ACHIEVING DIVERSITY AND EQUITY IN THE SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS (STEM) FIELDS

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This paper provides a brief overview of gender and cultural diversity in STEM fields, barriers to STEM participation by traditionally underrepresented populations, and best practices for promoting equity in STEM-related courses and careers.

BACKGROUND AND NEED FOR DIVERSITY IN STEM-RELATED FIELDS

According to the Center on Education and Work, the global competitiveness of the United States has been eroding steadily over the past decade. For example, in 2004, Fortune Magazine reported that China produced 500,000 engineers, India produced 200,000, and the United States graduated 70,000. New York Times columnist Thomas Friedman, in his book *The World Is Flat*, described this phenomenon as the "quiet crisis" (Byars-Winston, Estrada, & Howard, 2008).

The need to increase interest in STEM field has been recognized by the National Science Foundation; the America Competes Act of 2007; and the Committee on Science, Engineering, and Public Policy, among other public policies and institutions. These groups set a course to increase the overall numbers of individuals pursuing STEM-related careers and especially to increase the percentage of traditionally underrepresented populations, such as girls and women, African Americans, Latinos, Native Americans, and persons with disabilities. While modest gains in attracting these populations to STEM had been made in the 1990s, progress since then has been relatively flat. In 2004, for example, about 17% of all science and engineering degrees were awarded to students from these traditionally underrepresented backgrounds (Commission on Professionals in Science and Technology, 2004, as cited in Byars-Winston et al., 2008). In 2011, the percentage is roughly the same (National Science Foundation, 2011). Further, certain STEM disciplines, such as engineering, have even smaller representations. For example, individuals from minority groups with degrees in science and engineering are most likely to earn them in the social, computer, and medical sciences. Women are most likely to pursue degrees in social sciences and bioscience (National Science Foundation, 2011).

Interestingly, the lack of representation is not related to intentions to major in a STEM-related field or to current record of academic achievement. Approximately the same percentages of incoming college freshmen from white and nonwhite backgrounds intend to major in STEM fields, and the students have approximately the same grade point averages at the time of entry. However, females and individuals from communities of color (71%) are less likely than their nonminority peers to follow through on their intention to major in STEM fields and dropped out of the fields after they declared their major (Astin, 1994, as cited in Byars-Winston et al., 2008; Reichert, 1997, as cited in Byars-Winston et al., 2008).

A cohort study conducted by the American Council in Education found that the problem seemed to peak in individuals' third and fourth years of college, when African American and Latino students were no longer on track and oftentimes dropped out of the major (Anderson & Kim, 2006). Researchers cited several reasons why this trend might exist, including lack of a rigorous high school curriculum, age of the student when he/she entered college (those over 19 did not perform as well), and whether the student was full or part time (part-time students were more likely to drop out). Non-completers were also more likely to work 15 hours or more per week, have parents who did not complete college, and be less academically and socially engaged in school. The economic status of the student's family was also found to have a strong influence on completion, both because the economic status was related to where the student attended school and was related to his/her financial options while in school (Anderson & Kim, 2006).

Other factors serving as barriers to STEM equity have also been found in the literature. These factors are related to context, individual cognition, and cultural influences.

CONTEXTUAL FACTORS

Contextual factors include perceptions of the environment. Research has shown that individuals from underrepresented backgrounds are much more likely than their peers to report:

- an unwelcoming climate in their classrooms (Cabrera, Colbeck, & Terenzini, 2001, as cited in Byars-Winston et al., 2008);
- experience of prejudice or discrimination on their college campuses (Brown, Morning, & Watkins, 2004, as cited in Byars-Winston, 2008);
- negative attitudes from precollege and college-level educators regarding the need for academic or physical accommodations (Burgstahler, 1994); and
- negative perceptions of being in STEM-related fields because the fields are viewed as "masculine" (Byars-Winston et al., 2008). For example, one study showed that women reported that they are perceived more negatively and viewed as less competent than men in the same STEM careers as theirs. These women were more likely to be seen as competent when their work was highly visible; yet when this happened, they were also

viewed as less likeable. Being perceived as both competent and likeable were found to be important factors for workplace success (Hill, Corbett, & St. Rose, 2010).

Cognitive Factors

Cognitive factors are related to self-efficacy and self-confidence in one's ability to perform well academically and a feeling that the pursuit of a goal is worthwhile. Research shows that:

- Academic self-efficacy predicts interest and retention in STEM-related fields, but that students from communities of color are less likely to feel academically efficacious than their peers (Byars-Winston et al., 2008);
- Females tend to rate their personal math skills lower than what their actual performance, grades, and test scores reflected, leading to diminished interest in pursuing math courses and STEM careers (Hill et al., 2010); and
- Girls score higher on math tests and increase their interest in continuing math courses when parents and teachers communicate that boys and girls can perform similarly well in math and science (Hill et al., 2010).

Cultural Factors

Cultural factors are related to one's sense of racial/ethnic identity and group orientation, including comfort with interacting with others different from oneself. Studies revealed that:

- Lack of persistence in STEM fields is associated with experiencing low levels of comfort when relating to people with racial/ethnic backgrounds that differ from the students' own backgrounds (Byars-Winston et al., 2008);
- Girls have fewer out-of-school science and computing experiences than boys, which has been found to be correlated with less participation in science and computer science courses (Farenga, 1995, as cited in Fanscali & Froschl, 2006; Sanders, 2002);
- Latinas still feel pressure from their families to enroll in local community colleges rather than universities that are farther from home, and their parents still promote traditional roles for women, thereby discouraging them from pursuing STEM-related careers (Villegas & Vincent, 2005; Tomás Rivera Policy Institute, 2002); and
- Members of communities of color report having fewer role models in STEM-related careers and often have little or no information from their families and communities about STEM-related career pathways (Davis-Lowe, 2006).

Programmatic Factors

These factors relate to program-specific features. Research demonstrates that:

- Many students from underrepresented populations lack support from mentors or advisors (Byars-Winston et al., 2008);

- Teachers' and professors' have very limited understanding about inclusive pedagogies and lack time to work with students with disabilities individually (Moriarty, 2007); and
- Students with disabilities often cannot access supportive and assistive technology and frequently face barriers in the form of inaccessible software, web pages, and facilities (National Center for Education Statistics, 2000; Smith & Jones, 1999).

Promising Practices Within STEM Equity Programming

Recent research summaries, briefs, white papers, and technical reports point to several commonalities among programs that have had success at increasing STEM participation among underrepresented groups. A brief summary of each factor is described, with references and additional resources sections providing information on where to find more information.

- **Family Involvement and Starting Young**

    - Research suggests that increasing interest in STEM among underrepresented groups should start early when students' interests are still being formed (Gandara, 2006; Habashi, Graziano, Evangelou, & Ngambeki, 2009).

    - Parents, guardians, and 'important others,' are essential to promoting students' early involvement in STEM and their aspirations in the field (Beier & Rittmayer, 2008; Building Engineering and Science Talent, 2004; Clewell & Campbell, 2002; Taningco, Mathew, & Pachon, 2008).

    - Personal factors such as self-efficacy, self-determination, and self-advocacy skills are important to instill within children when they are young, especially for students with disabilities, since these factors are related to interest and persistence in STEM subjects (Bremer, Kachgal, & Schoeller, 2003; Rule, Stefanich, Haselhuhn, & Peiffer, 2009). In addition, self-confidence in one's ability to succeed in STEM-related fields was associated with positive outcomes at every level of education, elementary through college (Byars-Winston et al., 2008).

- **Effective Instructional Approaches and Programs**

    - Hands-on and/or inquiry-based STEM-related learning opportunities are more effective than traditional instruction in promoting the interest of diverse students in STEM subjects (Clewell & Campbell, 2002; Henderson & Dancy, 2011; Moriarty, 2007). Effective instructional approaches to stimulate involvement also include student-initiated experiments or research (Beier & Rittmayer, 2008; Tsui, 2007); the use of interactive displays or models (Rule et al., 2009); contextual learning projects (Davis-Lowe, 2006); and project-based experiences to apply knowledge to real-world problems (Building Engineering and Science Talent, 2004).

- Comprehensive programming designed to increase diversity in STEM courses and careers should include academic enrichment in science and mathematics, contextual learning that enhances personal meaning, and college readiness experiences for students (Building Engineering and Science Talent, 2004).

- Students with more rigorous and intensive preparation in STEM-related content perform better than those with less demanding classes (Building Engineering and Science Talent, 2004).

- The American Institutes of Research and Blue Ribbon Panel on Best Practices n PreK-12 Education identified no programs that met its standards for effectiveness, but several were promising, with positive impacts in at least two studies ("probable effectiveness") and included Direct Instruction in Mathematics and Project SEED. Programs of "notable effectiveness" (at least one study with substantive positive findings) included Advancement Via Individual Determination (AVID), The Algebra Project, Gateway to Higher Education, Project GRAD, Puente, and Yup'ik Mathematics (Building Engineering and Science Talent, 2004).

- The Institute of Education Sciences (IES) Practice Guide cites moderate evidence supporting classroom practices that encourage girls to pursue elective math and science classes in high school and STEM-related college majors and careers. The classroom practices include teachers conveying to students that academic abilities are expandable and improvable not fixed; providing students with prescriptive, informational feedback regarding their performance; and choosing activities that connect classroom learning to careers in ways that do not reinforce existing gender stereotypes and that spark curiosity about math and science content (Halpern, Aronson, Reimer, Simpkins, Star, & Wentzel, 2007).

- **Mentoring and Career Exposure**

  - Students from diverse backgrounds who are provided with mentors achieve more and persist longer in STEM-related courses than those who do not (Cohen, 2006; National Alliance for Partnerships in Equity, 2007; Rule et al., 2009). Informal mentoring and naturally formed relationships have shown to lead to better outcomes (Tsui, 2007).

  - An important dimension of the mentoring role is exposing students to real-world professions and possible career opportunities (Clewell & Campbell, 2002).

- **Access to Resources**
    - Access to educational technology, including computers and calculators, has been shown to be associated with higher academic performance in STEM-related fields (Tomas Rivera Policy Institute, 2002).
- **Extended Learning-Out-of-School Time and After-School Activities**
    - Participation in after-school programs leads to positive outcomes for underrepresented groups within the STEM disciplines (Fancsali & Froschl, 2006)
    - After-school programs help youth avoid self-destructive behavior, while strengthening participation in other efforts related to effectiveness, such as participation in mentoring relationships (Fancsali & Froschl, 2006).
    - After-school programs should be substantively different from classroom experiences. Successful programs that encourage diversity have included camps (Beier & Rittmayer, 2008), trips to museums (National Institute on Out-of-School Time, 2007), and summer bridge programs (Tsui, 2007).
    - After-school programs are most successful when they have a youth development focus, connect with the student’s home, have high-quality staff, and include experiential activities (Fancsali, 2002).
    - After-school programs that create an environment fostering adult-student connections with adults other than teachers are associated with positive outcomes (Fancsali, 2002).
- **Teacher Professional Development**
    - To increase student outcomes, teachers need to be properly trained to incorporate STEM curricular materials into their classrooms (Battey, Kafai, Nixon, & Kao, 2007; Clewell & Campbell, 2002; Rockland, Bloom, Carpinelli, Burr-Alexander, Hirsch, & Kimmel, 2010; Zarske, Sullivan, Carlson, & Yowell, 2004).
    - Combining subject matter professional development with information on attaining gender and minority equity has a more powerful impact than offering these training sessions separately (Battey et al., 2007).
    - Teachers who learn and implement active learning strategies are more likely to nurture STEM-related student achievement than teachers who use more traditional methods (Clewell & Campbell, 2002; Henderson & Dancy, 2011; Moriarty, 2007)

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Additional Resources

A sampling of Web sites that provide resources related to STEM diversity research

American Association of University Women
(http://www.aauw.org/index.cfm)

BEST (Building Engineering and Science Talent)
(http://www.bestworkforce.org/index.htm)

Center for Urban Education
(http://cue.usc.edu/)
Cisco Learning Institute. Gender Initiative Strategies
(http://gender.ciscolearning.org/Strategies/Index.html)

Disabilities, Opportunities, Internetworking, and Technology (DO-IT) Center
(http://www.washington.edu/doit/)

Education Commission of the States
(http://www.ecs.org/)

Great Science for Girls
(http://www.greatscienceforgirls.org/)

I-STEM Resource Network
(https://www.istemnetwork.org/index.cfm)

National Alliance for Partnerships in Equity
(www.napequity.org)

National High School Alliance
(http://www.hsalliance.org/index.asp)

National STEM Center
(http://www.nationalstemcentre.org.uk/)

Nontraditional Career Resource Center
(http://ncrc.rutgers.edu)

Programs and Practices That Work
(http://www.napequity.org/nape_programsthatwork.html)

PBS Teachers – Technology Integration
(http://www.pbs.org/teachers/librarymedia/tech-integration/)
STEM Equity Pipeline
(www.stemequitypipeline.org)

The National Academies
(http://www.nationalacademies.org/)

U.S. Department of Education, Institute for Education Science, What Works Clearinghouse
(http://ies.ed.gov/ncee/wwc/)

Virginia Partnership for Out-of-School Time
(http://www.v-post.org/resources/best-practice.html)

WDPI-Wisconsin Department of Public Instruction
(www.dpi.wi.gov)

Women and Mathematics Education
(http://www.wme-usa.org/home.html)

As diverse IT role models grow increasingly scarce, itâ€™s more important than ever to encourage and support girls and youth of color to aspire to STEM careers. This is one reason why ETR focuses on Diversity in IT. We work to find effective solutions that will increase the number of women and under-represented youth choosing STEM-related careers. I co-presented at a recent technology user's group with a woman developer who started programming when she was in high school. She said she wouldnâ€™t have even known this was possible if it wasn't for a computer science class at her school. Diversity refers to difference. As such, diversity is a property of groups, not individuals. Although I am a black man in a field where less than 2 percent of research grants are awarded to blacks, I am not diverse. An individual cannot be diverse, but groups of individuals (e.g., the scientific research workforce) can possess diversity. There are many dimensions of difference (hence, some of the confusion about what diversity means). I will focus on differences across social identity.Â Of course, there are caveats. Two people can be from similar social backgrounds and have lots of difference in perspective and life experience, or two people can be from distinct social backgrounds and yet approach problem-solving almost identically. I get that. Here's some background on this much-needed celebration. By Saoirse Kerrigan. July 05, 2018. gtjoflot/Pixabay.Â LGBT STEM Day is open to members of the LGBT+ community who work in STEM or STEM-related fields, as well as workers in STEM who simply want to show their support of the LGBT+ community. It is also open to businesses and academic institutions, and groups and organizations, who wish to show their support of the community. If you want to get involved, there are a lot of ways you can show your support and boost the profile of the LGBT+ community in STEM. - Join the Conversation Perhaps the easiest way to get involved in LGBT STEM Day this year is to simply show your support online. Efforts to increase STEM diversity target women and minorities, but not the LGBT community, leading LGBT scientists to feel invisible and underrepresented.Â LGBTQ+ issues in STEM diversity. June 15, 2017. 17.Â Because, to stay competitive in the world economy, America needs more scientists and engineersâ€”and evidence shows that diversity may lead to better science. Christopher Schmitt, a CAS assistant professor of anthropology and of biology. Photo by Eva Marina. While itâ€™s important to tackle underrepresentation for all minority groups, the often-hidden struggles of LGBTQ+ individuals in science, technology, engineering, and math (STEM) fields are particularly challenging to quantify and address.