Traversing STEM: Creating Pathways for Social Justice in the United States

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Abstract: The system that once motivated Americans to pursue science, technology, engineering and mathematics (STEM) careers now presents obstacles to racial and ethnic minorities, women, and the poor. This paper highlights both the advantages and hindrances inherent in STEM professions while advocating for improved access to these pathways.

The education system often finds itself at the heart of social justice movements, and with good reason, but the current narrative surrounding science, technology, engineering, and mathematics (STEM) education has yet to rise as the modern crux for access, equality, and equity for minority groups underrepresented in those fields (Cech, 2015; Gutstein, 2003). No one could argue that the federal government and many states have not purposely targeted the reduction of this underrepresentation (Gonzalez & Kuenzi, 2012), but the full-extent of STEM-for-all has not yet caught the attention of social justice activists doing more than simply advocating for more computers in schools (Vakil, 2014). This paper makes the case that STEM fields, more than any other, offer our children the greatest opportunities to find success in our technology-saturated global economy. When once jobs existed for those with varieties of skills, the demand for STEM skills, both in STEM and non-STEM careers, has almost ensured that unequipped young people will fall victim to nearly insurmountable class struggles (National Science Board, 2015; National Research Council [NRC], 2011). Although this holds true for all groups of people, in the United States, strong gender and racial divides create unfair disadvantages for many.

A Pattern of Discrimination

Historically, STEM fields have suffered from the same hegemony found in various facets of American culture. For example, outside of a few token female and racial minority scientists and mathematicians, the general population would be hard-pressed to name historically significant non-White STEM professionals. That does not mean that they did not exist, but walk into any K-12 classroom and ask students to draw a scientist, and quickly it becomes evident that when students think of science, they think of White males in lab coats (Finson, 2002; Steinke et al., 2007). These issues not only persist in our country's perception of who practices STEM, but they also play out in the workforce.

Men outnumber women in almost every field of STEM, especially in physics and engineering (Hill, Corbett, & St. Rose, 2010). Even in the few fields, like Biology, where the number of women majors matches that of men, women continue to face drastic underrepresentation at the tenured-faculty level—not to mention consistent income inequality (National Science Board, 2015). Some have gone as far as suggesting that this dichotomy exists not because of bias in the academic system, but because women have less capable brains than men do (Hill, Corbett, & St. Rose, 2010). Although women clearly perform just as well, if not better, than men on STEM-related assessments, much more continues to be expected from them (Hill, Corbett, & St. Rose, 2010). The social role of women as caretakers of the home and primary child-rearing parent has not changed much, nor does it change when they choose to pursue careers in STEM (Xie & Shauman, 2003). Often women have to choose between a STEM career and a family. Those who have both face the high likelihood of carrying dual burdens.

Even more astounding things can be said about the dearth of participation in STEM from members of racial and ethnic minority groups. The culture of STEM in the United States extends out of a system propagated by White, Western Europeans (Heilbron, 2003), as evidenced by the famous scientists lauded in popular culture (e.g., Albert Einstein, Charles Darwin, Isaac Newton, Stephen Hawking, Thomas Edison, Bill Nye) and even famous fictitious scientists (e.g., Sheldon Cooper, The Doctor, Indiana Jones, Victor Frankenstein, Captain Nemo). Many have noticed the ramifications of this in the dismal representation of diverse groups. Just ten years ago, the number of people from underrepresented minority groups (i.e., African American, Hispanic, and American Indian) participating in STEM proportionately represented about a third of the total minority population in the country (NRC, 2011).

Nora (2003), a renowned expert for his work with ethnic minority student populations, made the case that Hispanic students lag behind the general population in terms of college preparation. Hispanic students drop out of high school at incredibly high rates (i.e., 46% between eighth and ninth grade, and 50% between ninth and twelfth) and enter college at much lower rates than their White or Black counterparts (i.e., 17% as opposed to 35% and 28%, respectively). Nora argues that the majority of Hispanic students choose to attend two-year institutions before transferring to four-year colleges. Nevertheless, he cites the transfer rate for Hispanics at only 10%. The transfer rate for the general population is 22%. At the time of his publication, the trends had not changed for twenty years. Fortunately, the drop out rate for Hispanic students has decreased by nearly half in the past ten years, but for other underrepresented groups, including Black students, they continue at the same level (US Department of Education, 2015). They paint a bleak picture for racial and ethnic minorities, especially when taking into account the almost ubiquitous requirement of four-year degrees in almost all STEM professions (National Science Board, 2015).

Moreover, an overrepresentation of White individuals exists in these fields—67.4 % in the general population and 74.5% in the population of the science and engineering workforce) (NRC, 2011). In fact, in 2015, people from minority groups earned less than 15 percent of Bachelor’s degrees awarded in STEM fields with the smallest number of degrees in the physical sciences, engineering, and mathematics and statistics (National Science Foundation, 2015). These low graduation numbers stand despite minorities, as a whole, attending full-time, two-year and four-year institutions at just below the same rate as White students. In other words, the percentage of the minority population going to college mirrors the percentage of the White population going to college, but a much lower percentage of people from minority groups actually graduate.

Minority Groups and Poverty

Ethnic and racial minority populations in the United States face overcoming additional, serious disadvantages that hinder their ability to compete in the education arena. While racial and ethnic group categories often differ across studies (e.g., White, Caucasian, Black, African American), similar patterns emerge. Research published by the American Psychological Association (APA, 2013) points to significant correlations between belonging to a racial or ethnic minority group and classification under low socioeconomic status. African American children, for example, have three times the likelihood of living in poverty than do Caucasian children, the study cites. Their parents typically confront double the unemployment rates than parents of Caucasian children. This association between identifying as a minority and having low income has repercussions on education. The same study revealed that more frequently than Caucasian children in similar contexts, African American youths, as well as Latino youths, attend low-income schools with fewer resources and teachers who expect less from them. A sizeable percentage of these young people end up dropping out of school altogether.

Overall, one out of every three children in the United States lives in poverty (DeNavas-Walt & Proctor, 2015). According to another study, children from Hispanic, Black, American Indian, or Alaskan Native families are more likely to live in poverty (Macartney, Bishaw, & Fontenot, 2013). These groups experience a nearly ten-point higher rate of poverty than the Caucasian population. Children living in these conditions must also battle poor health, low access to quality healthcare, lack of nutrition, and mental health issues (APA, 2013). Under these circumstances, the plight of youths from underrepresented populations pursuing STEM appears insurmountable. In addition to the fact that primarily White males designed the STEM pipeline they must traverse, youths of color who choose to tackle that unfamiliar labyrinth must bear the significant burdens to education brought on by poverty.

Fighting For a Cause

The bleak picture for minorities and women in STEM contrasts against the privileges experienced by STEM professionals. In 2011, the U.S. Department of Commerce projected 17.8% growth in STEM-related workforce needs, compared to 9.8% growth in non-STEM jobs (Langdon, McKittrick, Beede, Khan, & Doms, 2011). The White House Initiative on Educational Excellence for Hispanics (2012) presents data showing tremendous growth in STEM professions like biomedical engineering and system software development, which strongly outperform the overall expected occupational growth for 2020. Moreover, STEM workers earn on average 26% higher salaries than non-STEM workers (Langdon et al., 2011). These higher earnings remain true for those that earn degrees in STEM regardless of whether they pursue STEM related jobs. Data from 2012 suggests that the average science and engineering occupant earns twice as much as the average U.S. worker (National Science Board, 2014). At around the same time period, while the average unemployment rate hung at 9%, the unemployment rate for science and engineering workers was down to 4.3%, which reflects greater job security (National Science Board, 2014).

The global economy has shifted significantly toward favoring STEM-related jobs (National Science Board, 2015). These jobs range from non-degree-requiring to highly specialized employments. The need for these in the United States varies by sub-field and geographic location. The National Science Board heralds that a variety of business sector and research-field reports proclaim a growing demand for workers with STEM-related skills. From a global perspective, developed countries like China, India, and Brazil have diverted a large portion of funding toward generating highly skilled STEM professionals, increasing the pressure for the United States to maintain a viable STEM workforce.

Regarding this movement, recent national reporting confirms the persistent underrepresentation of women and minorities in STEM that would otherwise offer talent and help meet the country’s workforce requirements (National Science Board, 2014). Women, overall, make up only 28% of the STEM workforce, and despite exhibiting equal and sometimes overrepresentation in certain fields (e.g., life sciences and social sciences, respectively), less than one in three persons working in STEM identifies herself as a woman. The picture is equally bleak for African Americans and Hispanics who in 2010 made up 11.5% and 13.9% of the U.S. residential population, respectively, but only about 9.8% percent of workers in STEM fields pertain to both these groups (National Science Board, 2015).

Connecting to Access

For a few, the STEM fields have opened up avenues out of poverty. Groups of K-12 students across the country have experienced free STEM enrichment both in and out of school thanks to state and federal attention given to STEM. Many graduate students have enjoyed the benefits of fully paid tuition as a result of having chosen a STEM pathway. Faculty have grown their programs and have had their research paid for thanks to the federal attention given to STEM. The U.S. government spends billions of dollars a year funding STEM-related research. For example, the NSF and the National Institutes of Health (NIH) distribute approximately 40 billion dollars' worth of grants every year. This does not count federal research funded through agencies like the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Administration (NOAA), the Department of Energy (DOE), and the Department of Defense (DOD). The U.S. government directly employs approximately one quarter million scientists and engineers (Burrelli & Falkenheim, 2011).

In countries across the globe, the same opportunities exist. Countries like China invest in their STEM graduates, supporting their education overseas, often in the United States, and incentivizing their return to the home country. European nations have adopted the STEM rhetoric with similar fervor, devoting national attention to related programs and funding. International businesses, including a myriad of Fortune 500 companies, have partnered together to form groups like *Change the Equation* to promote STEM literacy at a range of levels, deliberately influencing students, educators, and policymakers.

Should not all have an opportunity to benefit? A significant portion of future jobs will require STEM skills and content knowledge (National Science Board, 2015). Given these twenty-first century changes, this nation must ensure that all children have the same preparation to pursue the kinds of jobs that will help them acquire success (President's Council of Advisors on Science and Technology, 2010). Our K-16 education system must change to accommodate the cultural context of the disadvantaged. To do so, the country must find ways to counteract the under-resourced educational experiences of children living in low socioeconomic circumstances. Leaders must approach the teaching and learning of STEM from a perspective that welcomes the variance in students' cultural milieu. Education practitioners must accept that the differences between those who are considered the successful students and the unsuccessful ones are not biological, but rather a result of changeable circumstances. More importantly, administrators and educators should feel confident that, given the right setting, all students could acquire skills, regardless of their learning preferences or backgrounds (NRC, 2012; NRC, 2000).

Solutions and Limitations

The short response to the circumstances presented above is simple: Funding and resources must be redirected to explicitly counter the cultural and gender-related imbalances in the STEM system. At the heart of this response lies the principle that change requires passion and love for the students in STEM classrooms. Still, even more specific, pragmatic solutions do exist. These can be divided into two categories: external and internal. Any one of them may find its implementation at all three levels of education administration: local, state, and federal.

Externally Oriented Solutions

The lowest hanging fruit for improving access to STEM education involves the adequate implementation of reformed education curricula and approaches in related K-16 courses. Curricular changes that promote greater depth of content—rather than breadth—facilitate the development of critical thinking skills crucial to STEM professionals. Many states have seen this kind of change with the Next Generation Science Standards that build off *A Framework for K-12 Science Education* (NRC, 2012). These documents encourage curriculum builders to forego the typical wide, unreasonable scope of science classes. Covering such a broad range of context in any science or math course pressures administrators and educators to default to ineffective pedagogies of teaching, which include lecture, rote memorization, and basic summarization of content. Not only have these techniques proven to fail at increasing subject comprehension, they can also leave damaging impressions about science and math careers (Dou & Gibbs, 2013).

By contrast, student-centered teaching approaches facilitate improvement of students' comprehension, and also positively influence affective constructs like interest, performance goals, self-efficacy, and vocational outcome expectations—all of which contribute to a person's career decision-making process (Lent, Brown, & Hackett, 1994). Students should find themselves engaged in activities that promote learning through meaningful discourse, situated in contexts analogous to those of STEM professionals (e.g., moving away from "recipe" labs to more open-ended forms of inquiry using the tools of the field). Students should also be focused on knowledge building and creation rather than memorization, and deliberately involved in discussions about the hidden curriculum in STEM pathways that inadvertently dissuade women and minorities from traveling along them (Freeman et al., 2014; Hazari et al., 2013). These techniques will help generate positive experiences and attitudes with regard to STEM and STEM careers.

Inquiry-based approaches where the focus is on student-centered learning rather than teaching-centered instruction, have been a central tenet of science education reform efforts (National Committee on Science Education Standards, 1996). When compared to traditional instruction, student gains in knowledge, reasoning, and argumentation have been shown in multiple contexts to exceed those of traditional learning (Prince, 2004). In fact, research on these pedagogies has proven their effectiveness so much that to knowingly offer otherwise would represent malicious intent on the part of the instructor (Freeman et al., 2014). Inquiry-based learning is effective for students with different learning styles, and works across gender, race, and socioeconomic status (Tuan, Chin, Tsai, & Cheng, 2005; Wilson, Taylor, Kowalski, & Carlson, 2010), making this approach particularly appealing in the diverse domestic student population. Moreover, students who engage in inquiry-based learning maintain higher interest in and more positive attitudes toward science careers (Gibson & Chase, 2002)—key elements in shaping the future scientific workforce.

Although not all students may choose to pursue STEM careers, all deserve the opportunity to do so if they wish. Much research on the factors involved in the STEM career decision-making process continues to take place, but a large body of understanding already exists. Some of the most effective changes involve direct discussions of underrepresentation in STEM fields in classrooms across the K-12 range and recruitment of diverse K-12 STEM educators (Dou & Gibbs, 2012; Hazari et al., 2013). At the higher education level, changes should include hiring more diverse faculty and researchers, as well as explicitly addressing the implicit biases in graduate school programs. These biases exist at every point, from entrance exams (e.g., well-proven bias against people from minority groups taking the GRE) to microagressions coming from advisors and major professors (Gibbs & Griffin, 2013; Miller & Stassun, 2014; Solorzano, 2000).

Internally Oriented Solutions

Despite the many funding avenues that exist to create new STEM education programs directed at women and minorities, few of these require purposeful and transparent counteraction against systemic, academic prejudice. Without reforming the STEM pathway itself, prejudice may prevail in subtle, unexpected ways. This requires change at the individual level. Transforming minds to accept that all students, given the right resources, could and would succeed in STEM fields may have more powerful long-term effects on the number of STEM professionals recruited. This would require administrators, teachers and faculty to approach their practice introspectively, sensitive to their least successful students who may likely come from racial and/or ethnic minority groups, and recognizing that high performing individuals have learned to game the system and will succeed *despite* the instructor. This change in understanding will create a change in attitude, one that encourages a more proactive approach toward teaching struggling students. Such a state of mind may also result in changes to the policy of education, which plays a meaningful role in creating or removing barriers. Yet, tax dollars are rarely directed to address these obstacles. Funds should support workshops or conferences directed at STEM professionals working to promote inclusion in STEM fields, as well as nurturing communities of faculty, researchers, and educators that share the common goal of increasing access and generating context-specific solutions to local challenges.

Challenges

Like most things, talking about these ideas sometimes requires less effort than implementing them. The major challenges the country faces will always come from resolving individual and collective internal struggles. These include those listed above, but others, as well, such as changing the perspective some university faculty have about introductory STEM courses being “weed-out” classes as opposed to recruiting opportunities (Reyes, 2011), or changing the system that grants tenure to professors from valuing research and grant reception to valuing effective teaching (Baldwin, 2009). Although both should matter to the STEM enterprise, the latter will likely have greater direct impact on motivating diverse students to pursue STEM. More broadly, the issues brought on by poverty require creative and just solutions. Battling the system the underserved poor communities face via under-resourced schools requires complete overhaul at both administrative and political levels. By targeting needy communities, some of this positive change can begin to take place.

Final Words

As an ethnic minority in STEM, I experienced firsthand much of the antagonism described in this essay that faces students of similar backgrounds. While working for the federal government, I would later read about these issues in national reports, discovering that my experience was not unique. Somehow, I managed to travel down what some have called the STEM pipeline. Like more recent authors have noted, the pipeline is more like a series of unknown and sometimes unknowable pathways. Those that have traversed this difficult yet awe-inspiring landscape now have a moral responsibility to those that come behind. Having earned credibility in their communities, STEM professionals who resonate with this message of social justice have the power to facilitate positive changes. This will require making our voices heard and that of our students’, periodically reflecting on whether implicit bias exists in our teaching and mentoring practices or the practices of those around us, and, given the opportunity, sponsoring reform. This movement should move beyond simply reducing underrepresentation in STEM. Rather, these concerns should be framed around issues of injustice and lack-of-access for women and those in minority groups. Much implicit and systemic prejudice continues to prevent individuals from pursuing careers that would otherwise allow them to enjoy benefits often reserved for the privileged. The country must raise an alarm that will be heard by more than just members of the STEM community.

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