Texas Education Review

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Volume 2, Issue 2, pp. 163-172 (2014)
Available Online at www.txedrev.org

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Science, Technology, Engineering, and Math (STEM) education has become increasingly important as the U.S. continues to grow and develop in the age of innovation. This article inventories the literature on the topic by exploring the current landscape of STEM education, achievements in the field, and challenges that stand in the way.

According to economic experts in the U.S. Department of Commerce's Economics and Statistics Administration (2010), technological innovation accounted for almost half of U.S. economic growth over the past 50 years, and the 30 fastest-growing occupations in the next decade will require at least some background in science, technology, engineering, and math (STEM). Yet, American business leaders are concerned about the supply and availability of STEM employees. If this critical shortage of the STEM labor force continues to increase, American businesses will find it difficult to remain competitive in the global marketplace (U.S. Department of Commerce, 2010; National Science Foundation, 2006).

Importance of STEM Education

Due to its historical legacy in the global economy, U.S. leaders have been, and continue to be, concerned with producing adequate STEM workers to maintain its economic position in the world (e.g., NSF, 2006; Obama, 2009). A recent study by the National Science Foundation (2006) showed that the United States has one of the lowest STEM to non-STEM degree rates in the world, resulting in a pipeline of educated workers who lack necessary skill sets in the STEM workforce. In fact, the same report by the NSF indicated that in 2002, STEM degrees accounted for only 16.8% of all bachelor's degrees awarded at four-year universities to all students. Considering that the international average of STEM degrees awarded globally is 26.4% with Japan leading at 64% and Brazil just below the U.S. with the lowest at 15.5% (NSF, 2006), the future prospects for the U.S. maintaining its position as a powerful player in the knowledge-based economy looks bleak.

As a result, domestic leaders have not only increased funding, but also encouraged young Americans to pursue education and careers in the STEM fields. In 2009, for example, President Obama launched the "Educate to Innovate" campaign, a $260 million nationwide effort to move American students to the top of the pack in science and math achievement over the next decade. The campaign created a series of high-powered initiatives involving leading companies, foundations, non-profits, and science and engineering societies dedicated to motivating and inspiring young Americans to pursue studies in science and math. In his address to the key leaders of the STEM community, President Obama (2009) stated:

> For decades, we led the world in educational attainment, and as a consequence, we led the world in economic growth…but in this new economy, we've come to trail other nations in graduation rates, in educational achievement, and in the production of scientists and engineers. That's why my administration has set a goal that will greatly

> enhance our ability to compete for the high-wage, high-tech jobs of the future–and to foster the next generation of scientists and engineers.

Obama is not the first president to call attention to the knowledge economy gap. During President G.W. Bush's administration, a report entitled *Rising Above the Gathering Storm,* published by the National Academies' Committee on Science, Engineering, and Public Policy (2007), drew national attention to the STEM pipeline issue and called for legislative action to address this crisis. This report resulted in the passage of the America COMPETES Act (2007, 2010) to strengthen science-related education, programs, and research (Eagan, Sharkness, Hurtado, Mosqueda, & Chang, 2010; Hurtado, Newman, Tran, & Chang, 2010). The Act established a national priority to develop, recruit, and retain talent in science and engineering to advance U.S. economic competitiveness in the context of rapid globalization. However, Hurtado et al. (2010) argued that the report did not address the racial/ethnic STEM achievement gap or recommend how institutions with fewer resources could produce knowledgeable and innovative scientists.

Despite this gap in the America COMPETES Act (2007, 2010), the Congressional Commission on the Advancement of Women and Minorities in Science, Engineering, and Technology Development (2000) highlighted three important reasons explaining why racial/ethnic diversity in STEM is important. First, the current and projected need for more STEM workers coupled with the fact that underrepresented minorities comprise an increasing proportion of the labor pool, argue for greater racial/ethnic diversity in STEM education and careers. Second, recent surveys by Fortune 100 and American Management Association found that increasing diversity not only correlated with performance outcomes, such as annual sales, growth revenues, and worker productivity, but also with workplace culture outcomes, such as enhanced creativity, increased team problem-solving, and better utilization of talent.

Finally, a diverse workforce also propels businesses in reaching both global and domestic markets. For many STEM firms and corporations, foreign sources are becoming increasingly prominent in their revenues, which embolden the need for U.S. businesses to understand the market preferences of different cultures (Museus, Palmer, Davis, & Maramba, 2011; Toldson & Esters, 2012). Diversity in the workforce increases these firms' abilities to enter and enhance their presence in these global markets. Further, as minority populations become increasingly abundant in domestic markets, increasing diversity also promotes the cultural understanding and sensitivity needed for local markets. Some higher education institutions, as a result, have already begun to create minority initiatives that help recruit, retain, and graduate underrepresented students in STEM. The Center for Urban Education housed at the University of Southern California, for example, established the STEM toolkit, which "features tools that help colleges and universities reflect on how institutional practices and resources, as well as individual actions and behaviors, affect underrepresented student success" (Center for Urban Education, 2012, para.7).

Most recently, many national and regional organizations, such as the American Association of Community Colleges (AACC), the Institute for Higher Education Policy (IHEP), Educational Testing Service (ETS), The College Board, and the Association of Public and Land-Grant Universities (APLU) have raised the issue of the relative lack of success of boys and young men of color in K-12 schools and higher education. The APLU (2012), in particular, created a minority male STEM initiative that is charged with providing leading public higher education institutions with the tools, information, and perspectives that will assist them in their practice in identifying, retaining, and graduating minority males in STEM fields. Given the precedence and urgency, more research is needed to identify why an achievement gap exists for underrepresented minority men in the STEM pipeline, and to support institutions in helping these students become successful scientists.

Barriers to STEM Success

Two barriers that are particularly salient to underrepresented students in the STEM fields are psychological and sociological barriers, both of which have been well documented in the literature.

Psychological barriers. Ample research has suggested that psychological factors play an important role in the attainment of STEM degrees for all racial and ethnic minorities as well as women (e.g., Chang, Cerna, Han, & Saenz, 2008; Gloria & Kurpius, 2001; Hernandez & Lopez, 2005; Hurtado et al., 2008; Leslie, McClure, & Oaxaca, 1998; Waller, 2006). Self-concept (Bandura, 2010), the perception of oneself, and self-efficacy (Bandura, 2010), the belief in one's ability to accomplish a goal, are two of the most commonly cited psychological factors related to involvement and achievement among minority STEM college students. Leslie, McClure, and Oaxaca (1998) found that self-efficacy is an important predictor for STEM participation among racial/ethnic minorities and women. In addition, they found that White men have much higher levels of self-efficacy than students of color and women. These racial patterns are of particular importance because studies have consistently shown that higher levels of self-concept and self-efficacy are strongly correlated with a greater likelihood to enter science and math fields, personal commitment to science and math, and higher levels of adjustment, performance, and success in science and math (e.g., Anderson, 1990; Hackett, Betz, Casas, & Rocha-Singh, 1992; Leslie et al., 1998). Consequently, self-concept and self-efficacy are important psychological factors that affect the participation, retention, and success of underrepresented minorities.

Even though Leslie, McClure, and Oaxaca's (1998) study showed the importance of self-efficacy in STEM participation, other studies found that the impact of self-efficacy on STEM success is much more complicated. According to Seymour and Hewitt (1997), Blacks and Hispanics struggle with conflicting experiences of overconfidence and poor preparation, which inhibits their success in the STEM circuit. For example, the majority of Black and Hispanic students who enter college as a STEM major come from high schools where they were academically superior compared to their peers. As a result, these students developed strong confidence, but lacked the knowledge and skills necessary to achieve at high levels in a rigorous college classroom. Unfortunately, many of these students feel overwhelmed in their first semester and switch to less intense majors or drop out of college altogether because they begin to question whether or not pursuing a STEM degree is the right choice for them.

In order to combat this feeling of helplessness and increase a sense of belonging, Carlone and Johnson (2007) suggested a focus on the development of science identity as a useful lens to construe the experiences of ethnic/racial minorities and women. According to this research, exploring science identity can provide a better understanding of the social and cognitive processes surrounding learning, which provide researchers with the tools to revamp science education in an effort to make it more accessible. Endeavoring to tackle the notion of a student's science identity, Carlone and Johnson developed a conceptual model, which included three overlapping components of performance, recognition, and competence. Feelings of neglect or discrimination by meaningful others could upset or destroy a component of a student's science identity. These "meaningful others" include individuals who have power over a student's academic career, which are typically faculty members, but may also be peers and graduate students (Museus et al., 2011). Thus, Carlone and Johnson's framework informs scholars of the importance of self-concept and self-efficacy in the development of future scientists.

In addition to self-concept and self-efficacy, another major psychological theory related to STEM success for underrepresented minorities is stereotype threat. Stereotype threat can be defined as a minority students' fear of being reduced to a negative stereotype that is prominently acknowledged by society (Steele & Aronson, 1995). Steele and Aronson (1995) began their study hypothesizing that stereotype threat increases student anxiety, and therefore, inhibits performance on challenging tasks such as tests. Through their study, they demonstrated that performance peaked when students' anxiety was reduced, specifically regarding the confirmation of a negative stereotype. In addition, Perna et al. (2009) reported that stereotype threat adds to performance gaps between Blacks and Whites (see also, Brown et al., 2004; Gonzalez et al., 2002; Steele & Aronson, 1995) and between women and men (see also, Brown, 2004; Gonzales, Blanton, & Williams, 2002).

While research on stereotype threat can be disheartening, several studies have developed and tested interventions that can reduce the negative effects of stereotype threats (Aronson, Fried, & Good, 2002; Good, Aronson, & Inzlicht, 2003; Wilson & Linville, 1985). For example, the study conducted by Good, Aronson, and Inzlicht (2003) randomly assigned 138 seventh-grade students to four groups that had college student mentors to determine if a mentoring intervention could reduce the gender stereotype threat and close the gender gap in math test scores. The first treatment group was taught about the malleability of intelligence. The second treatment group was taught about challenges in adapting to a new grade level, as well as normalized feelings of isolation and anxiety during the transition. The third treatment group was taught a combination of both messages. Finally, the fourth group served as the control group and received no messages. At the end of the school year, students took a state standardized test in math and reading. Good, Aronson, and Inzlicht (2003) used analysis of variance tests to determine that the gender gap had disappeared in all three experimental groups. While this particular study focused on combating stereotype threats surrounding gender, it demonstrates that achievement gaps resulting from stereotype threats can be closed, and supports the need for further research.

Sociological barriers. In addition to psychological barriers, research has also shown that sociological factors have influenced Latina/o STEM degree attainment, specifically through cultural capital and cultural congruity theories. First conceptualized by Bourdieu (1984), cultural capital theory examines how a dominant group imposes systemic and evaluative standards on non-dominant groups. The purpose of Bourdieu's theory is to explain the struggles and virtual inability of lower class citizens to gain membership into the aristocracy. In order to move up in social class, the non-dominant group must conform to the norms and values of the dominant class, otherwise known as the process of acquiring "cultural capital." Nevertheless, because the aristocratic community seeks to maintain its status, it creates societal norms and standards that are difficult, if not impossible, for the non-dominant group to acquire cultural capital. In this way, the aristocracy is able to keep their position in society by creating and manipulating a system that benefits them and disadvantages non-dominant groups.

Numerous educational researchers have used cultural capital theory to explain the struggles of racial/ethnic minorities and women in moving up in social class (e.g., Dumais, 2002;

Monkman, Ronald, & Theramene, 2005). Cultural capital theory may also be applied to the STEM fields, where White males have historically created and currently maintain the knowledge, skills, and mindsets associated with being successful in these disciplines. In this case, White males constitute the aristocratic community and racial/ethnic minorities and women represent the non-dominant groups. Because White males created the STEM culture, racial/ethnic minorities and women must learn and adapt to their norms and expectations in order to succeed, such as the number of hours expected to study per week, the way to interact with faculty, or the way students should be learning. The extent to which a STEM student is able and willing to comply with these behavioral standards determines the value of his/her cultural capital, and thus, determines how successful the student will be in these disciplines (Rypisi, Malcom, & Kim, 2008).

Cultural capital also includes the knowledge, skills, and mindsets that are passed down to the student from the parents (what Bordieu calls *habitus*). According to a NCES report entitled *The Nation's Report Card* (2007) that used NAEP data, White and AAPI children ages 6 to 18 were more likely to have parents with higher levels of educational attainment than Latina/o children. On the one hand, researchers such as Dennis, Phinney, and Chuateco (2005) have theorized that White and AAPI students generally have more access to cultural capital through their parents, which not only better prepares them for college, but also serves as a stronger support system for coping during college. On the other hand, non-college educated parents are less likely to know how to support their children socially and academically during their college experiences (Pascarella & Terenzini., 2005). Due to this imbalance of cultural capital, Latinas/os are more likely to experience cultural incongruence, which occurs when minority or low socioeconomic students are immersed into White, middle class values at research-oriented universities (Gloria & Kurpius, 2001; Jones, Castellanos, & Cole, 2002). As a result of cultural incongruity, Latinas/os may feel isolated, culturally alienated, and unwanted during their college experience (Gloria & Rodriguez, 2000). Nevertheless, a recent study by Phinney, Campos, Kallemeyn, and Kim (2011) demonstrates that despite student preparation and ability representing important predictors of students' navigation along paths to a major in the STEM disciplines, progression through undergraduate science majors may be strongly influenced by the types of opportunities, experiences, and support students receive in college. Therefore, university administrators and faculty members potentially have tremendous power in influencing policies and programs that can ensure the success of all STEM students, regardless of their backgrounds or experiences.

In addition to cultural capital and cultural congruence theories, differences in cultural values may also create barriers for minority students in the individualistic and highly competitive STEM disciplines (Guiffrida, 2006; Museus, & Harris, 2010). Since many ethnic minority students come from cultures that are more intrinsically collective (Fisk, Kitayama, Markus, & Nisbett, 1998), past educational research has suggested that collectivistic pedagogy and environments can contribute to higher rates of success among racial and ethnic minority students (Guiffrida, 2006; Museus & Harris, 2010). Nevertheless, the gatekeeper courses that weed out students who are supposedly not academically prepared are usually driven by class environments that are individualistic and competitive, which generally conflict with minority students who do not ascribe to such cultural values (Massey, 1992; Seymour & Hewitt, 1997).

Concluding Thoughts

Due in large part to advancements in science, technology, engineering, and mathematics, the world has experienced unprecedented growth and evolution over the past few decades. The shift from the post-industrial/mass production economy to the knowledge economy has created an economic imperative for a workforce composed of critical thinkers and innovators who possess strong skills and backgrounds in science, technology, engineering, and math (STEM) (Florida, 2002; Schirato & Webb, 2003; Thussu, 2010). As such, U.S. educational institutions must ensure the success of American youth in the STEM disciplines in order to remain globally competitive.

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