Guest Editorial

Conversations about Diversity: Institutional Barriers for Underrepresented Engineering Students

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Introduction

The United States is becoming increasingly more diverse. Specifically, demographics are shifting because of growth among historically underrepresented racial and ethnic minorities, including African Americans, Latinos, and Native Americans. At the same time, a declining number of skilled workers in science, technology, engineering, and mathematics (STEM) fields threatens U.S. global competitiveness and national security. Low participation, representation, engagement, and inclusion continue to reduce the intellectual capacity of the U.S. STEM workforce. The aforementioned societal changes require diversity in STEM education and the nation at large. Past research offers additional support for the importance of diversity. For example, racial diversity can improve educational outcomes such as complex thinking among students in college (Antonio et al., 2004). In STEM fields such as engineering, encouraging contact among undergraduate students from different economic, social, or racial and ethnic backgrounds can produce greater perceived learning gains (Strayhorn, Long, Williams, Dorimé-Williams, & Tillman-Kelly, 2014).

Despite the societal and educational benefits of diversity, U.S. engineering and related STEM fields are dominated by persons whose background is White, male, English speaking, and middle class (National Academy of Engineering and National Research Council, 2009). Underrepresented populations' limited access to engineering and related STEM fields has a historical context, a history predating landmark court decisions such as *Brown v. Board of Education* that sought to provide equal educational opportunities to all racial/ethnic groups. The educational crisis for underrepresented minorities must be solved not only through encouragement and engagement of students but also through policy and practice in institutions. We believe that a new conversation about diversity needs to begin, a conversation examining policies and actions that pose unnecessary institutional barriers for underrepresented minority students in STEM fields such as engineering.

ASEE's Focus on Diversity: The Turning Points Panel

In 2015, we participated in a conversation about diversity, specifically focusing on what affects minority students in engineering. At the 2015 American Society for Engineering Education (ASEE) Annual Conference and Exposition, we were part of a four-member panel titled "Turning Points: Addressing Diversity-Related Challenges" (Squires, 2015).

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Our panel was part of a larger effort, ASEE's Year of ACTION on Diversity, which sought to provide a space for members to discuss, engage, and highlight ways to advance the society's diversity and inclusion efforts. With a shared academic and research interest in engineering education, our panel consisted of a Native American female graduate student and a hearing-impaired Asian female graduate student, along with the authors of this editorial, who are a Latino male assistant professor and an African American male assistant professor. The intent of our panel and conversation on diversity was to have an open dialogue around how some institutional factors and narratives create obstacles for many minority engineers.

We would like to take the discussion further and encourage others to evaluate how a deeper understanding of the ways in which we see diversity (for example, of race, ethnicity, gender, socio-economic status, ability status, sexual orientation, gender identity or expression) can help us challenge preconceived narratives and beliefs. We will recount our experiences and apply our unique perspectives to assess how engineering education can become more inclusive. We will also explain why far more attention should be paid to understanding and eliminating barriers to minority student success at the macro level (e.g., the institution, legislation) rather than just the micro level (e.g., students, teachers). Lastly, we will provide recommendations in the areas of research, policy, and practice that can help eliminate barriers to minority student success in engineering.

Institutional Barriers

One of the co-authors of this editorial, Dr. Joel Alejandro Mejia, experienced poor academic guidance and counseling during high school. He was the first in his family to graduate from high school, but did not have the information necessary to complete admission forms or apply for scholarships to college. Dr. Mejia was advised to look into vocational or technical schools instead of being given adequate counseling that would help him succeed at a four-year university. He was also told to enroll in "sheltered" mathematics and science courses designed for English as a Second Language (ESL) students. Dr. Mejia was not allowed to take any Advanced Placement courses in high school because of his ESL status and the perception that language, or inadequate language proficiency, created a barrier for his success. Low expectations from faculty and staff members in high school decreased his preparation for engineering in college. The poor academic guidance and counseling Dr. Mejia was given are a result of deficit-based thinking – the notion that students, particularly low-income minorities, fail in school because their families experience deficiencies that obstruct their learning process (Valencia, 1997). Faculty and staff's perceived but inaccurately stereotyped deficiencies about minority students can include attributes such as limited intelligence, lack of motivation, and inadequate socialization (Valencia, 1997).

It was the intervention of an instructor that ultimately helped Dr. Mejia navigate a system that was completely unfamiliar to him. Thus, his instructor acted as an institutional agent by providing him with valuable intellectual and social resources. Eliminating deficit-based expectations at an institutional level will eliminate barriers for underrepresented minorities. The ultimate goal of programs seeking to increase diversity must be to convince high schools and colleges that deficit-based models hinder students' achievement, especially for students from underrepresented groups.

Students from underrepresented populations are adversely affected not only by inadequate counseling, but also by restrictive admission policies and curricula. Many undergraduate engineering programs have rigid and lengthy course requirements. Restrictive admission policies and curricula can increase costs as well as time to degree for students who do not enter

college with the appropriate educational background to immediately enter and succeed in a series of required calculus and physics courses. The other co-author of this editorial, Dr. Leroy Long, experienced restrictive admission policies and curricula as a freshman engineering student. He attended K-12 schools that were underfunded and rated as low performing. However, he had numerous talented teachers who offered encouragement and support for his academic endeavors. He also made the best of his high school's course offerings by taking both an honors-level calculus and a general physics course. Despite being a straight-A, honors-level student in high school, Dr. Long was unable to test into Calculus I in college and took a pre-calculus course instead. After taking calculus and physics behind schedule, he initially struggled academically – obtaining Cs in math and a D in physics.

Two interventions in college helped Dr. Long overcome the early curricular barriers he experienced: taking a freshman-level course, Introductory Mathematics for Engineering Applications, and finishing his physics sequence at a local community college. The mathematics course was based on the innovative university model known as the Wright State Model for Engineering Mathematics Education (Klingbeil & Bourne, 2013). The course – a combination of lecture, lab, and recitation – was taught by engineering faculty using an application-oriented, hands-on approach. Course topics included physics, computer programming, electrical circuits, and engineering mechanics along with other math topics that are used in core engineering classes. Not only did the course individually help Dr. Long, but longitudinal data shows it improves engineering student retention, motivation, and success, with the greatest impact on members of underrepresented groups (Klingbeil & Bourne, 2013). The physics courses at a local community college offered Dr. Long a more personalized learning environment – smaller class sizes and more student-instructor interaction – than his larger four-year university. His undergraduate engineering program and tuition-based scholarship also gave him the ability to transfer funds and course credits between institutions. Without the previously mentioned policies, Dr. Long would not have had access to the alternative option of learning physics in a more personalized learning environment. Certainly, other universities interested in the success of underrepresented students should consider similar changes to curricular and educational policy.

Research on Institutional Barriers

A small body of engineering education research has approached diversity from a macro level rather than a micro level. At the macro level, legislation and educational policies hinder underrepresented populations. Social inequities and prejudice also actively drive both women and underrepresented males out of engineering and related STEM fields. Unequal student representation in STEM fields such as engineering can negatively affect minorities since an isolating environment, directly or indirectly, may damage students' self-esteem, ethnic identity, and ability to tackle societal problems.

To better understand the underachievement of underrepresented groups in STEM, it is important to begin with an examination of the cumulative effects of inadequate educational preparation and policies. As highlighted by our experiences, restrictive admission policies and curricula along with insufficient counseling harm underrepresented students who dream of enrolling at four-year institutions. Our experiences are not only common among underrepresented students but also detrimental.

In admission decisions at colleges, standardized exams continue to weigh heavily, even though no national curriculum exists in U.S. high schools to justify the use of a standardized curricular exam (Atkinson & Geiser, 2009). Many admissions offices at colleges consider

standardized test scores at an equal or higher level than students' cumulative grade point average (GPA) in high school, although cumulative GPA in high school is the best overall predictor of student performance in the first-year of college (Atkinson & Geiser, 2009). Furthermore, standardized exams are used to predict the collegiate performance of diverse students even though standardized exams are biased against low-income and underrepresented minority students (Hoover, 2010).

Restrictive and flawed admission policies can limit student participation and success in STEM programs among underrepresented groups, who may already lack access to college-preparatory services. Prospective underrepresented STEM students can also be hindered by deficit-based thinking among K-12 school instructors and advisors that ultimately increases their enrollment at community colleges (Solórzano, Villalpando, & Oseguera, 2005). Community colleges may offer opportunities for job training and credentialing, but they may also serve as places that intensify the problems of poor preparation and inadequate counseling encountered by underrepresented students in U.S. high schools (Solórzano et al., 2005).

Several institutionalized factors add to the lack of attention given to underrepresented minorities at the K-12 and collegiate level. However, a dearth of critical sociocultural knowledge about K-12 and collegiate students is a primary cause of the lack of attention and limited knowledge surrounding underrepresented students (Brown, 2011; Mejia, Wilson-Lopez, & Drake, 2015). As educators, we often define, consciously and unconsciously, what is and is not important to ourselves, our students, and society at large. As a result of our conscious and unconscious biases, stereotypes emerge and ultimately persist (Lintner, 2004). It is sometimes impossible for us to overcome our own biases since we have been taught to evade controversial topics such as racism, sexism, classism, and social justice. What appears to be an apolitical, normal, and neutral retelling of history may harm how students view themselves and their communities (Kersten, 2006). It is a serious problem when society inaccurately stereotypes minorities as low-income and poorly educated, while ignoring their resilience, efforts to change the status quo, and contributions to American society.

Overall, underrepresented minorities encounter many academic and social barriers to their success in engineering and related STEM fields; these barriers cause them to typically take longer to graduate than their White peers (Strayhorn, Long, Kitchen, Williams, & Stentz, 2013). Some research has investigated the effect of poor teacher preparedness and a lack of textbook representation of people of color in science and engineering (Provenzo, Shaver, & Bello, 2011). Other work has focused on limited engagement in educationally purposeful activities among underrepresented minorities, misconstrued perceptions from faculty and staff toward underrepresented minorities, and an insufficient number of diverse institutional and societal role models (Barton, 2003; Carter, 2006; Strayhorn, Bie, Long, & Barrett, 2014). Lowered academic expectations, social pressure, and microaggressions – negative verbal and nonverbal actions that can intentionally or unintentionally create a hostile environment – contribute to educational isolation and alienation of underrepresented minorities at predominantly White institutions (Strayhorn et al., 2013; Yosso & Solórzano, 2006). Unwelcoming environments can cause anxiety and reduced performance of minority students because of a phenomenon called "stereotype threat," or the perceived danger of confirming negative, false assumptions about one's race or ethnicity (Steele & Aronson, 1995). Negative experiences may also result in efforts to "prove them wrong," or to work harder than usual to achieve goals while simultaneously dispelling inaccurate beliefs of inferiority held by certain races and ethnicities (Moore, Madison-Colmore, & Smith, 2003).

Recommendations

Some scholars suggest transformative initiatives to increase the number of underrepresented minorities in science and engineering (Barton, 2003; Maton, Hrabowski, & Schmitt, 2000; May & Chubin, 2003; Saenz & Ponjuan, 2011; Yosso & Solórzano, 2006). To increase the number of underrepresented minorities in engineering, K-12 and collegiate institutions can provide students with information about how colleges operate, act as bridges for different opportunities, advocate and promote their interests, act as role models, and provide the emotional and moral support students need (Stanton-Salazar, 2001). The systemic obstacles underrepresented minorities face along their academic paths must be removed in order to advance educational equity.

Most importantly, faculty and staff must actively engage in conversations with diverse students to learn more about how to provide the adequate support they need. Conversations between educators and diverse students should focus on current and past events – ones involving educational barriers underrepresented students have faced or overcome – in addition to how they have shaped society. Such conversations with students can provide us with the opportunity to have an open dialogue about educational equity as well as an evolving society and democracy.

As instructors and administrators, we need to develop *conciencia*, or conscience, about the issues affecting underrepresented students. It is through awareness and *conciencia* that we can challenge our own deficit-based thinking. We can create empowering pedagogies that celebrate the cultural, ethnic, and linguistic differences of our students rather than perceiving such differences as deficits (Mejia & Wilson-Lopez, 2015; Wilson-Lopez, Mejia, Hasbún, & Kasun, 2016). Educators must learn how engineering relates to the social, cultural, or historical contexts in which their students live so curricular materials can begin to portray engineering in ways that excite the interests of all students (National Academy of Engineering and National Research Council, 2009). Instructors must help students use their existing social, cultural, and historical resources in new, productive, and meaningful ways (Mejia & Wilson-Lopez, 2015). In doing so, educators must provide opportunities for underrepresented minorities and other marginalized students to explore connections between their sociocultural resources and the practices of engineering. Students can then work in authentic engineering experiences where they provide solutions to problems affecting their communities (Mejia et al., 2015). Instructors who acknowledge and understand the diversity of their students can make course material more appealing, comprehensible, and meaningful for students. When instructors learn more about the sociocultural knowledge of underrepresented students, they can engage them at higher levels.

Finally, as academics, we need to act as institutional change agents who support our students to help them navigate through engineering curricula. We firmly believe – based on our own personal experiences – that acting as an institutional agent is very important for the recruitment, retention, and success of diverse students. It is important to build *confianza*, or trust, with students – especially students who share interests, culture, language, and practices in common with the institutional agent (Stanton-Salazar, 2001). Instead of lowering engineering students' academic confidence and ability to endure hardships, we must find ways to produce more "buoyant believers," or students who are both confident and resilient (Long, Kitchen, & Henderson, 2015). We also need to help minority students feel like they belong in engineering and related STEM fields, since belonging is positively linked to satisfaction and academic success (Strayhorn, 2012).

In summary, low participation, representation, engagement, and inclusion in engineering and related STEM fields among underrepresented students must be improved to enrich the intellectual capacity of the U.S. STEM workforce. Broadening participation can also enhance U.S. global competitiveness and national security. In the future, faculty and staff must devote far more attention to understanding and eliminating barriers to minority student success at the macro level rather than just at the micro level. Universities interested in the success of underrepresented students should change curricular and educational policy. Continued conversations on diversity – ones where underrepresented minorities have a voice – are imperative.

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