successfully attaining baccalaureate degrees in STEM majors at research intensive institutions.

With adequate support and resources in college, women of color could fulfill a critical U.S. shortage of technical skills and knowledge, while diversifying the workforce in response to the rapidly growing global economy. This largely untapped human resource, among minority women specifically, can improve the country's move from the longstanding degree attainment of 39% to 60% by 2025 (Lumina Foundation, 2009) and support President Obama's 21st Century goal of U.S. global preparedness by cultivating domestic talent (Obama, 2009).

This scholarship has implications for practitioners and policymakers in postsecondary settings to prepare minority women for the STEM majors and careers in the global economy through mentoring and shifts in institutional climate. First, mentoring programs have proven successful in providing support to minority students in a variety of circumstances (Chang, Park, Singh, & Sung, 2008; Gordon, Iwamoto, Ward, Potts, & Boyd, 2009; Whiting & Mallory, 2007; Zand et al., 2009). Mentoring programs for minority students appear to support increased student engagement and student learning as well as an overall positive outlook for school (Converse & Lignugaris-Kraft, 2009; Whiting & Mallory, 2007). Mentoring is also effective in facilitating outcomes of persistence, retention, and graduation (Crisp & Cruz, 2009).

Second, the climate of the institutional environment must also be conducive to minority student success. Since STEM baccalaureate degree recipients are more likely to be white or Asian and male, organizational learning theorists suggest that the isolating STEM cultural environment promotes a negative learning environment that adversely impacts learning for minority and women STEM students (Kezar, Glenn, Lester & Nekamoto, 2008). Thus, it is critical that institutional leadership provide strong strategic policies that support a warm, welcoming, and multi-cultural institutional climate and structure. Some initiatives might include creating recruitment and retention programs along with services to target and support women of color, minority, and women students on the trajectory towards degree completion. By doing so, it is likely that the *glass can be shattered* for undergraduate minority women pursuing STEM majors, and the U.S. gains a strengthened and more diversified STEM talent pool for addressing our country's global challenges.

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