Paving the Way: Institutional Interventions for Academic Excellence and Success in Engineering

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Introduction

The adequacy of the U.S. science and engineering workforce has been an ongoing concern for more than 60 years. However, the nation's colleges and universities are failing to produce a sufficient number of engineering graduates to meet the burgeoning demand for technical talent, a critical labor force gap that is exacerbated by a retiring Baby Boomer technical workforce. One obvious opportunity to increase the number of engineering graduates is to ensure those that begin their collegiate education in engineering earn their degrees in a reasonable period of time.

The National Society of Black Engineers (NSBE), in partnership with ExxonMobil, investigated research- and practice-based components of undergraduate engineering programs that are essential to markedly change the trajectory of student success in engineering. This approach operationalizes the knowledge gained from the ExxonMobil-NSBE Engineering Impact Awards Program as well as interviews with university administrators with a collective 88 years of experience in successfully graduating underrepresented minority (URM) students in engineering. Based on this prodigious body of knowledge, NSBE identified a list of **interventions** (that are by no means exhaustive) that have proven to facilitate the success of students of color in engineering:

1. Institutional leadership engagement
2. Summer bridge programs
3. Collaborative learning (and living) environments
4. Facilitated study groups
5. Early alert systems
6. Scholarships
7. Positive self-efficacy development
8. Positive identity development
9. Faculty development programs

Taken together, these interventions offer a comprehensive solution to colleges and universities striving to improve the retention and success of all students.

For most[1] of the interventions described, we have provided the following:

a. **Research-based rationale:** A definition of the intervention followed by a brief review of the research literature demonstrating how the intervention is associated

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[1] For a handful of the interventions, the administrators did not articulate their challenges, possibly because the initiative had become institutionalized.

with success of underrepresented minority students in engineering. This is intended to articulate the validity of the strategy.

b. **Best practices:** Input from leaders at four exemplar institutions that have implemented the intervention with demonstrated success in graduating African American and other underrepresented minority engineering students. Because it was difficult to tease out individual interventions, since many of the institutions utilized a comprehensive approach to achieve academic success among their engineering students, we also include case studies that illustrate how the institutions link the most salient interventions together.

c. **Challenges:** Obstacles or barriers the exemplars experienced while implementing the intervention, with suggested mitigations.

Finally, we provide a brief guide for universities to consider when implementing one or more of these interventions. Here, we identify key institutional allies who are critical to achieving success, including various mechanisms to engage NSBE and other student chapters on their campus.

Methodology

We identified a preliminary list of the common interventions that are associated with academic success in engineering for African Americans and other underrepresented groups. The interventions were distilled from studies by the American Society for Engineering Education (ASEE), the National Academy of Engineering,[2] the Institute for Broadening Participation

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[2] National Academy of Engineering. *Surmounting the Barriers: Ethnic Diversity in Engineering Education: Summary of a Workshop*. National Academies Press, 2014.

(IBP)[3], and other relevant research.[4] From this list, 12 interventions emerged that served as the backdrop for a comprehensive review of the literature for each intervention.

We identified universities that have been recognized for their success in graduating underrepresented engineering students to validate the interventions and to provide the reader with grounded experiences (Refer to Table 2.). This was a "convenience sample" of institutions drawn from the winners of the ExxonMobil-NSBE Engineering Impact Awards Program and those referred to NSBE by their peers. Five institutions were invited, and four chose to participate. The fifth institution was unavailable during the designated times to participate in the subsequent phone interviews.

We conducted five phone interviews of officials at the four institutions. The interviews averaged 70 minutes, followed by a series of email messages for clarification. Each interview was recorded, transcribed and then analyzed using a thematic analysis to uncover patterns or themes among institutions. Each interview began with an inquiry into the three most effective interventions practiced at each institution, which they were prompted to discuss in great detail. The choice of interventions was entirely theirs, although all of the respondents noted the difficulty in identifying any one intervention that can be credited for their success.

Of the 12 initial interventions, nine emerged as preeminent. The three remaining interventions—Learning-Style Assessments; Internships and Cooperative Education Opportunities; and Undergraduate Research—did not emerge as primary strategies across the institutions. The remainder of the interview probed their use of the nine interventions highlighted. The interview protocol is included in the Appendix. To expedite the interview process, quantitative data were subsequently collected and clarified via email.

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[3] Institute for Broadening Participation. *Designing for Success: Positive factors that support success in STEM pathways and reduce barriers to participation: What does the research say about what enables students to succeed and persist in STEM fields?* January 2, 2014.

[4] Reid, K. (2013). Understanding the Relationship among Racial Identity, Self-Efficacy, Institutional Integration and Academic Achievement of Black Males Attending Research Universities. *The Journal of Negro Education 82*(1). pp. 75–93.

Five administrators, including deans and directors of diversity centers, spoke frankly about the benefits of these interventions, challenges associated with implementation, and advice to those wishing to institute these interventions at their home institution. The participants were: [5]

- Dr. Kendall Harris, Dean of Engineering, Prairie View A&M University
- Dr. Darryl Pines, Dean of Engineering, the University of Maryland, College Park
- Mr. Derrick Scott, Director of the Inclusion and Multicultural Engineering Programs and Co-director of the Michigan STEM Academy, the University of Michigan
- Mr. Robert Scott, Managing Director, Center for Engineering Diversity and Outreach, the University of Michigan
- Dr. Bevlee Watford, Director, Center for Enhancement of Engineering Diversity and Associate Dean, the Virginia Polytechnic Institute and State University (Virginia Tech)

After the themes were identified and the data sorted by intervention, subthemes of "challenges" and "best practices" were highlighted and are subsequently presented in this paper along with words of wisdom directly from respondents. The statistical data provided by the participants (i.e., enrollment, retention, graduation rates) were largely descriptive: no advanced statistical treatments were applied (See Section II under "NSBE Best Practice Exploration Interview Protocol.").

The Four Exemplars

To validate the original list of 12 interventions, NSBE selected four institutions that have been recognized as exemplars in graduating underrepresented minorities in engineering. Although they do not reflect all engineering institutions, they demonstrate successful model usage of the nine interventions that resulted. Table 1 illustrates the total and underrepresented minority engineering enrollments at the four institutions.

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[5] 3 Large (>35,000 students) selective public institutions and 1 less-selective public (6,315 students) Historically Black College or University (HBCU)

Table 1: Undergraduate Engineering Enrollment at Exemplar Institutions
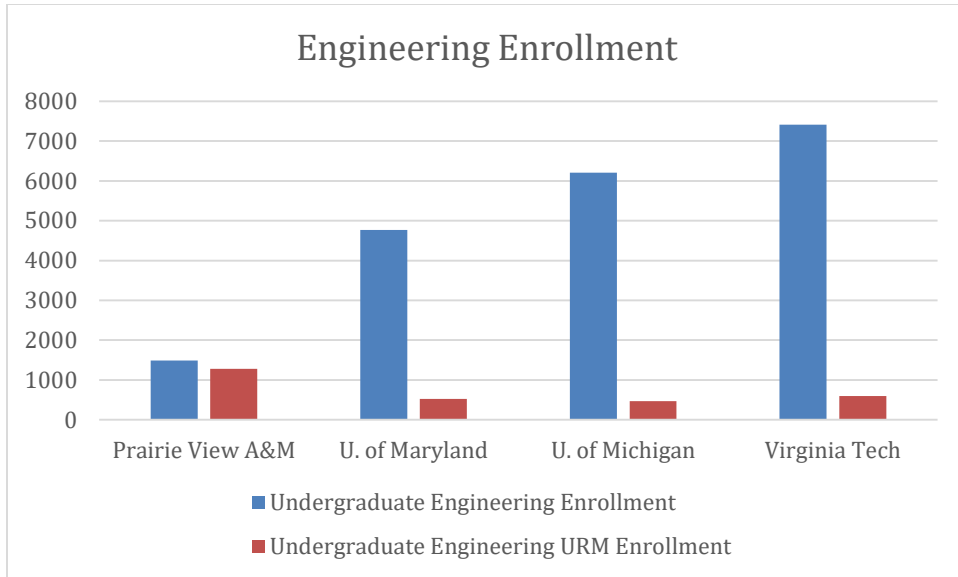
Table 2 illustrates graduation rates of underrepresented minorities in undergraduate engineering programs at the exemplar institutions.

Table 2 Last Reported 6-Year Graduation Rates
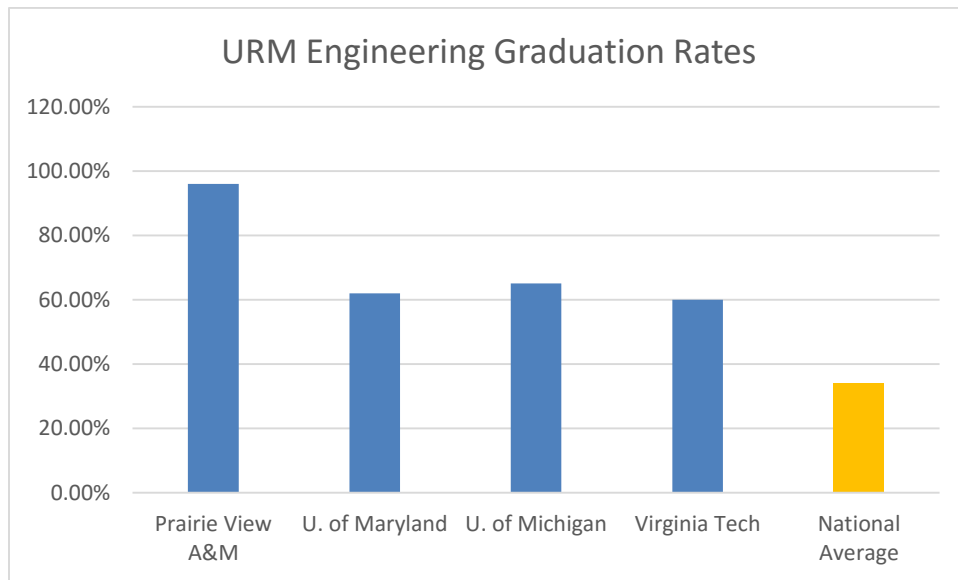
The engineering deans and administrators agreed that broadening participation in STEM takes a relentless institutional commitment to that agenda for students on campus, while also giving attention to building a pipeline for future students (Pines). Moreover, although the

interventions we describe are presented independently, the administrators strongly suggested that they be established comprehensively. The most effective approach is "a complete plan…something from the time that [students] hit your campus…to the time they successfully complete an interview, and everything in between*"* (Harris).

Although this holistic effort may sound daunting at first, as a person committed to diversity in engineering, the reader must keep in mind that markedly improving academic outcomes is "years in the making" (Watford). Improvements do not happen overnight but require long-term investments in the strategy, with course corrections throughout the duration that are informed by the data.

Finally, just as engineering is not a career for individuals working in isolation, neither is the business of increasing URM student graduation rates. The African adage "It takes a village" applies here, when referring to graduating underrepresented students. "What can make a difference is the ability to draw upon a number of resources from across your college and university" (Scott).

The reader should thus utilize this paper as a holistic collection of resources that were more than eight decades in the making.

Institutional Interventions

Institutional Leadership Engagement

Institutional leadership typically comprises the president, provost, chancellor, deans, department chairs, vice presidents, and other senior leaders responsible for setting the direction, priorities, and policies of the college or university, and for influencing curriculum, pedagogical practices and the culture of the institution.

Literature. Leaders must be singularly committed to diversity and inclusion to the degree that these beliefs are embedded into the core values of the institution that influence every aspect of admissions, teaching, and learning; hiring; staff evaluations; and faculty tenure and promotion decisions. Much of the literature that addresses the attraction, retention, and subsequent graduation of URMs in engineering implicitly attribute their success to institutional leadership. The adoption of such novel programs as summer bridge programs, collaborative learning environments, cooperative experiences, early alert systems, faculty development, and scholarships could not be facilitated without institutional leadership engagement (Felder, Brent, & Prince, 2011), although there is a dearth of literature that specifically links the success of URM students and institutional leadership.

Best Practices. Although the literature may not show a direct linkage between institutional leadership engagement and underrepresented minority engineering student performance, every administrator with whom we spoke opined about the importance of leadership in support of their efforts. Institutional leadership is critical, according to Watford. Another participant echoed this sentiment: "The tone is set from the top…the tone is set by the president, the provost and the deans" (Pines).

Achievement in the area of increased URM representation requires "a long-term commitment from leadership on the problem, and long-term means five to ten years" (Pines).

Along with their strong stance on institutional leadership involvement, the participants offered the following advice on how to engage leadership in supporting increased investment in URM undergraduate engineering success:

- "Generate annual reports, remain visible, and stay engaged with the entire department and greater university/college community" (Watford).
- "Make sure that leadership meets your students" (Scott).

- "…show excellence, and show how it's improving the environment…keep it as a priority" (Pines).
- "…show that you have value, that you add value to the enterprise" (Watford).

Challenges. Engaging institutional leadership in matters of diversity and inclusion as specifically relating to underrepresented student success in engineering is a significant challenge when leaders fail to "get it." However, leveraging the literature, for instance that cited in this paper, and generating empirical evidence through campus pilots could lead to increased support for boosting investment in these and other intervention strategies. After presenting the research, you should be prepared with a list of well thought-out initiatives with budgets, timelines, anticipated impacts, and implications for the university.

To increase your credibility in making the case for leadership commitment, advocates should thoroughly explore and be able to articulate the risks of failure or the risk to the administration of taking a public stand on diversity if one was not previously articulated. By articulating both sides of the argument, you demonstrate that you can be a reliable champion by helping the leadership think through all contingencies (pros and cons).

As already stated, these efforts take time: "You're not going to see anything in a couple of years […] it takes lots of effort, so I would say leadership commitment is key." (Pines).

Summer Bridge Programs

Summer bridge programs are typically residential academic and socialization programs hosted by the institution for incoming freshman. These programs provide early engagement and academic enrichment, while introducing students to the university, the faculty, and to the expectations of a rigorous engineering undergraduate program.

Literature. Summer bridge programs have been developed and implemented across the country at various institutions intent on preparing students to overcome many of the known obstacles to collegiate success, such as: 1) lack of self-confidence; 2) misplaced expectations or knowledge about college environment; 3) lack of connection to the college community; 4) lack of early validation within the college environment; and 5) lack of faculty engagement (Kezar, 2000). The overarching goals of many of these programs are to increase student academic success and social integration.

The impact of summer bridge programs on underrepresented engineering student success is well documented in the literature. One study reported comparative academic success among its participants. Minority engineering students who participated in the bridge program earned, on average, a higher first semester grade-point average (average GPA of 3.00) than nonparticipants (average GPA of 1.85) (Reyes, Anderson-Rowland, & McCartney, 1998).

The Arizona State University summer bridge program for women reported a one-year retention increase from 60 percent to 80 percent, which the university attributed largely to its new program (Fletcher, Newell, Newton, & Anderson-Rowland, 2001). When the researchers surveyed their students, they found that elements such as feeling comfortable on the campus, advising, mentoring, tutoring, and time management training were paramount to the program's success (Fletcher et al., 2001).

Finally, a 2011 study reported that a summer bridge program produced significantly higher self-efficacy, slightly higher sense of belonging, significantly higher academic skills, and slightly higher social skills of URM engineering students at the close of their program (Strayhorn, 2011).

Best Practices. The summer bridge program is the flagship intervention for all four of the exemplar universities. Each institution has its version of the program: The Summer Bridge Program for Scientists and Engineers at the University of Maryland; M-STEM at the University of Michigan; Panther Pride at Prairie View A&M University, and the Student Transition Engineering Program (STEP) at Virginia Tech. All are five-week residential programs, serving 20–90 students. Some are restricted to URM students, whereas others are open to all incoming engineering freshmen, regardless of race, gender, socioeconomic status, or academic achievement.

The programs are primarily staffed by graduate students and premiere faculty. The focus of these summer bridge programs is to create learning communities and increase preparedness for the rigors of engineering curricula, particularly in mathematics, as "mathematics is the No. 1 reason why students are not successful" (Harris).

Few of the incoming underrepresented minority students at these institutions are calculus-ready by the first semester in large part because of a lack of access to advanced placement courses. In addition, the rigor and the sequence of the prerequisite courses create roadblocks for many of these students. The engineering curriculum is dependent on a "critical path." For instance, in some of these institutions, a student must successfully complete Calculus I and II before taking Physics. Moreover, they are precluded from registering for any electrical or computer engineering courses without successfully passing Physics I and in some cases Physics II. Under these circumstances, if a student does not complete Calculus I and II in his or her first year, the student's sequence will be delayed by as much as one year. Prairie View reported that its Panther Pride program for the last five years has ensured that 95 percent of participants in the program have successfully been placed in Calculus I or higher in semester one.

Challenges. The primary challenge associated with establishing a summer bridge program is funding. These programs can cost on average $6–8K per student. Most of the institutions offer this program free to students; however, one university charges nearly $2,200 per student in an attempt to reduce costs.

Administrators cited college and university financial support, National Science Foundation (NSF) grants, endowments, foundation support, and "being creative" as means of financing this very costly intervention. For example, one university administrator emphasized the use of graduate students for coordinating and staffing the programs, and "taxing" other successful programs to aid in funding summer bridge programs. (Their program was open to all students, so such tactics were justified.)

All of the administrators credited their summer bridge with being the largest contributor to increased graduation rates. These programs provided a strong academic foundation for their students, an opportunity to establish learning communities through relationships with their peers/cohort, and a gateway to other support services throughout the academic year. Derrick Scott put it this way: "…one thing that has been consistent over my close to 40 years around how to approach [URM engineering retention], no matter what institution you work in…is building community, and doing it as early as you can."

Collaborative Learning (and Living) Environments

Collaborative learning environments are residential communities, first-year engineering (FYE) programs, and/or design- or team-based courses that facilitate academic and social integration in which two or more students learn together.

Literature. First-year engineering (FYE) programs are prevalent nationwide and have proven to be effective in fostering retention of underrepresented students. Before the adoption of FYE programs, universities that were included in one study were experiencing 50 percent to 84 percent attrition rates in the first year (Knight, Carlson, & Sullivan, 2007). However, after instituting a first-year engineering program, the University of Florida, for instance, reported first-to-second-year retention gains of 225 percent for women and 33 percent for minority students. Texas A&M University reported a 22 percent improvement in retention of women, 20 percent among African American students, and 14 percent among Latino students after introducing their FYE program (Knight et al., 2007).

The Colorado School of Mines reduced its attrition of first-year engineering students by more than half, doubled the two-sequence Physics completion rate, improved the Calculus pass rate by 40 percent, and significantly improved Physics and Calculus finals performance after instituting its residential program (Pendergrass, Kowalczyk, Dowd, Laoulache, Nelles, Golen, & Fowler, 2001).

Although increased retention and pass rates are key motivating factors for establishing a FYE program, institutions have realized additional benefits, including students' increased understanding of practical applications of theory, greater faculty engagement and student confidence (Knight et al., 2007; Olds & Miller, 2004), and improved graduation rates (Olds & Miller, 2004). For instance, the University of Colorado at Boulder reported confidence gains of 19 percent in successfully participating in, contributing to, and completing engineering design tasks after students' completion of the FYE program (Knight et al., 2007). Another institution attributed its 94 percent increase in five-year graduation rate to its intensive FYE program (Olds & Miller, 2004).

Best Practices. The exemplar institutions discussed two often overlapping ways in which they have implemented collaborative learning (and living) interventions: first-year engineering (FYE) academic programs, and residential communities.

Some of the universities dedicate entire departments to developing and managing first-year engineering programs to include one or more introductory engineering courses, study skills (learning how to learn), and design projects, all intended to foster academic and social integration on campus. Other universities did not have the resources (i.e., money, institutional support, or faculty) to take on such a large endeavor. Instead, they modified their curriculum and graduation requirements to front-load collaborative learning efforts (e.g., design-, project- or team-based learning courses). For example, Prairie View A&M students declare engineering before arriving on campus and thus get exposed to an introductory engineering course that establishes the distinction between the various engineering disciplines. Citing that "before we introduced this course in 2006, students just left engineering" out of frustration, it became clear that they did not fully understand the nature of the discipline they selected (Harris). In the absence of knowledge, when they were confronted with the reality (and the rigor) of the coursework (e.g., computer hardware design as opposed to software development), they would leave engineering for another major. This introductory course thus broadens their knowledge of the various engineering disciplines to help students make more informed choices about their degree programs.

Another best practice: Prairie View A&M incorporated voluntary supplemental peer-to-peer instruction into faculty-led recitations for all freshman and sophomore engineering courses. Doing so fosters academic and peer integration, key factors in increasing student engagement and persistence.

All incoming freshmen (not just engineering students) at Prairie View A&M University live in residential communities of 100 students grouped by major and other common characteristics. Residential communities at Virginia Tech are much more than a place to sleep: they are an engineering community that provides readily accessible classmates with similar coursework, tutoring in the residential hall, organized study groups, maker spaces, and social support through community activities orchestrated by engineering student mentors. At the

University of Michigan, where the students "live together in the first year… play together, the whole nine yards…the residential communities are [seen as] a supportive community" (Scott).

Although these and other freshmen residential communities are a very expensive endeavor, the return on their investment has been significant. For instance, Virginia Tech discovered that retention rates of freshmen who lived in the engineering community were approximately 15 to 20 percentage points higher than for students who did not live together.

In these settings, according to the exemplars, students also learn how to, and the need to, work collaboratively, a key engineering skill. Thus, residential communities are one approach to providing professional training on how to work together.

Several colleges incorporate curricular or co-curricular collaborative learning courses into their FYE program.

> "Right when you walk on campus…it's... completely a hands-on experience. [Students] get immersed in the design culture and learn about the design principles and practices. [Students] work with a group of students in their very first fall semester designing a system, and are not being graded necessarily on whether that integrated system works completely properly, but instead being graded on the process by which they design the system, which is what engineering design is all about" (Pines).

Collaborative learning initiatives for first-year students, such as project-based courses and service learning projects, create an environment that encourages the freedom to fail, empowers students through creative exploration, and inspires students to work together and build strong bonds. Here, it is important to assign students to the groups to foster greater meaningful interactions across gender, race or other affinity groupings.

Challenges. As mentioned earlier, residential communities designated for engineering students (in some cases, of a single gender or discipline) are an expensive intervention. However, one suggested alternative is to designate a floor or a wing of an existing residence hall for engineering students. None of the institutions segment their communities by race or ethnicity, although underrepresented students are strongly encouraged to reside in the facility and in some cases are mandated to do so because of scholarship requirements.

Paying upperclassmen to staff the hall to facilitate study times, coordinate events, and serve as peer mentors and advisors could be a low-cost way to host an academic community that

fosters social and academic cohesion. One administrator recommended offering incentives to upperclassmen by substantially discounting the residential fee.

Finally, carefully coordinating these efforts with student affairs departments, which have their own set of objectives and structures, was noted as a key success strategy.

Facilitated Study Groups

Facilitated study groups are typically regularly scheduled study sessions for engineering students to increase understanding of course material and challenging concepts. These groups, which complement the lecture and recitation with supplemental instruction and problem-solving, are typically facilitated by graduate students or upperclassmen with demonstrated proficiency in the subject area. Student participants can earn credit, although this is not always the case.

Literature. May and Chubin (2003) characterized the "highly-involved" student in a report that emphasized the attributes associated with successful students. These attributes included spending a considerable amount of time integrated in both the social and academic milieu on campus. In the context of their report, the researchers discussed the tendency of URM students to separate their personal and academic lives on campus (See also "Positive Identity Development."), which "often deprived [them] of the benefits of sharing information and group study with peers" (May & Chubin, 2003).

Theorists argue that learning is commonly situated within communities of practice that consist of members who are not only bound by task but also by "socially constructed webs of belief, which are essential to understanding what they do" (Brown, Collins, & Duguid, 1989). Thus, in order to truly learn, students must become a member of a community of practice that provides an environment that fosters identity development and increased engagement in learning.

Treisman (1992) saw this duality for identity and learning engagement when studying Chinese students at UC Berkeley. He discovered that successful Chinese students seamlessly blended their academic and social lives, which enhanced their learning through the development of communities of learning. The resultant Challenge Calculus Workshops that Treisman first founded at Berkeley and subsequently replicated nationwide in a range of subjects and demographic groups, have been shown to help students greatly in mastering core subject matter and developing analytical reasoning, study skills, and other essential collaborative learning strategies that lay the groundwork for future academic success.[6]

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[6] Although MIT did not participate in this project as one of the exemplars, its facilitated study group program (Seminar XL), modeled after Treisman's workshop, has been successful at dramatically increasing the first-semester success rate of underrepresented students among those freshmen who also participated in the university's summer bridge program. One of the co-authors of this paper, Dr. Karl Reid, co-authored the unpublished MIT study.

Best Practices. All four exemplary institutions utilize voluntary or mandatory facilitated study groups. Some are for all students, whereas other study groups are designated only for at-risk students (C or below). The study groups are largely staffed by students with proven success in the subject areas. This approach has been highlighted by all of the respondents as a low-cost, non-resource-intensive approach to strengthen student confidence, increase academic achievement, and build community.

Prairie View A&M University pays academically successful students who offer to organize and lead study groups for one- to two-hour sessions. The University of Michigan Center for Engineering Diversity Office partners with the university's learning center to facilitate tutoring, supplemental instruction, time management, and other development workshops delivered through an intervention platform.

Early Alert Systems

Early alert systems are proactive, ongoing interactive interventions by faculty, advisors, or first-year program leaders that both affirm successful students and identify those at risk of failing their course(s) early in the semester, to foster a turnaround in behavior or performance. In some cases, these systems are triggered automatically by a software system, for instance, after a certain number of absences occurred, or manually by an advisor, mentor, teaching assistant, or faculty member. The trigger mobilizes an array of people and services directed to the student.

Literature. Early alert systems are the proactive attempt to actively monitor and address academic or behavioral deficiencies of students before they irreversibly impact academic outcomes in a class or during a semester. Early identification of students who require additional resources and mentoring is one mechanism for retaining students in the first year of engineering (Faulconer, Geissler, Majewski, & Trifilo, 2014). In one study, academic difficulty incited conversation between the student and faculty 85 percent of the time (Faulconer et al., 2014).

Although most systems provide early interventions that require academic and behavioral attention, feedback provided by this intervention can also be positive and affirming for students performing well, because it fosters self-efficacy. In the same study, positive alerts or "kudos" were found to be motivational for 93 percent of the student population.

These and other studies suggest that early alert systems promote dialog between faculty and students, aiding in facilitating broader "academic success" conversations (Faulconer et al., 2014). This dialog creates a more welcoming environment for students by fostering faculty engagement outside of the classroom, a critical factor in increasing persistence and success (Pascarella & Terenzini, 1991; Tinto, 1993).

Best Practices. All four institutions had an early alert system in place to aid in the academic success of their URM students. Although not all were automated, each intervention employed at least a dedicated student, staff person, or one or more faculty members to monitor and react to student progress.

Virginia Tech established a mentoring program for freshmen and sophomores. The upper-level student mentors are required to submit weekly reports to the Center for Enhancement of Engineering Diversity that trigger a meeting with an administrator if a student's performance

slips. In addition, a student information system that tracks student achievement triggers a meeting with an administrator when a student's GPA falls below 2.5.

The University of Michigan employs a staff person "coach" who complements the traditional advisor. The coach is tasked with "keeping up with academic, personal, and professional activities" of freshman and sophomore engineering students (Scott).

Traditional personal engagement was also mentioned as an early alert initiative. At the University of Maryland, administrators "typically engage with [students] multiple times the first semester to make sure everything's going okay, making it obvious that we are checking their grades" (Pines). Prairie View relies heavily on their faculty as advisors to track freshmen and facilitate their introductory courses. Having these freshmen advisors in regular contact with the students fostered stronger relationships with students. If students are identified as having a C or lower in a course by midterms, they are required to attend peer-to-peer supplemental instruction.

Challenges. Early alert systems, whether they are manual or automated, are personnel-intensive. They increase the workload on faculty and administrators and, depending on the institution, may be viewed as placing unrealistic burdens on the same. This challenge has prompted the use of student mentors as the first line of engagement with underclassmen, a lower-cost option and one that is relatively easy to implement depending on the size of the engineering department.

Such a system could consist of weekly reports augmented with automatic flags for attendance and GPA thresholds. The advisor of the student experiencing difficulty would be subsequently notified, who would then initiate contact with the student and establish an intervention plan with follow-up facilitated by the student mentor(s). Student mentors would then be responsible for introducing underclassmen to resources on campus, including supplemental instruction and tutoring, while providing weekly status updates to the advisor on the student's progress. The mentors would reengage the advisor if they have any difficulty contacting the assigned student or when a higher level of intervention (e.g., counseling) was required.

For the exemplars, the main challenge of implementing a mentoring model was establishing the first few cohorts and institutionalizing the effort. Once it was implemented and

proven, the program became self-sustainable. For instance, one university noted that the mentors returned year after year to guide the next cohort of students.

Faculty and staff engagement could be challenging if the department lacks the resources to provide instructional relief for faculty or to hire dedicated staff members to serve as coaches. The universities that exclusively utilize faculty and staff mentioned workload as a major hurdle to implementing an early alert system.

Finally, software-triggered early alert systems do not alleviate the need for dedicated personnel to manage the program. These systems simply automate the alerts sent to the student and the advisor. To truly be successful, program oversight must be provided to ensure that the students, advisors, and other support personnel follow through on their responsibilities.

Scholarships

Scholarships are grants or payments made to support a student's education, awarded on the basis of merit, performance, or need.

Literature. A study conducted by the National Action Council for Minorities in Engineering (NACME) brought to light that meeting the financial need of minority engineering students is a key factor in addressing the problem of attrition (Georges, 1999). Underrepresented students with higher scholarship funding have higher rates of persistence in science, engineering, or mathematics programs than do students with "self-help" aid (or loans) (Fenske, Porter, & DuBrock, 2000). More broadly, in a comprehensive regression analysis of nearly 400 scholarship programs, UNCF found that as little as $5,000 awarded to African American freshmen—many of them majoring in science, technology, engineering and mathematics—increased the likelihood of graduation in five years by more than 7 percentage points (Richards, Bridges, & Awokoya, 2013).

Although the effects of scholarship awards on collegiate persistence are well known, the impact of *performance-based scholarships* is emerging. Performance-based scholarships differ from typical scholarships in that students are directly awarded payments once they meet benchmarks designed to stimulate persistence (e.g., completing a targeted number of credit hours, maintaining a certain GPA, etc.). Preliminary research suggests that incentive-based scholarships may influence behaviors that foster more timely progress toward degrees (Patel, Richburg-Hayes, de la Campa, & Rudd, 2013), although there are no known studies linking URM engineering student outcomes with performance-based scholarships.

Best Practices. The studied institutions see the hardship of students' being concerned with academic achievement and paying their tuition bill, and provide scholarships to lessen the burden. Pines noted that funding their education is often a challenge, "particularly for this demographic group," and Harris and Watford both expressed that their institutions try to disseminate scholarships to as many students as possible. The institutions also attempt to protect their investment by a) requiring that their scholarship students live in the engineering residence halls (where applicable); b) requiring that the students participate in supplemental instruction and tutoring if their GPA dips below 2.5; and c) designating a staff person to monitor scholarship recipients' trajectory in the engineering program.

Another recommendation was to add value to existing scholarships. For instance, Prairie View A&M's College of Engineering enhances scholarships given by the institution to improve the retention of successful students by further reducing their financial burden. The risks of making these higher investments in student success are mitigated by the aforementioned interventions (e.g., early alert systems, residential FYEs, etc.).

Challenges. Scholarships are an investment. These institutional leaders recommend working with the institution's Resource Development department, the Alumni Association, or equivalent functions to solicit alumni to endow URM engineering student scholarships. Not surprisingly, these accounts take time to establish and mature. In the shorter term, pooling alumni contributions to create scholarship funds that are annually replenished is a much more achievable goal. Either way, it is essential to have students write letters to their benefactors offering testimonials about their (positive) undergraduate experience and to express their appreciation for the support.

Positive Self-Efficacy Development

Self-efficacy beliefs are defined as an individual's belief in her/his capacity to execute behaviors necessary to achieve specific outcomes (Bandura, 1977). They reflect confidence in the ability to exert control over one's own motivation, behavior, and social environment (Bandura, 1989). Self-efficacy has been proven to influence a person's choices, effort, and persistence when faced with obstacles and failure.

Literature. Although studies report no statistical difference in the association between engineering self-efficacy beliefs and gender and race/ethnicity (Concannon & Barrow, 2009), numerous studies have focused their investigation on the role of these beliefs on retention in science and engineering (Hutchison, Follman, Sumpter, & Bodner, 2006; Brainard, 1998; Seymour, 1997; Sax, 1994; Margoli, 2002; Felder, 1995; Besterfield-Sacre, 1997). Lent, Brown, and Larkin (1984) discovered the link between self-efficacy beliefs and persistence in STEM fields with a study that examined 42 undergraduates' persistence and success in pursuing science and engineering college majors. Students with high self-efficacy achieved higher grades and persisted longer in technical and/or scientific majors than those with low self-efficacy beliefs.

Self-efficacy beliefs are acquired from four sources of information: performance accomplishments; vicarious experiences; verbal messages and social persuasions; and physiological states (Pajares, 2002). Students develop a sense of efficacy as they experience academic success (Schunk, 1983). Outcomes interpreted as successful raise self-efficacy, whereas perceived failures lower it. Indeed, self-efficacy beliefs are challenged when a student encounters material that he or she did not understand or felt incapable of learning (Hutchison et al., 2006).

The observed experiences of others with whom a student can relate are also crucial to fostering self-efficacy beliefs, especially when the individual is uncertain about his or her own abilities or has limited experience with the task or in the domain, as is the case for freshmen. The success of a role model who possesses similar attributes is particularly helpful in raising self-efficacy beliefs (Pajares, 2002). This may be represented by the educational levels and occupations of parents, or the accomplishments of an upperclassman. On the other hand, watching a role model fail could have a deleterious effect on self-efficacy.

Family, professors, peers, and others who offer verbal judgments that affirm one's capabilities can build up an individual's perceived self-efficacy (Pajares, 2002), although it is easier to weaken self-efficacy through negative appraisals than to raise it with verbal praise (Morris, 2004). An African American student can be empowered by persuaders who cultivate beliefs in their abilities. Honors, awards, and elected positions can provide this important source of self-efficacy. Likewise, negative judgments, such as hearing doubts about a student's likelihood to succeed in engineering can weaken these self-perceptions (Pajares, 2002).

Finally, anxiety, stress, fatigue, and moodiness while undertaking an academic task may cause a student to judge his capabilities as lacking. For instance, a student who experiences test anxiety and subsequently performs poorly will have lowered his sense of self-efficacy toward tests in that subject. Subsequent efforts become tentative, leading to a downward spiral that interweaves his lack of confidence with lower performance outcomes (Bandura, 1997; Pajares, 2002).

Best Practices. Pines succinctly commented that the goal "is to get [our URM engineering students] believing in themselves. They are already very smart students, but I want them to believe even more that they can be the best students they can be." The exemplar institutions discussed numerous ways in which they foster healthy development of self-efficacy in their URM engineering students, which include:

- Making success pledges recited at the completion of the summer bridge program
- Hosting recognition events at the end of summer bridge programs and at the midpoint of first semester
- Teaming students with mentors who reflect their image, to serve as role models of success in engineering
- Offering a combination of recitation, supplemental instruction, and facilitated study groups for freshmen and sophomores
- Deliberate and distributed instances of community building, as "[students] gain confidence within the community" (Watford)

Positive Identity Development

Identity is a complex social-psychological construct that defines who we are as individuals. Our identity is shaped by our backgrounds and the social arenas in which we function (Brickhouse & Potter, 2001). According to Dorothy Hollard, "Identities are the stories we tell ourselves and the world about who we are, and our attempt to act in accordance with these stories" (Perry et al., 2003, p. 50). Although identity includes elements such as race, ethnicity, and gender, it also may comprise the roles that we assume in our day-to-day lives (i.e., son, sister, student, engineer, scientist, mathematician, designer, etc.).

Literature. Science educators have discovered through research that learning and identity are inextricably linked. They argue that learning is not simply acquiring knowledge, it is also a matter of deciding what kind of student the learner is or wants to be (Brickhouse, 2001). The more a student participates in activities that link them to a scientific community, the more her/his identity becomes congruent with the social context and therefore becomes more engaged in learning (Brickhouse, 2001).

Students have multiple stems of their identity (gender, race, religion, socioeconomic class, etc.) that become salient depending on a range of internal and external interactions (Brickhouse et al., 2000) and which also can become the source of great internal conflict. This conflict may demand that an individual prioritize competing elements of themselves (Kozoll & Osborne, 2004), for instance, when their racial, ethnic, or gender identity competes with their engineering identity.

If the community renders these two identities mutually exclusive (e.g., engineering is masculine), then it may be that the women in the program, for instance, will leave if their gender identity is stronger (or more salient) than their engineering identity. Brickhouse and Potter (2001) found that to be the case in a study of the scientific identity formation of two young women of color. One participant's computing identity was more salient than her identity as an African American young woman, thus, she engaged freely in the computing community, which in turn contributed to her success. The other young woman never "felt" as if she belonged, and therefore left the computing program at her school (Brickhouse & Potter, 2001). Successful

programs must identify and cultivate positive engineering identity, while helping the student reconcile internal conflicts that may exist.[7]

Best Practices. The administrators at the exemplar institutions discussed the conundrum of identity development of their underrepresented students. Whereas some students seek and thrive in an environment that surrounds them with like-faces and additional support for/from other URM engineering students, others are put off by the notion of being identified simply by their race/ethnicity. They prefer to engage with the broader engineering community.

There were many theories behind this dialectic. Two include: a) fear of being spotlighted for their race or gender, often accompanied by stereotypes of not being as prepared as their majority counterparts; and b) ideals of being in a post-racial society where such affinity groups or accommodations are no longer necessary. Even with the complexity of this dilemma, all of the administrators believed that diversity offices, outreach, and initiatives were necessary, because there still exist students who need and flourish with these types of resources. One recommendation includes "ditching the deficit model" and instead focusing on the capital that URM students contribute to the campus environment.

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[7] Although not interviewed for this paper, the Northern Illinois University (NIU) College of Engineering and Engineering Technology's #WhyEngineering pledge campaign encourages all students to state why they chose engineering and what motivates them to stick with it. Submissions are posted in social media and published on posters throughout the department. Although NIU embraces diversity (NSBE, SHPE, and SWE students and chapters are on prominent display.), #WhyEngineering fosters a complementary engineering identity for all of its students, faculty, and staff. http://www.niu.edu/ceet/whyengineering/index.shtml

Faculty Development Programs

Faculty development programs are resources provided by the institution to strengthen pedagogical practices, heighten cultural awareness, and increase mentoring skill sets.

Literature. Engineering education has largely remained the same for decades with regard to pedagogical practices. A common misconception among engineering faculty is that engineering dropouts are the result of weaker students, when in fact it is largely attributed to dissatisfaction with the quality of the teaching/learning experience (Felder, Brent, & Prince, 2011). Quality of teaching benefits all students but especially those who may have gaps in their preparation but who would otherwise make excellent engineers (Brent & Felder, 2003; Daempfle, 2003; Felder et al., 2011).

Development programs for faculty teaching engineering courses in the first two years have been shown to increase freshman student retention by nearly 8 percent, and by nearly 13 percent for sophomores (McShannon et al., 2006). In this study, the faculty development program taught proven techniques for increasing student retention and achievement through the use of student learning style assessments; tools to cultivate and implement appropriate teaching strategies; and in-class observations of and feedback on faculty and students' classroom behavior. This focus proved to have long-term effects on pedagogical practices of the faculty: 100 percent of participating faculty reported continued use of at least three strategies, and 89 percent used a suggested teaching strategy at least once a week (McShannon et al., 2006).

The National Science Foundation- (NSF-) funded initiative SUCCEED saw similar results in its efforts to promote recruitment and retention of minorities and women through faculty development (Brent & Felder, 2003). The published study reported improvement in engineering student learning by 69 percent of participating faculty.

Best Practices. The University of Maryland has made faculty development a cornerstone of its retention strategies through the Keystone Program. Pines explains:

> The strategy has been for all students to get the best instructors and staff members that care about undergraduate education, do well in undergraduate education, and engage students, and put them (our very best instructors, and very best advisors, and very best TAs)…through a

program, that we have to enhance their skills. Then we put them all in the first two years of our engineering courses (Pines).

A prestigious appointment to which faculty aspire, Keystone faculty are nominated by their peers and the administration. Once their training is completed, they receive supplemental funding to aid in the enhancement of their curriculum. Although expensive—roughly $800,000 per year—this initiative has been in existence for eight years and has had tremendous success in terms of faculty participation and student success.

Another of our exemplars recommended that tenure and promotion criteria reflect the importance of teaching, and that this responsibility not be subjugated by other criteria such as research funding, publications, and conference participation that typically hold higher prestige in research universities.

Challenges. As stated, the Keystone Program and others like it are expensive initiatives for which the University of Maryland's College of Engineering receives university funding. However, colleges/universities that do not have the resources to fund such a program could consider a smaller-scale initiative, for example, providing professional development stipends to faculty, curriculum evaluation and restructuring stipends, and course release for faculty to research and reformulate existing curricula. Although these ideas still require some investment, they can be implemented in existing structures as well. Prairie View A&M uses a portion of faculty orientations and department meetings as opportunities to expose faculty to the latest research on pedagogical approaches for the various disciplines.

Tying tenure and promotion decisions to faculty development has significant political and cultural obstacles. However, doing so ensures that this important intervention becomes institutionalized in the culture of the college of engineering. Here, effective teaching and research do not have to become an "either-or" proposition but a "both-and" approach to improving the success of students of color in engineering.

How To's: Implementing These Strategies at Your Institution

The synthesis of the research literature and interviews of exemplar institutions suggest the following key steps for college of engineering administrators interested in investing in programs and initiatives to boost underrepresented engineering student performance:

1. **Foster a community of university administrators from various institutions that are collectively interested in increasing URM engineering student success.** There is a lot to learn from peer institutions about initiatives, scalability, sustainability, failures, and creative implementation. Committed faculty and administrators should utilize discussion forums and other national venues to share ideas and best practices and offer recommendations. The modern research university is built on the pillars of collaboration and mutual respect. Applying this ethos to increasing underrepresented engineering student attainment will surely benefit the collective.

    Here, we recommend national organizations such as the National Association of Multicultural Engineering Program Advocates (NAMEPA)[8] and the American Society for Engineering Education (ASEE).[9] NAMEPA provides training, forums, and resources for faculty and administrators committed to increasing diversity in STEM. Likewise, ASEE develops and hosts programs, conferences, and other forums to support increased student enrollments in engineering and engineering technology colleges and universities, although their audience is engineering faculty and deans. These associations provide underrepresented student success with new advocates, exceptional resources, and a community of practice built on decades of practice.

2. **Get institutional leadership buy-in.** Although many of these interventions can be implemented in pockets, to have a dramatic effect on achieving parity for those who are underrepresented in engineering, universities must institutionalize these practices in such a way as to holistically affect culture and practice. Doing so requires that leadership be

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[8] http://www.namepa.org

[9] http://www.asee.org

committed, both in word and in deed, to the broader, inclusive goal of ensuring that all students, including underrepresented minorities, can and will succeed.

Toward this end, the administrators whom we interviewed suggested the following ways to gain institutional commitment:

- Pilot new initiatives using sound program and research design principles (see below). Here, it is important to let the data speak to the efficacy of the intervention, rather than relying on secondary research to make the case.
- Generate annual reports, remain visible, and stay engaged with the entire department and greater university/college community.
- Make sure that leadership meets your students.
- Show excellence, and articulate how the program can benefit and add value to the university overall.

3. **Pilot new programs to prove success.** As noted earlier, it is important that interventions be developed and data collected using respected research designs to ensure the reliability and integrity of the case you are making for the interventions.

   Here, engineering college administrators should consult social science colleagues who can assist in setting up program and data design that leverages the soundest practices (e.g., randomized assignments, treatment and control groups, longitudinal studies, etc.). This intentional design approach squelches arguments against "confirmation bias" by ensuring that the results can stand up to the scrutiny of skeptical senior administration and faculty.

4. **Collect data, publish annual reports, and maintain visibility and relevance of your efforts.** Let the data speak for themselves through regular reports and papers, particularly for a skeptical administration that is uncertain about the validity of proposed efforts. Augmenting secondary data from the research literature with primary results collected from new and existing programs removes emotion and morality from the equation—dual rationale that were effective a generation ago but which are losing ground in a higher education landscape increasingly characterized by cold rationality and return on investment (ROI).

5. **Utilize graduate and older undergraduate students as teachers, advisors, and mentors in your programs**. In addition to the practical benefit of minimizing cost, the presence of graduate students and upperclassmen as mentors and role models becomes an implicit and oftentimes explicit source of self-efficacy for first- and second-year students. Older students connect well with freshmen and sophomores and give the younger students an aspirational target to shoot for (vicarious experiences), a key source of self-efficacy. Many of the exemplars recruit student leaders from NSBE, AISES, SHPE, and SWE[10] chapters, important partners in these efforts.

6. **Pursue external funding.** Whereas sourcing new program funding from existing university resources is a logical first step to secure the resources to pilot and scale interventions, the exemplars also suggest that alumni be engaged to support and sustain the programs. The scholarship winners are encouraged to write letters or testimonials about their collegiate experience, which are published and distributed to the donors. In the short term, soliciting alumni to fund scholarships and other programs fosters a direct connection between donors and recipients. In addition, it shields the program against institutional funding fluctuations that occur during budget crunches.

   Several of the exemplars sought, and were successful at securing federal grants to underwrite their retention programs. The National Science Foundation was often cited, but other agencies such as the Department of Education, the Department of Energy, and state Equal Opportunity Programs (EOPs) have funded university-based, pre-collegiate bridge and retention programs.

   Building program endowments also ensures sustainability, although these efforts take time. Thus, partnering with Resource Development and the alumni association to ensure that your programs are included in their portfolio when they engage alumni and major gifts is key to creating sustainable programs and publicizing your success and impact.

   In addition to securing alumni funding, at least one of the exemplars formed an industrial advisory board of corporations that actively recruit from and fund research at the

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[10] The American Indian Science and Engineering Society, the Society of Hispanic Professional Engineers, and the Society of Women Engineers

institution. Paid membership in these councils could generate needed discretionary funds for the advocate to pilot new programs and perhaps scale-up existing programs. Here, it is important to coordinate with corporate relations functions at the university to ensure that your efforts are not working at cross purposes with this corporate engagement.

7. **Institutionalize the intervention.** The diversity landscape is replete with "one and done" interventions, many of which have worked but lost the funding to sustain them. A sustainable intervention is one in which there is leadership commitment, a culture of inclusion, and a consistent funding source written into the college's operating budget (and/or funded from endowments or external sources). Building endowments from alumni and other external gifts and regularly publishing findings and success stories further ensure that the program becomes institutionalized and shielded from budget cuts.

8. **Engage student chapters of NSBE.** Our exemplars developed synergistic relationships with their NSBE student chapters. Many of the colleges of engineering and minority engineering program offices provide funding for the chapters to host programs and to attend conferences, while also tapping this energetic student community to assist in staffing key intervention programs. (It is likely that the AISES, SHPE, and SWE student chapters are equally engaged on these campuses, although this line of questioning fell outside of the scope of our interviews.)

   It is critically important to guide chapter leaders to focus their efforts on improving academic performance and becoming efficient leaders. Providing intentional onboarding of new NSBE leaders so they know how to navigate the university and perform their duties with alacrity will ensure that their aspirations and their involvement do not detract from their prime directive to "excel academically."

9. **Always have a list of wants and needs at the ready**. Although it may not be possible to implement all of the interventions we cited, it is important to have a list of proposed projects in hand with the cost for their implementation, in case a senior administrator or potential donor asks what you need. At the start of every fiscal year, prepare and present a list of proposed programs, your wish list, to the Resource Development community on campus. The list should include the rationale (including results from a pilot or secondary research), the project narrative, the projected impact, and a proposed budget for each new

intervention. Having such a list builds your credibility by demonstrating that you have thought through the program. Donors give to people and not just to programs.

10. **Recognize that matters of diversity and equity take time and commitment.** Be in it for the long haul. Be cognizant (and communicate to others) that moving the needle on underrepresented student success takes time. In many cases, you are battling against deep-seated beliefs and, more likely, unconscious biases[11] that must be exposed and addressed. Still, communicating progress is critical to success in establishing a sustainable program.

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[11] Project Implicit is a non-profit organization and international collaboration of researchers that provides a great source for education and online tools to objectively uncover hidden biases that influence attitudes and behaviors: https://implicit.harvard.edu/implicit/aboutus.html

Future Considerations

To enhance the information presented in this paper, we recommend the following additional steps be taken:

- Expand the best practices study to include a broader spectrum of colleges and universities (i.e., public, private, small, medium, and large, highly selective, non-selective). We estimate that this more comprehensive approach will require a minimum of two years of commitment for the study.

- Expand the interviews on each campus to include a broader range of departments, offices, and support services that engage URM engineering students. At larger, more comprehensive institutions, the contributors to the success of URM include diversity offices (minority engineering programs, or MEPS), support services, deans offices, undergraduate programs, writing centers, tutorial services, career services, financial aid, etc.

- Conduct surveys and a meta-analysis of the literature to determine the impact or strength of each intervention on graduation, and perhaps to estimate the additive results of implementing many interventions.

- Expand the intervention list. There were a number of programs mentioned that were deemed effective/necessary to URM success that did not get discussed in this paper because of time limitations, including:
    - University of Michigan Scholar Power
    - The University of Michigan/Atlanta University Center Dual Degree program in Engineering
    - The University of Maryland agreement with community colleges for transfer students (Opening Pathways)
    - Prairie View's "comprehensive plan" for success
    - Virginia Tech mentoring program
    - Advising practices

Finally, it is important to examine the role that the NSBE collegiate chapter has in underrepresented student retention on campus, particularly at institutions that lack resources but whose services can be supplemented by the NSBE student chapters.

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Appendix

Interventions for Future Investigation

The following interventions, although grounded in the literature, were not singled out by the exemplar institutions as key elements that contributed to graduation rates. Still, we thought it would be informative to include them for further exploration.

Career- and Learning-Style Assessments

Literature. Students have different strengths and **learning style** preferences, which determine the way in which they acquire and process new information. Some students are more receptive to concrete facts, whereas others are attuned to abstract concepts. Some retain information presented in graphical formats best, whereas others prefer verbal explanations (Felder & Spurlin, 2005). When the learning styles of most of the students in a class and the teaching style of the professor are incompatible, the students are likely to become bored and disengaged, which results in unfavorable test scores, and increased discouragement in their course work, the curriculum and themselves (Felder & Spurlin, 2005). These factors can contribute to high attrition in a major and the university.

Incorporating learning styles research and practice into faculty development can not only contribute to teaching and learning effectiveness, they also improve the overall climate of the university engineering community. Within these communities, professional identities are developed (e.g., engineering identity). Some identity scholars would argue that learning and identity development are not mutually exclusive. In fact, they would make the case that identity development is learning.

Undergraduate Research Opportunities

Undergraduate research opportunities provide experiential opportunities for understanding the engineering profession while contributing to the research enterprise of the university. They are largely facilitated by faculty with a focus on creating opportunities for undergraduate students.

Literature. In 1994, there was a call to increase undergraduate participation in STEM research opportunities as a means to bridge the gap between curriculum and real-world expectations post-graduation (Sabatini, 1997). In recent years, this call to action has translated to higher retention rates of URM in STEM, caused in part by these students' increased self-confidence in STEM fields. Undergraduate research opportunities have been reported to provide students with: 1) a greater depth of knowledge in the STEM field; 2) involvement in teamwork; 3) experience with open-ended problems; 4) exposure to a holistic approach to problem-solving and career; and 5) career identity development (Hunter, Laursen, & Seymour, 2006; Sabatini, 1997), all of which benefit the emerging engineer.

Although all students benefit from the existence of undergraduate research opportunities, URM students reported gains in learning, independence, intrinsic motivation to learn, and active participation in courses (Lopatto, 2007). One study reported that 68 percent of the underrepresented undergraduate students who participated in research experiences either sustained or increased their interest in science, specifically in post-graduate education, and reported a personal gain in tolerance of obstacles (Lopatto, 2007; Zydney, Bennett, Shahid, & Bauer, 2002).

Internships, Cooperative Education Opportunities

Cooperative education is defined as the convergence of classroom, laboratory instruction, and work experience. **Internships** are best described as apprenticeships for professional careers. Each provides an opportunity to take the training and theory acquired in the classroom to the workplace under real-world constraints.

Literature. The benefits associated with participation in internships and cooperative education for students, universities, and industry appear to abound. Research studies in recent years reflect increased grade-point averages, shorter time to graduation (even with consideration of the time taken from studies to participate), and higher starting salaries (Haag, Guilbeau, & Goble, 2006; Parsons, Caylor, & Simmons, 2005). One study points out that the benefits to universities are the explicit alignment with ABET accreditation criteria, more specifically math, engineering, and technical competence; design and product realization; and students' communication skills, awareness of professionalism and ethics, lifelong learning, teaming competence, and knowledge of societal, political, and community issues (Haag et al., 2006; Parsons et al., 2005).

Employers also express high satisfaction with student participants' academic preparation and overall performance (92 and 89.7 percent, respectively, agreed or strongly agreed with the survey item.) during the internship/cooperative learning experience (Haag et al., 2006).

NSBE Best Practice Exploration Interview Protocol

12 Interventions for URM Engineering Success

Purpose: To better understand the elements that have contributed to your university's success of underrepresented minority engineering students.

The purpose of this interview is to gather feedback from university administrators on the mechanisms, efforts, and initiatives established at your university that you feel have contributed to the success of URM engineering students on your campus. This information will aid in the development of a "tool-kit" or model for other institutions. This effort is a sub-set of a larger effort in which NSBE has partnered with ExxonMobil to increase the retention, success, and graduation rates of URM engineering students. In particular, I am interested in learning more about: Graduation rates for the past 5 years, both for all students and underrepresented minorities (URMs) specifically? What deliberate efforts have been taken to increase graduation rates (more specifically of the list of 12)? What are the obstacles, challenges, and barriers? What have been the greatest successes? I'd also like you to share your thoughts on the sustainability and portability of such efforts? Finally, how were these initiatives/programs implemented? Etc.

This interview will take approximately 60 minutes. All of your responses to my questions will be recorded and later transcribed (strictly for accuracy) for possible use as a case study. This is a voluntary effort and for that I am greatly respectful and appreciative of your time.

Section I: Statistics

The first area of inquiry consists of the numbers. What kind of data are you currently collecting on your URM population and how is it utilized, reported, etc.?

1. What is your university's engineering enrollment by year (freshman, sophomore, junior, senior, masters, PhD)?
   a. What are the enrollment trends over the past five years for engineering students?
2. What is your university's URM engineering enrollment by race/ethnicity, gender and by year?
   a. What are the enrollment trends over the past five years for URMs??

3. What are the graduation rates of your engineering students (4, 5, 6-year, or ALL)?

4. Does your engineering department/university track graduation rates of your URM engineering students (4, 5, 6-year, or ALL)?

    a. If not, what data are available that can be used as a proxy to track and/or report URM student success?

    b. If so, what are the current graduation rates of URM engineering students (4, 5, 6-year, or ALL) by race/ethnicity?

5. What are the five-year trends for graduation rates? By race/ethnicity? By gender? Can you discuss graduation rates over the past 5 years? Increases, decreases? By how much?

Section II: 12 Interventions

The second area of inquiry is an exploration of 12 interventions that literature identifies as necessary for success for URM engineering students.

*Please review the table below and indicate the attributes your institution, department, program, etc., either has **considered** instituting, have **instituted**, has seen **success** in. This will aid in facilitating the rest of the discussion.*

#	*Intervention*	*Considered*	*Instituted*	*Success*
1	Institutional leadership engagement			
2	Summer bridge programs			
3	Collaborative learning (and living) environments for the first two years of engineering education (e.g., first year engineering efforts, engineering residential arrangements, etc.)			
4	Internships and cooperative education opportunities			
5	Early alert systems			
6	Facilitated study groups			

7	Career- and learning-style assessments			
8	Faculty development programs			
9	Performance-based scholarships			
10	Undergraduate research opportunities			
11	Positive self-efficacy development			
12	Engineering identity development			

6. Which interventions did you select (e.g., 3, 6, 8). For each intervention we will explore the following questions.

7. If you had to rank your efforts for impact, which intervention/initiative do you think was the most impactful and why?

    a. How do you know it was most impactful?

8. If you had to rank your efforts for impact, which intervention/initiative do you think was the least impactful and why?

    a. How do you know it was least impactful?

9. Tell me about your university's implementation of [insert intervention here].

    a. When did you initiate the effort?

    b. What were the obstacles?

        i. How much leadership engagement was necessary?

        ii. Financial dependency. Investment

    c. Tell me about the success or shortcomings?

    d. Share your thoughts on the impact of this effort on graduation rates.

    e. Share your thoughts on sustainability.

    f. Share your thoughts on portability.

Section III: Other Efforts

The last area of inquiry, are the exploration of other efforts (outside of the 12 listed above) that you feel have been paramount in the success of your URM engineering students.

10. Does your institution currently have minorities in engineering or women in engineering programs?

11. Does your institution currently have an active National Society of Black Engineers chapter?

12. Are there other initiatives about which I have not explicitly asked that you wish to share?

Closing

Is there anything you would like to add? Anything you think we missed or you think I missed?

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