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peerReview

EMERGING TRENDS AND KEY DEBATES IN UNDERGRADUATE EDUCATION

At the Soul of Leadership

Authentic Perspectives on STEM Reform from HBCUs

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Tone Begins at the Top:
Broadening Participation in STEM Higher Education

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Self-made men [and women] are [those] who, under peculiar difficulties and without the ordinary helps of favoring circumstances, have attained knowledge, usefulness, power and position and have learned from themselves the best uses to which life can be put in this world, and in the exercises of these uses to build up worthy character. They are the [women and] men who owe little or nothing to birth, relationship, friendly surroundings; to wealth inherited or to early approved means of education; who are what they are, without the aid of any favoring conditions by which other [women and] men usually rise in the world and achieve great results. . . . They are in a peculiar sense, indebted to themselves for themselves. If they have traveled far, they have made the road on which they have traveled. If they have ascended high, they have built their own ladder. . . . Such [women and] men as these . . . are entitled to a certain measure of respect for their success and for proving to the world the grandest possibilities of human nature, of whatever variety of race or color.

—Frederick Douglass, "Self-Made Men," 1872

Recent shifts in US higher education demographics, along with increasing threats to our nation's global competitiveness in science and technology, have focused national attention on the centuries-old systems that marginalize certain groups and deny them access to quality STEM education and, indeed, a better quality of life. This contemporary reality makes clear what Hippocrates, the Greek physician, noted about the state of disease—for extreme circumstances, extreme methods of intervention are most suitable.

The conventional workaround approaches that we've habitually come to rely upon—usually aimed at fixing the student or ignoring opportunities to develop the responsible faculty—are no longer suitable. Rather, extreme method reform—or implementation of a specific range of authentic, culturally sanctioned interventions aimed at broadening participation—has become necessary for redressing current trends in undergraduate STEM education. Chief among these interventions is building the leadership capacity of STEM faculty who, in every way imaginable, determine the cultural and climatic tone of undergraduate STEM classrooms, laboratories, and departments.

Indeed, tone begins at the top. Money alone cannot set a new tone. Our federal and nonfederal funding agencies have made significant financial investments in broadening participation in STEM, yet students from racially and ethnically diverse backgrounds continue to be marginalized within and excluded from full participation in these critically important fields. The growing body

of research on pedagogical reform will not change the tone either. Despite our knowing what works, culturally responsive pedagogies aimed at broadening participation are still not consistently implemented with fidelity or at scale. How, then, do we ensure higher education delivers on its promise and chart a course that is not only suitable, but daring?

In this issue of *Peer Review*, we posit that higher education, and certainly the nation, need look no further than to the leaders of our Historically Black Colleges and Universities (HBCUs), who are ideally suited for extreme method reform by setting and preserving an institutional tone that recognizes, desires, fosters, and requires the actions and outcomes that are necessary for inclusion in undergraduate STEM education (Mack et al. 2018). Historically and currently, HBCUs have significantly outpaced all other institutions of higher education in graduating Black STEM students (NSF 2017). To date, researchers have identified a wide range of strategic approaches that are believed to give rise to the unparalleled academic success of STEM students attending HBCUs.

Every indication from these and other studies, though, suggests it is not just these approaches in and of themselves, *but effective leadership of them*, that is responsible for broadening participation success at HBCUs (Waters, Marzano, and McNulty 2003; Allen-Ramdial and Campbell 2014). However, mainstream STEM education research rarely considers the leadership strategies and styles employed by HBCU leaders to support their successes in broadening participation (Hurtado et al. 2009). Additionally, the negative and incomplete depictions of these institutions, both in media and scholarly literature, have shifted them from the center of the national undergraduate STEM enterprise to the margins. Collectively, these complications give rise to a problematic narrative that ignores the influence of extreme method leadership in setting an institutional tone for broadening participation. Revising this narrative will require, as Dhunpath suggests (2000), understanding not only what HBCU STEM leaders know about broadening participation but also—and more importantly—how they have come to know it.

This issue of *Peer Review* takes on that challenge. It is guided by the nascent work of the Center for the Advancement of STEM Leadership (CASL), generously funded by the National Science Foundation HBCU-Undergraduate Program. One of CASL's principal goals is to provide STEM faculty with access to immersive and world-class leadership development opportunities. This mission represents an initial step in quieting, if not silencing, the limited narrative that situates HBCUs and their cultural capital as dispensable to a robust undergraduate STEM enterprise. More importantly, this issue of *Peer Review* features research findings, commentaries, opinions, and recommendations—from HBCU STEM leaders themselves—to help institutions broaden participation. Each article, in its own way, showcases how the institutional conditions of HBCUs can be manipulated by extreme method leaders to yield broadening participation success. Each article also demonstrates how the strategic use of symbolic, structural, political, and human-resource frames of leadership (Bolman and Gallos 2011) can shape an individual's leadership stance for broadening participation and, indeed, feed their leadership soul. In many instances, these authors, who represent a growing community of HBCU leader-scholars, unveil for us the unwritten codes that undergird how they, as Frederick Douglass suggested, "make the [broadening participation] roads on which they travel … [and] build their own ladders." What emerges from the following pages is a blueprint for all of us to follow—one that shows us how to integrate our own unique personal histories into an all-encompassing leadership practice that serves, with intentionality and specificity, positive outcomes from broadening participation. ▪

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Inclusive Research Excellence:
Deconstructing the Research Enterprise to Facilitate Responsible STEM Research

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Research is formalized curiosity. It is poking and prying with a purpose.

—Zora Neale Hurston

Knowledge can be transformed by shifting paradigms and philosophies, evolving disciplines and practices, emerging data and results, and prevailing theories and methods. Change, whether incremental or revolutionary, is the one construct researchers embrace unequivocally. Yet, as researchers, we also coexist in a contradictory state of mind that resists change. The operation of our intellect is caught up in our personal motivations, biases, emotions, images, and identities. Scholarly cognition is not cold or objective, but hot (Kunda 1999).

PLACING PRACTICES UNDER A MICROSCOPE

Our acts of teaching, applying, and disseminating knowledge may sometimes demonstrate this resistance to change. When these practices are placed under the microscope, our discomfort with change may cause us to embrace prevailing knowledge, despite obvious flaws. STEM research, in general, has been influenced by gatekeepers who control what knowledge will be disseminated, created by whom, through what venues, at what pace, and even at what cost. To the public, we celebrate peer review and tout its ethics and objectivity; in private, we discuss how research is undermined by implicit bias and so-called old-boys' clubs. We have yet to establish ethical norms and standards to address what has become a serious lack of inclusion in STEM epistemology and axiology. This continued oversight accounts for bias and inequity in research outcomes.

Buolamwini (2016) discovered a major problem with facial detection software—the systems could not "see," or process, faces with darker skin or those with bangs or other hair touching the face. The problem arose from coding and training data sets comprised of biases and, in particular, data sets with faces with a limited range of skin hues, primarily lighter skin. Buolamwini (2016) provides strong support for the need for diversity and inclusion in tech companies and universities. This is more than a moral imperative; it is a technological imperative. In her analysis of technological bias, Wachter-Boettcher (2017) describes technologies with designs that come from minimal cultural competence and inclusion. Technology failures include gender-biased card readers with algorithms that classified women with doctoral degrees as male, causing an incident where a female pediatrician's card swipes were repeatedly denied for entry into the *women's* locker room. Cathy O'Neil (2016) deconstructed recidivism algorithms used by judges and uncovered prejudices built into the algorithms. O'Neil describes how "quantitative" software applications predicted lower probabilities of re-arrest for White males

whose risk scores correlated with higher recidivism, while Black males with lower risk scores had higher predicted rates of re-arrest. Because of technological failures like this, we do a grave injustice to those who truly matter: the public we serve. Furthermore, these historical contradictions in STEM are front and center for faculty of color and prospective faculty of color, who view the flaws and biases in scientific practice and the research enterprise as reasons to leave or never enter the profession.

If institutions are truly to be "centers of hope" (Bolman and Gallos 2011, 7) and apply their own power and privilege to produce knowledge, then we need academic leaders who are willing to learn, convey, and act to prepare institutions for more diverse and inclusive approaches to STEM research. Bolman and Gallos emphasize the need for strong academic leaders who will commit to seeing the "same situation in multiple ways and through different lenses" (2011, 13). Building an inclusive research culture needs to be an espoused goal of academic leadership. Academic leadership that understands multiple lenses in research could create an institutional climate with actions, procedures, processes, incentives, and infrastructures that support more inclusive research programs. For example, university research officers could integrate efforts with academic affairs in courses that build students' strengths in the scientific method and in product and research design in ways that help students challenge prevailing (and often exclusionary) practices. Similarly, funding agencies, which provide significant monetary support and influence, should understand their role in advancing inclusive research as a practice and the impact this support may have on advancing societal benefits for all while avoiding negative consequences for some. In STEM, we are very much in need of a shift in mind-set toward more equitable ways and means to support, conceive, conduct, and disseminate research. Therefore, we offer a call to academic leaders to support inclusive research excellence (IRE).

Bolman and Gallos (2011) use four frames—human resource, structural, symbolic, and political—to describe cognitive schemas in academic leadership (see fig. 1). These frames can be used to engage academic institutions around an IRE model. For instance, a human resource frame values the contributions, talents, and capabilities of researchers within the institution. A political frame focuses on forming connections and relationships to achieve common ground. The symbolic frame may already fit a university that has moved significantly toward a climate of diversity, inclusion, and belonging. This frame would use an existing commitment to inclusion but could integrate research as a natural extension. And the structural frame would build operating models and processes to support collaboration across diverse faculty communities around interdisciplinary problems. The primary question of any stakeholder should be: Why is IRE especially important in STEM?

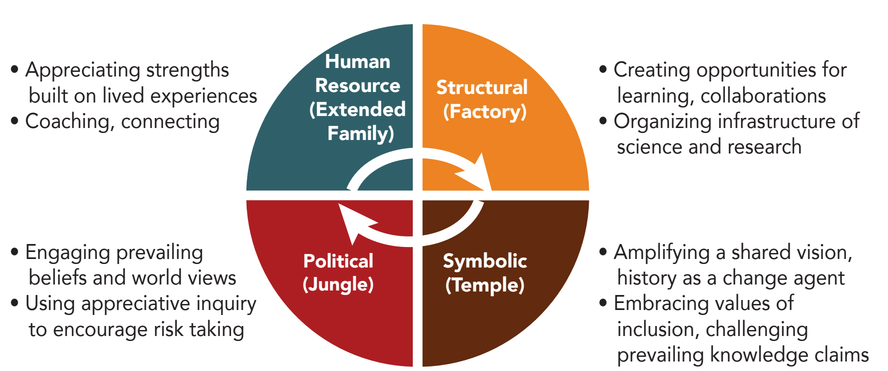
IMPLEMENTATION

IRE is grounded in the Association of American Colleges and Universities' (AAC&U) concept of inclusive excellence. IRE can be defined as systematic discovery that is valid, reliable, culturally responsive, useful, and meaningful for either the broadest range of target groups or explicitly identified target groups. While it overlaps somewhat with inclusive design, IRE is broader and more closely aligned with the AAC&U description of inclusive excellence, which addresses three fundamental needs:

1. To broaden a previous definition of diversity and redefine what it means for the academy
2. To be inclusive of more technologically focused universities
3. To provide a framework to empower faculty, staff, students, and administrators to reform institutional practices, cultures, and climates

AAC&U describes elements composing inclusive excellence to enhance the flexibility of the concept (see fig. 2). Yet, their core message is to integrate excellence in all aspects of the university through actively involving groups whose presence and agency have been overlooked, marginalized, and downplayed. The elements are diversity (presence and representation), inclusion

FIGURE 1. ADAPTED FROM BOLMAN AND GALLOS'S FOUR FRAMES OF LEADERSHIP

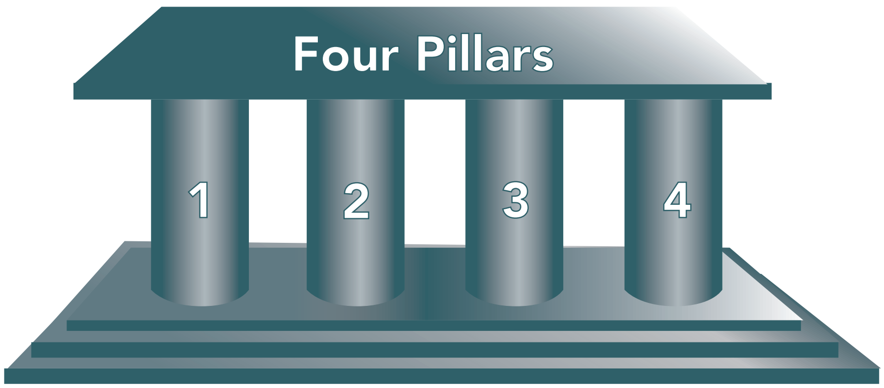


(engagement and social agency), equity (equal access and benefits), and equity-mindedness (active and consistent internalization).

Successful STEM-IRE rests on academic leadership embracing the four pillars in developing institutional research initiatives, infrastructure, and incentives. Such integration might have immediate impacts on research quality and student success, not to mention the equity and fairness of the outcomes (including technological outcomes). Implementation of such standards could help to attract and retain under-represented minority faculty. It is possible (and, at some point, may be measurable in the traditional academic value system) that institutionalization of STEM-IRE could facilitate research agency and minimize marginalization among underrepresented faculty.

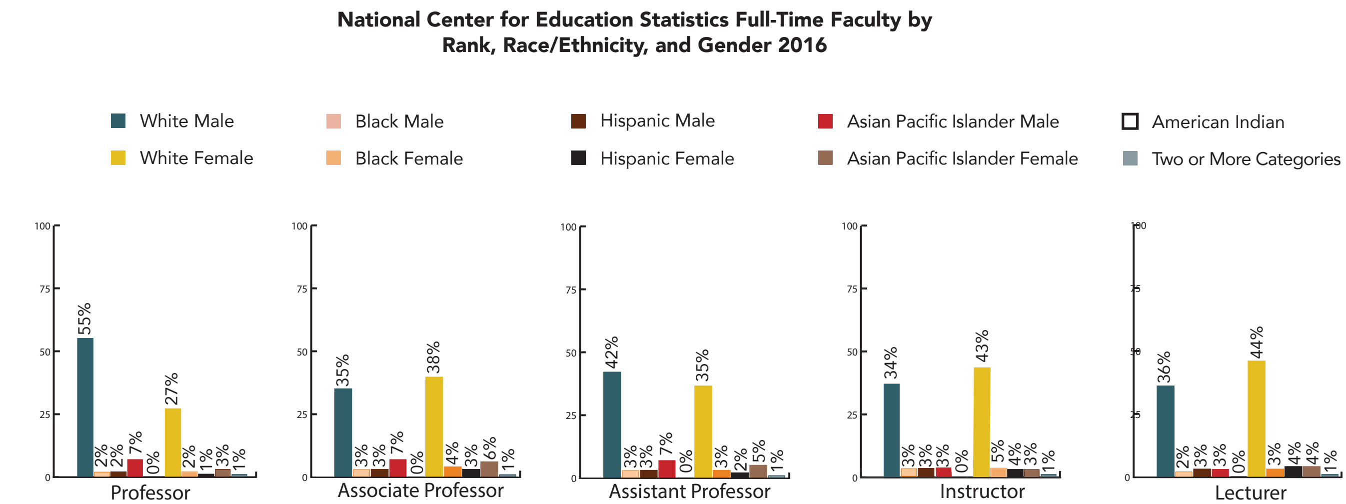
STEM-IRE is about reframing fundamental theories and practices around the activity of research, the process of innovation, and the enterprise of discovery. It includes integrating STEM with other disciplines such as the humanities, social sciences, and arts. STEM-IRE also involves sharing inclusive methods and practices and cultivating an intellectual landscape to advance the nation's capacity to use its rich and diverse research infrastructure. The intent is to build an inclusive research culture and climate that meaningfully integrates the four pillars to attract, retain, and promote more underrepresented scholars to academia, research, entrepreneurship, innovation, and discovery.

FIGURE 2. FOUR PILLARS OF INCLUSIVE EXCELLENCE



Diversity	Inclusion	Equity	Equity-Mindedness
• Individual differences • Ethnicity, gender, class, religion, experiences, nationality, perspectives	• Active engagement of all in the organization • Integration of cultural competence, real action	• Creation of equal access • Actions to close gaps	• Demonstrated values • Awareness and willingness when engaged with leaders, staff, students, and faculty

FIGURE 3. DATA ON FACULTY DEMOGRAPHICS IN THE ACADEMY



Due to rounding, numbers may not add up precisely to the totals

Source: National Center for Education Statistics

Two common theories frequently applied in human-centered computing, human-computer interaction, and human factors are Bandura's social cognitive theory and Maslow's hierarchy of needs. These so-called fundamental theories are given significant value when included in proposals to funding agencies. In 2002, Bandura referred to "contentious dualisms" that pervade the application of social cognition in various cultural contexts. Social cognitive theory is not accurate across all cultures, yet most researchers overgeneralize the theory, measuring concepts such as self-efficacy or individual agency without regard for the myriad cultures in which other types of agency are more important than individual agency.

Bandura is not the first to refer to dualisms that impact how agency operates in the world. The concept of dualism was first referenced as "double consciousness" by W. E. B. Du Bois in 1903. Double consciousness is a sense of having to see oneself through the eyes of those with power in a system of oppression. This need to use a persona emerging from a double consciousness should lead scholars to question how we use or conceptualize design practices, psychometric instruments and models, cases for prototyping, or other activities when designing for users whose demographics and culture-bound lived experiences vary. Research has also shown that Maslow's hierarchy of needs theory differs to a significant degree among Western-centric individualist cultures and non-Western cultures that are more collectivist (Gambrel and Cianci 2003). This is not surprising given that these theories were developed in universities with predominantly Western, White, and middle-to-upper-class human research subjects. Yet researchers, practitioners, and funding agencies still generalize these theories to all potential users regardless of context, culture, or lived experience.

Simply put, the currency of publication and dissemination, which is fundamental to survival in academia, can be undermined by biases introduced in the theories used to explain phenomena such as the underrepresentation of faculty of color in STEM. For instance, when faculty of color place value on decolonizing research methods or focus on social justice research in science and engineering, their efforts are often devalued and considered substandard (see figs. 3 and 4).

FIGURE 4. EXPLANATION OF HOW RESEARCH EXCLUSION MAY CONTRIBUTE TO THE CONTINUING LACK OF UNDERREPRESENTED FACULTY IN HIGHER EDUCATION

- Limited presence[1]
- Limited visibility[1]
- Exclusion from Peer Review Circles[2]

[1] Turner, Gonzales, and Wood (2008)
[2] Callister (2006)

- Delegitimization of research[1]
- Devaluation of socially engaged approaches[3/4]
- Counter narratives blocked by master narratives[3]

[3] Stanley (2007)
[4] Uriarte, Ewing, Eviner, and Weathers (2007)

- More likely to depart from academe pre- and post- tenure[5]
- More likely to depart pre-tenure[6]

[5] Perna (2001)
[6] Thompson (2008)

CONCLUSION AND RECOMMENDATIONS

While the pillars present a framework for research to emphasize the importance of inclusion and being equity-minded, it is important to understand what is being challenged and what opportunities result from these challenges. There should be a systematic focus on reversing the damage done by research emerging from exclusionary and privileged perspectives. Reversal means redoing research and ensuring problem conceptualizations, lines of inquiry, methods, and outcomes are considered in the context of inclusivity. It is important to fully question epistemologies and axiologies driving STEM in order to undo some of this damage. Scholarly cultures that welcome these challenges and, for instance, funding agencies that fund such challenges, are key to advancing more inclusive agendas in research.

Recommendations to advance inclusive research excellence have been offered by many researchers in the past three decades with little recognition by the wider research culture. However, recent efforts by professional societies and research sponsors have motivated researchers to pay attention to the role of bias in their research. Chilisa (2012) called for the use of indigenous methods, or methods conducive to the populations or target groups who are ultimately the users or beneficiaries of the research. In fact, agencies such as the National Science Foundation (NSF) have funded projects utilizing indigenous research methods at Tribal Colleges. Clearly, discussions are increasing regarding the importance of avoiding the use of majority methods and approaches on populations who are not operating in the same cultural spaces and contexts, and this includes technological design. Funding is also moving toward more emphasis on equity (Ioannidis 2018).

Another example is shown by a "Dear Colleague" letter issued by the NSF calling for proposals focusing attention on fairness, equity, accountability, and transparency (FEAT) in research in computing, information science, and engineering (National Science Foundation 2018). The letter intended to advance more inclusive research in computing. Sponsors like the NSF must continue to expand representation of ideas in science and limit bias by populating the funded research domain with individuals from diverse backgrounds.

Ultimately, STEM-IRE is about redistributing privilege and power to create and disseminate knowledge claims. It is also about opening doors to allow new ways to conceptualize and conduct research using a more inclusive lens. The challenge to all STEM leaders in academia is to reflect on whether the act of "opening the doors" of science and the research enterprise to advance inclusion is more valuable to them than holding on to the privilege gained from allowing only a select few to fully participate and benefit. ▪

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Successful Strategies for Enhancing Research Capacity among Early-Career HBCU STEM Faculty

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Historically Black Colleges and Universities (HBCUs) were created to educate formerly enslaved Americans of African descent. During the twentieth century, HBCU attendance became a major factor that moved Blacks into the middle class, and those institutions have continued to play a major role in educating a significant portion of African American students. The Higher Education Act of 1965 defines an HBCU as an institution that was created prior to 1964 with the explicit mission of educating Black Americans. The mission of HBCUs has evolved to include a focus on service and social justice as they continue to serve a population of marginalized and minoritized students. Today, there are those who ask whether HBCUs are still relevant in an age when African American students can attend any institution for which they qualify. This question has become increasingly common in the face of declining financial support for public institutions, stagnating endowments, dysfunctional leadership in many institutions of higher education, and increasing competition for high-achieving students.

US News & World Report consistently ranks HBCUs far below non-HBCUs. These rankings are based primarily on how institutions perform in the following areas: first-year student retention rates, assessment by administrators at peer institutions, faculty resources, admissions selectivity, financial resources, alumni giving, and graduation rates. The 2017 "Top Colleges" ranking by *Forbes* rated the nation's top 660 institutions using the following education-based metrics: post-graduate success (35 percent of the score), student debt incurred in pursuit of the degree (20 percent), student experience (20 percent), graduation rate (12.5 percent), and academic success (12.5 percent). For the 2017 rankings, only eight of the nation's 102 accredited HBCUs made the list, with Spelman receiving the highest ranking of all HBCUs at number 326. The other ranked institutions were Howard University (435), Fisk University (605), Bowie State University (628), Morehouse College (638), Florida A&M University (645), and Tuskegee University (648).

> *The mission of HBCUs has evolved to include a focus on service and social justice as they continue to serve a population of marginalized and minoritized students.*

It should be noted that Spelman College and Morehouse College were the solitary two undergraduate-only HBCUs to make the *Forbes* top colleges list. These institutions are also the only HBCU members of the Associated Colleges of the South (ACS), a consortium of nationally ranked colleges and universities.

What was not considered previously by either the *Forbes* or the *US News & World Report* methodologies is the fact that HBCUs disproportionately serve a population of marginalized students who may not have had access to the same level of preparation as the average student at a predominantly White institution. For example, more than 50 percent of the students enrolled at Morehouse College and Spelman College are Pell-eligible compared to an average of 20 percent at the other ACS schools (*Forbes*, n.d.). Nevertheless, Morehouse College's six-year graduation rate "is often 20 percentage points higher than the national average for Black men, and 52 percent of graduates enroll in graduate or professional school within five years of graduation" (*US News & World Report*, n.d.). For the 2019 rankings, *US News & World Report* took into consideration the social mobility impact of an institution. The rankings factored in a "school's success at promoting social mobility by graduating students who received federal Pell Grants" (*US News & World Report* 2018), and although this only accounts for 5 percent of the total weight, it is a step toward equity in the methodology used to rank highly selective schools and those who serve underrepresented populations.

According to a recent United Negro College Fund report, if non-HBCUs were to admit a "demographically identical population" of students as HBCUs, then by all the metrics that are used to measure college success, HBCUs would outperform non-HBCUs (Richards and Awokoya 2012). It is therefore both important and necessary to acknowledge the contributions that HBCUs have made and will continue to make toward diversifying the national STEM workforce by developing and training young Americans of African descent and those from other underrepresented backgrounds, despite the many challenges that these institutions face.

HBCUs are relevant and necessary because, though they make up only 3 percent of all colleges and universities in the United States, HBCUs awarded 14 percent of the baccalaureate degrees earned by African Americans in 2015–16 (National Center for Education Statistics, n.d.). HBCUs are the baccalaureate institutions of origin for more than 30 percent of all African Americans who go on to earn doctoral degrees (National Science Foundation 2017). Moreover, according to the National Science Foundation, the top ten baccalaureate institutions that produce African American students who go on earn doctoral degrees in science and engineering were, except for one institution, all Historically Black Colleges and Universities.

One of the deciding factors in acceptance to graduate programs is previous research experience, and STEM students at HBCUs seem to be engaged in research at a higher rate than African American students at predominantly White institutions (Hurtado et al. 2009). This raises the question: How do HBCUs, with all the challenges they face, continue to engage their students in authentic research experiences, thereby leading the nation in educating and training African American students who enter the STEM workforce? One way to gain a better understanding of how HBCUs produce high-quality graduates who go on to careers in STEM is to take a close look at faculty-focused interventions that are aimed at broadening participation in STEM careers. Here we focus on the factors and strategies that influence faculty success in establishing and sustaining research programs, thereby allowing them to be effective educators and mentors to students who go on to earn doctorates in STEM disciplines. We also summarize the mechanisms that Morehouse College implemented to ensure the success of early-career STEM faculty research programs.

STRATEGIES FOR SUPPORTING EARLY-CAREER FACULTY

Perhaps the most important intervention that has been employed at Morehouse to support early-career faculty and to establish a teacher-scholar model was to hire a critical mass of early-career faculty in a relatively short period of time (approximately five years), most of whom were products of the Fellowships in Research and Science Teaching (FIRST) postdoctoral program based at Emory University and the Atlanta University Center

Consortium institutions. The FIRST Program is an Institutional Research and Academic Career Development Award (IRACDA) program funded by the National Institute of General Medical Sciences at the National Institutes of Health to produce new faculty who not only excel in research but also in teaching (i.e., teacher-scholars). While the cohort of tenure-track faculty members who were hired in biology, chemistry, mathematics, and psychology over a five-year period had little in common with regard to research, they had similar preparation for assuming a faculty position at a small liberal arts college and shared common concerns about how to develop a research program or gain promotion and tenure. The development of those early-career faculty began with institutional support facilitated by the dean of the Division of Science and Mathematics. The faculty were provided generous start-up packages, which included 50 percent release time from teaching for the first two years. Additionally, a senior faculty member in the division held regular discussions with the group to discuss various issues relating to their achieving success in the goal of becoming teacher-scholars. As a result of these discussions, the early-career faculty developed a seminar series that significantly contributed to a growing collaborative research environment and provided a forum for scholarly discussion among STEM faculty at the college.

The early-career faculty also benefitted from various research training grants for students from private (e.g., Howard Hughes Medical Institute) and federal (e.g., National Institutes of Health, National Science Foundation, Department of Defense) funding sources that allowed Morehouse to develop core research facilities and computation rooms, and to purchase equipment and supplies that were also used by faculty members for their research. Other grants to establish new program areas in STEM, such as in public health, permitted us to provide research funding and release time for faculty. Institutional relationships between Morehouse College and research-intensive institutions provided the early-career faculty with opportunities for collaboration and visiting fellowships. Finally, participation in external professional development workshops, sponsored by professional societies and nonprofit organizations such as the American Society for Cell Biology and Quality Education for Minorities, resulted in several early-career faculty members receiving grants.

The success of this cohort of faculty is due in large part to the commitment of the dean of the Division of Science and Mathematics to establish a research culture at Morehouse, again pointing to the importance of institutional leadership and quality of the early-career faculty who were hired. The concerted effort by early-career faculty members and strong support by division leadership in tackling obstacles that limited their development as faculty members worked synergistically to facilitate the success of the faculty. These faculty members have gone on to assume major leadership roles at the college, including chairing departments, serving as principal investigators of research training programs, and directing major administrative departments.

The concerted effort by early-career faculty members and strong support by division leadership in tackling obstacles that limited their development as faculty members worked synergistically to facilitate the success of the faculty.

NEXT STEPS

Although the faculty cohort described above has been extremely successful in attaining tenure, receiving federal grants, publishing, and moving into leadership roles, obstacles still exist that could impede future faculty members from advancing in the professoriate. Perhaps the most significant barrier is the lack of institutional support for research at Morehouse, a problem that is common to institutions with small endowments, particularly HBCUs and small liberal arts colleges. Another barrier common to teaching institutions is the excessive teaching load, which does not permit adequate time for research, grant writing, and publishing. A third barrier is inadequate institutional support for proposal development and grants management, which, when combined with the high teaching load, reduces the chances of obtaining or successfully managing a grant. Finally, early-career faculty at Morehouse are having the same difficulty that other early-career faculty across the country are experiencing because of the decreasing availability of federal research funding, which limits chances of success, particularly for new investigators.

These obstacles are common at many institutions, and solutions vary based on institutional culture and resources. However, institutions can take several approaches to move toward achieving

a sustainable model for research development for early-career faculty. Leadership in academia is critical but may be extremely difficult, in part due to the structure of the institution and the autonomy of faculty. Listed below are three specific recommendations aimed at removing the obstacles described above, thereby initiating the kind of institutional change that could lead to a sustainable model for developing and continuing research capability among early-career faculty in STEM disciplines:

1. Senior leadership of the institution, in conjunction with faculty, must ensure that research is a part of the institution's strategic plan. This could include hiring faculty who cluster in related areas of research and encouraging interdisciplinary groups of faculty members to work on research related to aspects of the institution's mission.
2. Every effort should be made to reduce teaching loads in order to provide adequate time for research. We know that this will probably require an increase in the size of the faculty, which in turn must be funded. Additionally, at primarily teaching institutions, the scholarship of teaching and learning should be valued as highly as other research. This is particularly important in disciplines such as STEM education as they emerge as prominent areas of research.
3. Institutions must continue to expand their capacity to acquire and manage large grants. Many small institutions struggle to provide their faculty with adequate resources to develop proposals and manage grants. One solution may be to take advantage of external resources, such as training provided by funding agencies and other professional organizations, collaboration with other institutions of similar size, and professional networks to assist in grant writing. These strategies could also be used to increase efficiency in business practices to better manage grants.

Institutional change requires a vision from the top that is shared by all constituents who then work collaboratively to bring that vision to fruition. The theoretical framework described by Bolman and Gallos (2011) in *Reframing Academic Leadership* could be used as a guide for developing effective policies and practices that result in institutional change. While it will be necessary to take a structural approach to leading an institutional initiative, an effective leader must also be able to navigate the political terrain of academic institutions, while also being sensitive to individual agendas and concerns. Many faculty at small colleges, and particularly at HBCUs, view themselves as a family rather than as employees of a business. As such, strategies that have been transformational in the corporate world may not be effective in academia. To effect institutional change, one must be able to build relationships, create a nurturing environment that supports and encourages growth, empower others, and, most importantly, be transparent and communicate effectively. As previously stated, leadership in academia is difficult, and one of the most difficult tasks may be leading a campus-wide initiative that will result in a significant change in the status quo. Bolman and Gallos (2011, 65) remind us that successful academic leadership "depends on the three P's of change . . . patience, persistence, and process."

This not only requires institutional change, but also a shift in the way we think about and prioritize institutions of higher education. In a recent letter, six Democratic US senators implored *US News & World Report* to revise its methodology used to rank colleges and universities to more heavily weigh the extent to which an institution practices inclusive excellence (Coons et al. 2018). While the recent changes to the *US News & World Report* ranking methodology finally take into account the contribution of each institution toward social mobility, it is not sufficient to highlight the importance of institutions that serve marginalized and minoritized populations. The contributions that HBCUs and other minority-serving institutions have made to educating the nation's lower- and middle-class students have long been overlooked. It's time to stop asking whether these institutions have outlived their usefulness and start following their lead to identify and implement best practices in the training and education of a diverse STEM workforce. ▪

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A Call for Transformative Leadership:
Addressing the Lack of Female Full Professors in STEM at HBCUs

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Women faculty are underrepresented at the senior professorial and administrative levels of many institutions (Nelson and Rogers 2003; Xu 2008; Riskin et al. 2007). Often, this gap between men and women in the academy (fig. 1) has been attributed to factors such as "chilly" work climates, gender and sexual harassment, and exclusion by male colleagues (Spreitzer, Kizilos, and Nason 1997; Mack et al. 2010). Women experience pay inequities (Currie and Hill 2012; Renzulli, Grant, and Kathuria 2006; Porter, Toutkoushian, and Moore 2008); inequitable teaching, advisory, and service assignments (Dubeck and Borman 1996); and inadequate mentoring (Granovetter 1983; Sabatier, Carrere, and Mangematin 2006). Individually, any of these phenomena would negatively impact the career progression of a faculty member. Taken in concert, these phenomena create workplace environments that are particularly inequitable and hazardous to women.

Women faculty at Historically Black Colleges and Universities (HBCUs) experience these inequitable conditions with some additional complexities (Renzulli, Grant, and Kathuria 2006; Bonner 2001; Minor 2004). The mission of HBCUs has historically been, and continues to be, educating Black Americans. The focus of HBCUs on advancing minorities has, in many ways, limited discussions on the status and success of women faculty (Mack et al. 2010; Renzulli, Grant, and Kathuria 2006; Bonner and Thomas 2001). While women faculty at HBCUs experience some of the same conditions as women in other US colleges and universities (fig. 1), gender-related issues have been silenced on many HBCU campuses.

HBCUs play a critical role within US higher education (Mack, Rankins, and Woodson 2013; Mack et al. 2010; Mack, Rankins, and Winston 2011), especially within the STEM disciplines. These institutions make up only 3 percent of US colleges and universities but produce over 20 percent of African American scientists and engineers (Mack, Rankins, and Woodson 2013). Women faculty in STEM are significant contributors to HBCU student success, even under the aforementioned conditions, which are often not conducive to their advancement in the academy. Notably, the gender disparity among full professors has been widely reported nationally, but little work has been done to investigate these numbers at HBCUs. Given the record of HBCUs in producing STEM talent, and the high enrollment of women students at many HBCUs, the lack of women STEM faculty at the highest faculty and leadership ranks at HBCUs begs to be examined.

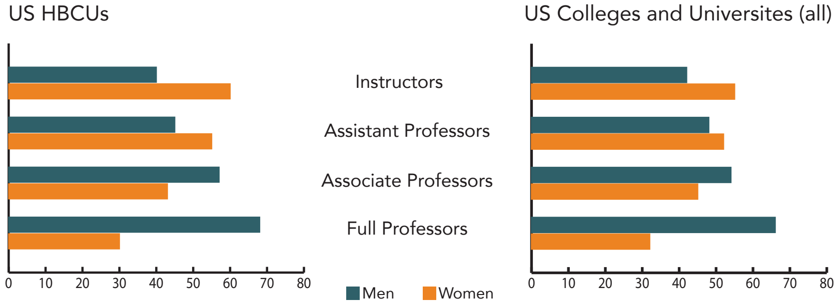
THEORETICAL FRAMEWORK

The theory of gendered organizations is central to the theoretical framework guiding this article. This theory posits that systemic inequities persist because they are built into systems of work organizations (Acker 1990), particularly in industries "characterized by long-term security, standardized career pathways, and management-controlled evaluations" (Williams, Muller, and Kilanski 2012, 574). Academia is a quintessential example of a gendered organization. The academic tenure system, with its standardized career ladder (assistant professor, associate professor, full professor) and prescriptive tenure review processes, follows a rigorous pathway that positions most academic institutions as gender exclusive and more favorable to men.

In “Hierarchies, Jobs, Bodies: A Theory of Gendered Organizations,” Joan Acker argues that organizational structures are inherently male dominant (1990). Positioning organizations, such as universities, as gender neutral misrepresents the realities of the departmental and university climates in which women faculty work. Gender represents more than biology. Gender in organizations is reflected in how decisions are made and the processes that govern the departmental cultures in which faculty reside and navigate their work. Gender is realized through processes like the division of labor, including teaching and service assignments, access to leadership roles, voice, and organizational logic, which rationalizes collegial hierarchies and legitimizes decision-making (Acker 1990; Williams, Muller, and Kilanski 2012). Academic STEM disciplines, consisting of primarily male-dominated fields, have cultural norms embedded in the disciplines that favor men. HBCUs, with historical foci on social justice and racial equality, have more oft than not underestimated the gendered realities in their hallowed halls.

Our study explores the composition of the STEM professoriate in HBCUs as gendered organizations. Additionally, it seeks to understand gendered organizational dynamics in institutions experiencing mission creep. In her 2013 article, “Faculty Sensemaking and Mission Creep: Interrogating Institutionalized Ways of Knowing and Doing Legitimacy,” Leslie Gonzales investigates the perspectives of faculty members at regional and teaching colleges and universities who find that their institutions, over time, are adopting a more research-intensive structure. Many HBCUs are experiencing similar changes in mission. While HBCUs were traditionally chartered to educate former slaves and their children as teachers and pastors, they have grown to offer comprehensive studies across diverse disciplines. Many HBCUs have expanded their research capacity and transitioned their hiring and evaluation processes to reward high research activity, even in instances where the needs of their students have not dramatically changed over time. These institutions have transitioned from a primarily teaching focus to a research focus and have selected aspirational institutions that are not well aligned with the HBCU historical mission. Women faculty, who have traditionally taken on more service assignments, are vulnerable in institutional systems that increasingly devalue such activities. This introduces a complex tension in which “women’s” academic work is needed by institutions, but women faculty who opt to do this work are penalized for it in hiring and promotion.

FIGURE 1. FACULTY DEMOGRAPHICS AT US COLLEGES AND UNIVERSITIES AND HBCUs BY RANK ACROSS ALL DISCIPLINES



Due to rounding, numbers may not add up precisely to the totals

Source: National Science Foundation, National Center for Science and Engineering Statistics, Integrated Science and Engineering Resources Data System.

IMPLEMENTATION/METHODOLOGY

This study selected a sample of six HBCUs representing the diversity among HBCUs: private and public institutions, single-gendered and coeducational institutions, institutions with a range of undergraduate students and science and math faculty, institutions with some research/doctoral focus, and institutions that are exclusively undergraduate. We collected, from their websites, data on the numbers of STEM female and male professors at the assistant, associate, and full professor ranks.

RESULTS

Our data show that, overall, there is a greater representation of males than females in the science and math disciplines at each faculty rank (fig. 2). For consistency among institutions, psychology and engineering programs are not included in these data. Of the total faculty at the six institutions combined, males represent 64 percent of assistant professors, 61 percent of associate professors, and 86 percent of full professors. Males make up 70 percent or more of assistant professors at each institution, with only two exceptions. Institution Three has a slightly lower percentage of males than the other institutions. The STEM faculty at Institution Five is predominately female, with 69 percent female assistant professors and 64 percent female associate professors. Without exception, women comprise a vastly lower percentage of the full professors at all the institutions, averaging less than 17 percent. Institutions Four and Six have no female full professors in their science and math departments.

Although the faculty at Institution Five is predominately female at the assistant and associate ranks, it is seemingly unable to make gains for women at the rank of full professor. Overall, in Institution Five the STEM faculty is 59 percent female and 41 percent male. Of the male STEM faculty, 29 percent are full professors while only 4 percent of all female STEM faculty hold this rank.

The low rates at which women are promoted to full professor may be linked to their heavy service and teaching commitments that do not align with the institutions' movement toward more research-intensive structures. Also not heavily weighted in promotion decisions is the work that some women do in mentoring and teaching, and even publishing their pedagogical work. A fuller understanding of the specific reasons for the gender disparity requires a deeper analysis.

CONCLUSION

Given the increasing enrollment of females at many colleges and universities, there is a need for more equitable representation of females among the STEM faculty. Women currently make up 56 percent of students at colleges and universities nationwide, and that number is expected to increase in the next five years (National Center for Education Statistics, "Fast Facts: Enrollment," n.d.). This is even more evident at HBCUs, where women are 61 percent of the student population (National Center for Education Statistics, "Fast Facts: Historically Black Colleges and Universities," n.d.). HBCUs are the leading producers of Black students who receive PhDs in the STEM disciplines, even though only 9 percent of Black undergraduates attend HBCUs (National Center for Education Statistics, "Fast Facts: Historically Black Colleges and Universities," n.d.). Given the role of HBCUs in producing STEM talent and the high enrollment of women at many of these institutions, an effort to address the disparate advancement of women STEM faculty to the highest faculty ranks is warranted.

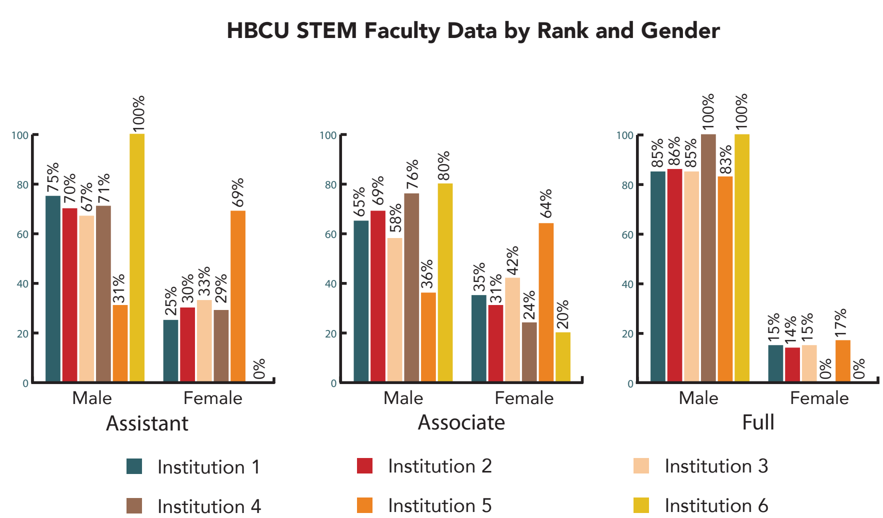
Ultimately, HBCUs will need to develop strategies to work toward transforming these numbers, and this can only be done with effective leadership. Higher education organizations seeking to address gender inequities need to reframe traditional decision-making processes to make them more inclusive. Bolman and Deal, in their book *Reframing Organizations: Artistry, Choice, and Leadership*, identify four frames that leaders can use to address organizational issues and change: structural, human resource, political, and symbolic (2017, 30). Bolman and Deal argue that effective leadership requires flexibility and the ability to adopt, when appropriate, the frame that most benefits the needs of the institution (48). All four of these frames provide a context through which HBCUs can address the change that is needed to ensure that women progress at equitable rates to the highest levels of the professoriate. Figure 3 provides a structure for how each leadership frame can contribute to eliminating gender disparity and unequal promotion rates at HBCUs.

The *structural* frame seeks to develop processes within the institution that alleviate gender disparity. This includes intentionally analyzing and restructuring tenure requirements to be aligned with institutional missions, paying women equitably for the contributions they make that add value to the institution, allocating resources to support the research capacity and leadership development of women, and developing recruitment efforts that target women.

The *human resource* frame recognizes the need for institutions to view employees as individuals with varying needs, especially given the gendered roles that exist within the context of society and work. A more inclusive institutional culture is one that provides training for faculty and administrators on gender bias and difference and that values work/life balance and the roles that employees have outside of the institution.

The *political* frame leverages the collective power of like-minded people to recognize the benefit of women in leadership roles at the institution. Key stakeholders, including faculty and administrators, can

FIGURE 2. PERCENT OF SCIENCE AND MATHEMATICS FACULTY AT SELECTED HBCUs BY RANK AND GENDER

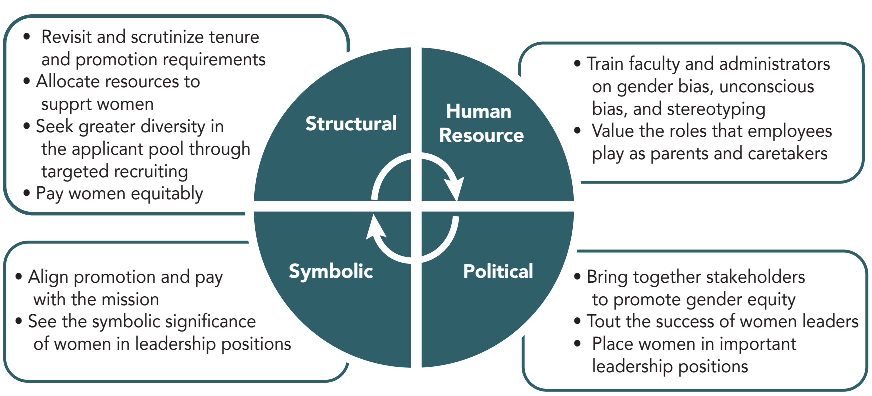


work synergistically to develop strategies that eliminate gender inequities and barriers to promotion. Such strategies may include celebrating the success of women leaders at the institution and strategically placing women in leadership positions that are meaningful. For example, positions on the institution's governing board could be reserved for women. Although gender cannot be considered when making hires, laws do not impact the composition of boards since these positions are not considered employment (Guy, Niethammer, and Moline 2011).

The *symbolic* frame places the mission of the institution at the forefront of decision-making processes and recognizes the importance of symbols in establishing a collective vision for the institution. Hence, reward structures should align with institutional missions. Institutions should also recognize the importance of having women in leadership positions and the message that is sent to others, especially students, when their presence is limited in these roles.

These strategies, in concert, provide a framework through which HBCUs can address the low numbers of female STEM faculty at the highest academic ranks at these institutions. The hope is that these strategies, if properly devised, will be transformative and long lasting and will provide a model for other academic institutions to follow. ▪

FIGURE 3. APPLYING BOLMAN AND DEAL'S FOUR FRAMES TO GENDER DIVERSITY IN STEM FACULTY



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Faculty Perceptions of Designing and Implementing Course-Based Research Experiences to Broaden Participation in STEM at an HBCU

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Over time, the population of the United States has become increasingly diverse. Such a population would benefit from having STEM professionals from diverse backgrounds working on cutting-edge research, but in 2012, Blacks accounted for only 7.5 percent of all STEM undergraduate degrees and only 4.5 percent of doctoral degrees (NCES 2012). Overall, underrepresented minority students enter college at the undergraduate and graduate level with an intent to major in STEM at the same rate as their White counterparts, but they have higher attrition rates (DePass and Chubin 2014) and lower STEM-degree completion rates (Anderson and Kim 2006; Higher Education Research Institute 2010).

The President's Council of Advisors on Science and Technology (2012) predicts the need for a million more STEM professionals by 2022 to meet growing economic and global demands in STEM fields and to create a larger and more diverse STEM workforce. Additionally, the American Association for the Advancement of Science (2011) has issued a national call for introducing more equitable ways of making research accessible for the diverse populations of undergraduate researchers.

To address these national calls that encourage diversity, underrepresented populations must be supported in their progress toward attaining STEM degrees. Therefore, it is important to create opportunities that contribute to the degree attainment, retention, and preparation of underrepresented students to create a strong and diverse workforce (National Science Board 2007; Griffith 2010).

FACULTY DEVELOPMENT INSTITUTE

Although there have been large amounts of data published on diversifying STEM fields and undergraduate research experiences, there has not been significant literature on professional development of faculty members at Historically Black Colleges and Universities (HBCUs) as a means of increasing research productivity and students' access to undergraduate research experiences.

Most faculty members agree with the need for effective and constant professional development workshops to stay current within the field. Since some HBCUs are gravitating toward the research-intensive model, there is an increased need for faculty to secure grant funding and publish their findings. Faculty members at minority-serving institutions benefit from faculty development opportunities that assist in scholarly activities that include grant writing, manuscript preparation, and discussions about internal and external collaborations. Although HBCU faculty members are held to high standards for productivity in teaching, research, and service like their counterparts at predominantly White institutions (PWIs), they tend to have comparatively higher teaching loads and fewer opportunities to fully engage in their research during the academic year. While HBCU faculty members continue to perform research and publish scholarly work, their productivity could

benefit from the introduction of additional or alternative ways of maximizing their current teaching and research efforts.

WHAT ARE COURSE-BASED RESEARCH EXPERIENCES AND WHO BENEFITS FROM THEM?

Research experiences are pivotal in the education and professional development of undergraduate science majors (Laursen et al. 2010; Lopatto 2007). Course-based research experiences (CREs) were developed to reach a critical mass of students, expose them to the practices of STEM professionals, and provide research experiences. To meet the increasing demands for undergraduate research experiences, faculty developed CRE projects that engage whole classes of students in addressing a variety of scientific research questions (Jordan et al. 2014; Shaffer et al. 2014; Wei and Woodin 2011). CREs engage undergraduate students in authentic research experiences while increasing the opportunities for faculty members to continue their research and publish with a critical mass of students within their classroom spaces.

Advocates of CREs argue that they offer a variety of advantages for students that include access to research for the whole class and not just a few select individuals (Bangera and Brownell 2014), unlike the traditional research internship (Auchincloss et al. 2014). For instance, there are many more undergraduates in the life sciences than can be accommodated through traditional research internships, which involve one-on-one mentoring by faculty members (Auchincloss et al. 2014; Wei and Woodin 2011). Although it has been shown that participation in traditional research experiences improves student interest in pursuing graduate degrees in STEM specifically (Seymour et al. 2004; Russell, Hancock, and McCullough 2007), CREs represent a scalable and affordable way to retain more undergraduate STEM majors and improve student STEM competencies (Rodenbusch et al. 2016).

Although previous work has been published about the benefits and challenges of CREs for PWIs (Shortlidge and Brownell 2016), there is not yet significant literature about the design, implementation, and challenges of CREs at HBCUs. To add to the existing literature and provide insight into alternative perspectives, this article will address the faculty-perceived barriers and successes of implementation of CREs at Hampton University.

HBCUs account for 3 percent of US colleges and universities and yet produce 27 percent of the African American students earning bachelor's degrees in STEM fields (US Department of Education 2016). Hampton University is a privately endowed, coeducational HBCU with approximately 3,200 undergraduate students. Hampton's current enrollment is approximately 92 percent Black (non-Hispanic), with 54 percent of the population identifying as Black females, 38 percent as Black males, and 8 percent identifying as other races or ethnicities. The university ranks highly when compared with institutions in the South and Southeast due to its selectivity in admissions, high standards of teaching, rigorous curricula, high graduation rates, and professional activities of the faculty.

CRE INSTITUTE PARTICIPANTS

The participants were diverse in faculty rank and level of experience and included thirteen males and nine females. Faculty participants included six associate professors, twelve assistant professors, one lecturer, one instructor, one course coordinator, and one program officer (two of the faculty members were department chairs). Overall, there were nineteen faculty members from the biology department, one from mathematics, one from psychology, and one from science education; most of the participants (fourteen out of twenty-two) were from HBCUs; six were from PWIs; one was from a community college; and one was from another institution.

METHODOLOGY

In order to establish the CRE professional development workshop with our STEM faculty, we worked with Erin Dolan, the principal investigator of the original CURENet—a network of people and programs that are creating course-based undergraduate research experiences (CUREs). Although there are CREs already in existence at these institutions, we cowrote a grant that was funded specifically to introduce CREs at different types of underserved institutions—including HBCUs and Minority-Serving Institutions—by hosting mobile institutes for faculty development.

Hampton, with the assistance of campus administrators, became the first site to launch the mobile CRE institute. There were thirty-two applicants from various STEM disciplines who applied to participate in our CRE institute, and we selected twenty-two from various institutions. Of the twenty-two participants, six were junior, nontenured STEM faculty members from Hampton University. Those six faculty members were asked to answer four open-ended questions before and after the CRE institute. The themes of the questions were: (1) preconceived notions of CRE; (2) feasibility of implementation of CREs; (3) perceived barriers of CREs at home institutions; (4) perceived support for CREs at home institutions; and (5) other reservations about CREs.

Our overall goal was to investigate faculty members' perception of the feasibility of implementing CREs, especially at HBCUs. We initially hoped to identify faculty members' preconceived notions of

what CREs were and whether they would feel comfortable implementing CREs prior to and after the faculty development workshop.

Participants in the institute also discussed faculty access to preexisting CREs, definitions of CREs, the difficulty and successes in funding preexisting CREs, the use of CREs created at other institutions, student and faculty buy-in, launching personal research in classrooms versus performing the traditional labs with no research experiences, data collection and trusting materials and data produced by students, and launching research and modules on websites before they are published (and whether they would count as scholarly productivity at their respective institutions).

KEY FINDINGS

Faculty Interests

Through our application process, we realized that many faculty members, locally and nationally, were eager to engage in this faculty development opportunity. They had multiple reasons that included updating their outdated introductory lab courses; creating exciting research opportunities for students that involved discoveries, inquiry, and the scientific methodology of having no predetermined answers; and using authentic research as a pedagogical tool to engage students in critical-thinking skills that will help them in all STEM disciplines and career trajectories.

Barriers and Opportunities

Although all responses from the participants were valued, perceptions of HBCU faculty members about the barriers and supports associated with CREs were the most interesting for this article (table 1).

There were many concerns from faculty related to CRE implementation, their research, and time commitment. Participants mentioned the need for peer mentors and graduate assistants. Different scenarios and cases were acted out to simulate the troubleshooting of situations that may arise during CREs. Faculty members were encouraged to think out loud about ways to handle potential issues.

Different stakeholders came with different expectations for the faculty development institute. The facilitators were most focused on producing a lesson that could be published online from the institute. Faculty participants were most focused on the need to design a lesson that they felt accurately represented some of the concepts they thought would be covered in the typical curriculum. Some faculty members spoke of creating lessons that could be progressive, with students continuing their research from their first year to sophomore year. They hoped their colleagues would buy in and allow the lessons to continue as students progressed through their undergraduate educations. The faculty also seemed concerned about whether this work would be counted toward promotion and tenure, and about authorship for the students involved.

Faculty members also cited some of the challenges to implementing their newly designed CREs on campus, including other faculty members who were resistant to change. Participants noted that some faculty were not willing to deviate from what they typically do. Others focused on junior faculty who were afraid to try something new, fearing that they could be perceived as troublemakers. There was also noteworthy discussion about determining which faculty members were seasoned or solid enough to introduce change to their departments. Finally, participating faculty members discussed grading and assessing their CRE participants fairly compared to the non-CRE participants in their classrooms.

Faculty who designed their lessons were hopeful about cross-institutional and cross-disciplinary collaborations to effect change across the curriculum.

OUTCOMES

At the end of the institute, faculty members created their CREs in different disciplines—with the assistance of web designers, facilitators, and the author—published their CREs online, and the site was launched shortly after on the CURENet2 website for free public access.

Other outcomes for our focus group showed that Hampton faculty mem-

TABLE 1. PERCEPTIONS OF FACULTY MEMBERS ABOUT THE BARRIERS AND SUPPORTS ASSOCIATED WITH CRE

Faculty-perceived barriers for CREs
Consistent funding to support CREs
Lack of departmental buy-in
Students that are not receptive to the idea of research in the classroom
Time commitment
Internal support systems to deal with students' questions during CREs
Faculty-perceived supports for CREs
CRE facilitators and hosts
Current CURENet websites
Initial departmental funds
Pilot studies to generate data for grant proposals
Other CRE institute attendees internal and external to their institutions

bers had a 100 percent success rate in designing and publishing CREs. They also formed an interdisciplinary education committee to work on sustaining their newly designed and published CREs within their respective departments.

Overall, faculty members felt equipped and empowered to implement and design more CURES after the institute, even faculty that had no previous knowledge of CURES before the institute. Testimonials from CRE institute participants showed excitement about creating new research opportunities for students:

- "Very excited to learn new ideas that I can implement in a course that I am redesigning. I had thought about it, but never tried to implement it."
- "The CURE institute was great because it gave me a clearer idea of how to incorporate undergraduate research to generate data sets for future studies."

CONCLUSIONS

Due to barriers and limitations on resources (funding, personnel, etc.), we anticipate that some, but not all, faculty members will be able to fully implement CREs and sustain them within their departments. We will continue to track these participants to collect data on the institutional and individual successes, barriers, and suggestions for implementation of their CREs at their home institutions.

The implementation and sustainment of CREs demand multiple supportive stakeholders, including students, faculty, administrators, and lab coordinators. Making faculty members feel supported in their endeavors to create lessons and programs that may be instrumental for their students' success starts with support from institutional leaders and the administration. Institutional change can occur only when administrators participate in conscious and consistent efforts to listen to the concerns of their faculty members and support them in many ways that include, but are not limited to, providing faculty development workshops and other resources that create opportunities for their faculty members to create and sustain programs within the university. ▪

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Fostering the Professional Advancement of Minority STEM Faculty at HBCUs

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Most workers in the coming decades will be expected to exhibit proficiency in science, technology, engineering, mathematics (STEM), and related fields. The STEM professoriate at American colleges and universities plays a critical role in preparing the twenty-first-century workforce to face these challenges. The STEM faculty role is twofold—they must dispense knowledge to students through instruction and contribute to innovations that advance science and benefit society (Lane 2008). Like any sector of the workforce, ideally the professoriate would resemble the country's demographics. Unfortunately, this is not what is found at most institutions of higher education. As a result, talent from individuals from certain underrepresented racial and ethnic minority groups (URMs) cannot contribute to STEM academia. This seriously limits diversity of thought and reduces the likelihood that science will address the needs of all segments of society. Additionally, the low representation of URM faculty in academia results in few role models for students of color, who often turn to faculty who look like them for mentoring and support (Benitez et al. 2017).

African Americans, Hispanic Americans, Native Americans, Alaska Natives, Native Hawaiians, and Native Pacific Islanders constitute 30 percent of the US population, yet account for only 9 percent of STEM faculty at US colleges and universities (National Center for Science and Engineering Statistics 2017). However, overall underrepresentation of minorities in STEM academia is only one aspect of the issue. Even when members from URM groups enter careers in academia, many do not appear to advance in the professorial pipeline at the same rate as individuals from non-URM racial and ethnic groups. Figure 1 presents the proportion of science and engineering faculty holding academic positions at assistant, associate, and full professor ranks in 2014. The expectation is that, as faculty advance through tenure and promotion, the proportion of full professors (the terminal status of professorial careers) should exceed that of associate professors, which in turn should exceed the proportion of assistant professors. That is, if most assistant professors attain tenure, the number of associate professors should increase and, if associate professors continue successfully advancing their careers, there should be an accumulation of full professors that consistently grows at the same pace as the size of the professorial workforce. However, White faculty are the only group that seems to follow the expected progression from assistant to full professor (fig. 1). This trend is reversed for African American faculty, the majority of whom are employed at Historically Black Colleges and Universities (HBCUs) (Strauss 2015). This may be due, in part, to institutional factors at HBCUs that are not conducive to STEM faculty advancement. For example, it is well known that faculty appointments at most HBCUs are characterized by (1) high teaching, advisement, and service responsibilities; (2) an absence of mentors; (3) a lack of peer collaborators; (4) inadequate access to research laboratories; and (5) little or no funds provided to start or supplement a laboratory, hire research assistants, or obtain supplies (Fields 2000; Jackson 2002). These institutional factors are compounded by external factors such as the persistent underfunding of HBCUs relative to predominantly White institutions (PWIs) (Shorette 2015). This negatively affects the scholarly productivity of HBCU STEM faculty, consequently reducing their success in obtaining tenure and promotion.

The literature on factors that facilitate or impair the advancement of early-career URM STEM faculty at HBCUs is very sparse. A recent report (Quality Education for Minorities Network 2016) outlines the minimum conditions necessary for scholarly productivity among early-career URM STEM faculty at HBCUs, but strategies to promote this productivity and ways to implement them have not been developed on any scale. It may also be financially prohibitive for HBCUs to implement strategies to eliminate or even mitigate the factors and practices that negatively impact the advancement of their faculty. Yet, there is an urgent need to propose meaningful and sustainable ways to support these faculty members for tenure and promotion immediately after they are hired.

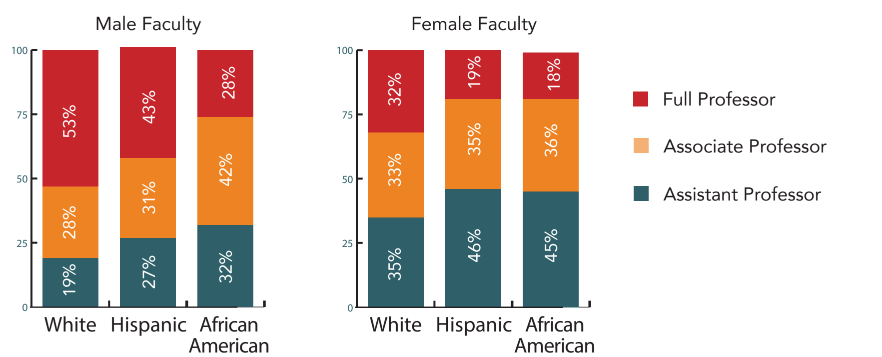
THEORETICAL FRAMEWORK

Most tenured African American faculty are found at HBCUs, and up to two-thirds of HBCU faculty are URMs (Gasman 2013). However, most of the current research on the conditions that determine the advancement of URM faculty has investigated their experiences at PWIs, not HBCUs (Frazier 2011). There are valuable reports that outline what is needed to support early-career faculty at HBCUs (Fields 2000; Jackson 2002; Quality Education for Minorities Network 2016), but there is a need to characterize why there is such variability in the success of early-career faculty in the HBCU environment. Early-career faculty may have unclear ideas of what is expected of them for tenure and promotion and may have difficulty adapting to the productivity expectations of their institutions, a problem very prevalent for URMs, at least at PWIs (Tillman 2001). Some interventions appear to facilitate the advancement of early-career faculty within different institutional settings and disciplines. They include, for example, strong networks of support within and outside the institution (Salazar 2009), formal mentoring by successful URM faculty (Tillman 2001), and networking with others who can provide advice (West-Olatunji 2005). However, a systematic model that incorporates these variables, along with explicit support for STEM research productivity, has not been investigated within the context of the challenges (outlined above) that are known to exist at HBCUs.

IMPLEMENTATION

In 2018, to help address these gaps in knowledge about URM faculty development, the National Science Foundation Alliances for Graduate Education and the Professoriate (AGEP) awarded $2.6 million to an alliance in the Southeast to establish the AGEP Historically Black Universities Alliance: A Model to Advance Early-Career Minority Faculty in the STEM Professoriate. Like all AGEP projects, this alliance of Tuskegee University, Jackson State University, and Tennessee State University—three research-focused HBCUs with thriving STEM programs—is designed to increase the representation of URMs in STEM academic careers by developing intervention-based models to mitigate difficulties faced by URMs with STEM academic aspirations at all stages of their professional development. The alliance also includes a knowledge-generating partner (Oakland University) and the Department of Energy National Laboratories. The alliance has proposed the Pathways for Advancement and Tenure at HBCUs (PATHs) model, which is composed of interventions to be implemented and evaluated at the three HBCUs (to better link it to the model it proposes, the alliance is known as the PATHs Alliance). Over the course of five years, the PATHs Alliance will recruit eighteen URM STEM faculty members (PATHs fellows) across the alliance who are within their first three years of appointment, to participate in a series of interventions—including a three-year residency program—designed to provide the support they need to successfully obtain tenure and promotion at their home institutions. Findings from these interventions will inform recommendations for how HBCUs can change policy and practice to better support their early-career URM faculty.

FIGURE 1. PROPORTION OF ASSISTANT, ASSOCIATE, AND FULL PROFESSORS IN SCIENCE AND ENGINEERING BY RACE/ETHNICITY AND GENDER (2014)



Due to rounding, numbers may not add up precisely to the totals.

KEY INTERVENTIONS OF THE PATHS MODEL

In their report, the Quality Education for Minorities Network (2016) made thoughtful recommendations to foster the professional growth of early-career STEM faculty members at HBCUs. Consistent with these recommendations, PATHs proposed an intervention-based model that focuses on promoting research produc-

tivity of early-career faculty and adopting wellness strategies to assist them in coping with the challenges present at HBCUs. An outline of these interventions is provided below.

The Grantsmanship Institute

Early-career STEM faculty at PATHs institutions are expected to show evidence of grant-writing success in tenure and promotion applications. A survey of STEM faculty at PATHs institutions revealed that many early-career faculty members find the prospect of seeking external funding intimidating and find it difficult to prepare applications in parallel with their teaching, advising, and service obligations. Some specific challenges included finding appropriate solicitations, assembling a suitable team of collaborators, preparing applications for institutional research compliance committees, and finding time to prepare proposals. A few of the nation's HBCUs have well-staffed offices of sponsored programs that assist with proposal preparation, but the majority of HBCUs do not have staff that can serve this function (Coleman and Matthews 2011). To address this need, PATHs has developed a grantsmanship institute around an ambitious cloud-based proposal preparation platform, HBCUs Networking to Energize Transformation (HBCU-NET). HBCU-NET is a network of interconnected partners that will provide constructive, progressive, and structured support to help PATHs fellows develop research ideas into competitive proposals. HBCU-NET will help match fellows with teams, which are composed of individuals from institutions across the country who have a history of successfully attaining awards. Fellows will work closely with their teams, to develop and refine research proposals for submission to funding agencies. The institute will provide workshops to assist fellows in preparing other proposal requirements (e.g., budget and research compliance). Thus, the grantsmanship institute integrates the functions of a mentor and a traditional office of sponsored programs into a unified intervention.

The National Laboratory Research Program

One of the challenges that early-career faculty face at HBCUs is the lack of access to adequate laboratory space, equipment, instrumentation, and graduate research assistants at their institution (Quality Education for Minorities Network 2016). This lack of resources can compromise their success in scientific research and reduce their interest in continuing in academia (Smart 1990). Focused interventions can help ameliorate the barriers that early-career faculty may encounter at HBCUs and create a support network that may extend beyond the institution. To that end, the National Laboratory Research Program will enable each PATHs fellow to spend summers at a national laboratory. Fellows who become visiting researchers at these centers will have access to cutting-edge resources to initiate and continue high-caliber research and will be able to allocate the majority of their effort to research, which highly correlates with research productivity (Bellas and Toutkoushian 1999).

Faculty Quality of Life

Productivity is closely linked to motivation, which is, in turn, associated with job satisfaction (Smart 1990). It is critical that young faculty members acquire a balance between the many demands of their work responsibilities and their personal goals and interests. URM faculty at HBCUs have traditionally expressed student-oriented service motivations (e.g., serve as a role model for the next generation) and fulfilling this motivation may be important for their quality of life (Benitez et al. 2017). However, it may also be detrimental to their research productivity (Bellas and Toutkoushian 1999). To help faculty navigate these issues, PATHs will hold workshops focusing on three main issues: effort allocation (e.g., time management, balancing teaching and research); establishing and managing a successful research team; and maintaining work-life balance.

EXPECTATIONS FOR THE PATHS PROGRAM

The PATHs interventions will be assessed to determine the extent to which they help develop an academic community that serves to support early-career faculty on their path to tenure and promotion. During their PATHs residencies, all fellows are expected to submit at least two proposals to an external funding agency, become a visiting researcher at least once in a partnering national laboratory, and successfully achieve tenure and promotion. Although it is out of the scope of the program to change the institutional variables that may create difficulties for early-career faculty's progression to tenure and promotion, the model is expected to provide an infrastructure that will allow faculty to overcome the barriers known to affect faculty at HBCUs, thus increasing their chances of continuing in productive academic careers and achieving tenure and promotion. The knowledge-generation component of this program will identify the variables that increase or reduce early-career faculty's motivation to progress in their academic career, as well as the personal factors that determine job satisfaction and commitment to academia.

CONCLUSION

Senior faculty members and other leaders in the HBCU community must commit to initiatives that provide academic and social support to their young faculty as they navigate the difficult tenure-track years. The AGEP program provides excellent opportunities to this community to form alliances and develop models based

on strategies to increase the number of early-career URM STEM faculty who successfully advance through tenure and promotion. Alliances among two- and four-year HBCUs, as well as among HBCUs, PWIs, and external agencies, can provide the resources needed to at least partially address the challenges that URM STEM faculty face on these campuses. Regardless of the type of alliance, the commitment of HBCUs to support their young faculty scientists should be as far-reaching as the dedication that these same faculty show and the compromises they make to prepare their students (Gasman 2013).

For any AGEP structure to be successful, the partners should be carefully selected to ensure they are committed and can meaningfully contribute to the development and implementation of the model. In the case of the PATHs program, the alliance partners were selected based on a long history of successful collaborations in STEM research and education. Intervention models should also seek to interfere minimally with the central mission of HBCUs, which is to prepare students through mentoring and instruction. For example, the National Laboratory Research Program intervention may prove to be beneficial to participating faculty fellows in terms of research production and the long-term outlook of their own career, but their time away from the institution may immediately interfere with teaching and mentoring of undergraduate and graduate students. To find a proper balance, the home HBCU institutions must commit to the development of long-term goals for their faculty members while implementing measures to address the short-term issues that may ensue, such as providing mechanisms to cover assigned classes and continued supervision of graduate students. In the longterm, faculty development will benefit the institution, so this commitment should be viewed as an investment in the institution's future.

An important broader impact of the PATHs Alliance will be the outcomes of its research investigation focused on social science, which will add to the literature and help strengthen future models for the development, advancement, and retention of URMs at research-focused HBCUs, such as the members of the PATHs Alliance. There is great need for other HBCUs in different settings (e.g., two-year, four-year) to also propose ambitious research-based models specifically tailored to these institutions' contexts to promote the professional growth of their early-career URM STEM faculty and contribute their findings to the knowledge base. The insights gained by the lead author's participation in the Center for the Advancement of STEM Leadership's first residency program helped the PATHs Alliance shape the proposed interventions and gain awareness of the leadership level needed to implement them. ▪

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Using Mindfulness to Reduce Math Anxiety in Preservice Elementary School Teachers

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In the US workplace, the increasing demand for STEM graduates to fill key positions has many implications. Economists and others project that the United States will need one million STEM workers by 2022 (PCAST 2012). According to the US Department of Labor (2007), our education system is simply not producing students interested in—or with the skills required by—STEM fields. This deficit may lead US employers to look outside the country for much of the STEM workforce (Hickey 2013).

Figure 1 presents a scenario that, although originally created with a mind toward increasing diversity in STEM, illustrates the need to start addressing disinterest and poor learning opportunities as early as kindergarten. These factors often lead to anxiety that can follow a student for life, affecting the decision to go to college, the ability to enroll in and matriculate through college, and the college path they pursue. This is particularly alarming in the case of elementary education graduates who are required to teach all subjects, including math. Their math anxiety is easily transmitted to elementary school children, thus continuing the cycle as depicted in figure 2.

Mathematics anxiety is "a feeling of tension and anxiety that interferes with the manipulation of numbers and the solving of math problems in a wide variety of ordinary life and academic situations" (Passolunghi et al. 2016). Anxiety can reduce the working memory needed for a person to retain knowledge and access it during exams (Eysenck et al. 2007; Passolunghi et al. 2016). The literature states that anxiety has a negative effect on various aspects of the learning process such as attention, memory and processing speed. Math anxiety is often caused by less than opportune experiences in math classes that lead to repeated poor mathematical performances and, ultimately, avoidance (Marshall 2015).

All too often, students with this background choose elementary education as their college major, erroneously thinking that they will only teach minimal, low-level math. However, teachers with math phobias or anxieties, those who don't feel good about their math skills, tend to minimize math instruction or in other ways unconsciously make students believe that it is ok that everyone can't "do" math (Barack 2018). The result contributes to students arriving at college with insufficient preparation in math or other STEM fields, and therefore disinterested in or unable to pursue STEM as a major.

A straightforward way to improve students' STEM learning is to improve their teachers' STEM knowledge and interest. In this study, mindfulness was used as a tool with a cohort of preservice elementary teachers to reduce their anxiety and to facilitate their learning of mathematics.

MINDFULNESS

One way to describe mindfulness is as simply being aware of what is occurring in the moment, compassionately and in a non-judgmental way (see fig. 3). Kabat-Zinn (1990, 11), considered to be the father of mindfulness in the United States, asserts the following:

> We routinely and unknowingly waste enormous amounts of energy in reacting automatically and unconsciously to the outside world and to our own inner experiences. Cultivating mindfulness means learning to tap and focus our own wasted energies. In doing so, we learn to calm down enough to enter and dwell in states of deep relaxation. This nourishes and restores body and mind. At the same time, it makes it easier for us to see with clarity the way we actually live and therefore how to make changes to enhance our health and the quality of our life.

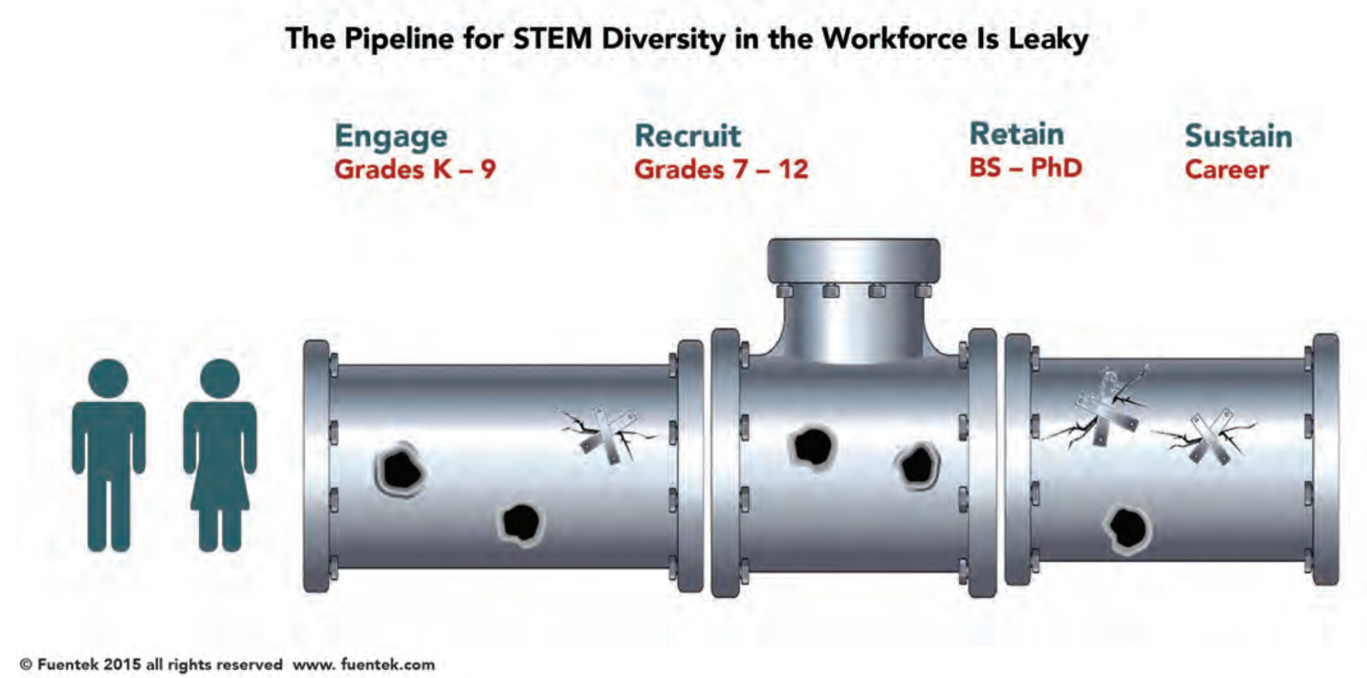
METHODS

This study required preservice teachers (hereafter called students) to create new habits. I chose to adopt the widespread thought that it takes thirty days to create a new habit, a time period that is long enough to actually see a change and short enough to enable a person to push through and make a determined effort to change. The study was designed for thirty days near the end of the semester. On day one, students were invited to participate in a study designed to reduce math anxiety. The students were in the first two of my sequence of three mathematics courses for education majors. There were twenty students in the first class and eighteen in the second class. The ranks of the students in the study vary from first-year students to seniors, so their graduation dates are in the future. All students were female; the racial composition was thirty-six African Americans, one Caucasian, and one African (n=34; four students chose not to participate in the study). One student was enrolled in both classes.

Prior to the discussion of mindfulness, students signed consent forms to participate in the month-long study. Students then completed presurveys, the Abbreviated Mathematics Anxiety Rating Scale (A-MARS), and the Five Facet Mindfulness Questionnaire (FFMQ). A-MARS presents twenty-five statements to which students indicate their level of math-related anxiety. The twenty-five statements reflect test anxiety (fifteen statements), anxiety related to manipulating numbers (five statements), and anxiety related to taking math courses (five statements). The thirty-nine-item FFMQ is a measure of mindfulness commonly used before and after mindfulness-based interventions to assess change. The five facets of mindfulness measured are *observing*—noticing or attending to feelings, thoughts, and sensations in the present moment (eight statements); *describing*—using words to label experiences (eight statements); *acting with awareness*—fully engaging in the current activity, rather than just automatically performing without being mindful of what you are doing (eight statements); *nonjudging of inner experiences*—acceptance of what you are thinking or feeling without criticism of your thoughts and emotions (eight statements); and *nonreactivity to inner experience*—noticing thoughts and feelings without showing a reaction toward them (seven statements).

I introduced mindfulness to my students using a multimedia approach. The introduction included information on the origins of mindfulness and the recent growing interest in using related techniques in the United States. I discussed the variety of major US entities that employ mindfulness, such as the Army, major companies, P–16 schools, and a growing number of minority-led institutions. A few students already had prior knowledge of mindfulness. One student remembered her high school dance instructor using mindfulness before and after practice, another student discussed an app on her Apple Watch, and two other students worked in schools that employed mindfulness. These students all shared their

FIGURE 1. DISINTEREST AND POOR LEARNING OPPORTUNITIES IN STEM BEGIN AS EARLY AS KINDERGARTEN



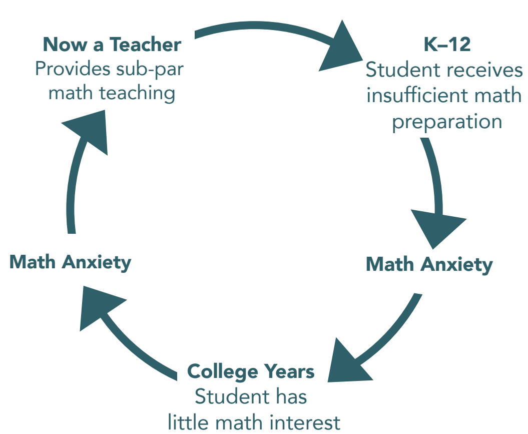
thoughts on the benefits of mindfulness.

Using a YouTube video, the students then experienced a three-minute mindfulness breathing exercise. The video was followed by a class discussion about their feelings before, during, and after. Students were introduced to various mindfulness apps available to them on any mobile device or desktop computer. It was important that students had access to this tool whenever and wherever they felt a need, as this might facilitate continued use.

For this study, I created journal folders for each student. I included mindfulness data and tips located on various internet sites, providing the URLs. I encouraged the students to jot down thoughts after each activity and not attempt to write full-page entries. The students were assured that their journals were anonymous and would not be collected.

Students were assigned to repeat the mindfulness breathing exercise that evening before they started their math homework, to journal about the experience, to review several apps, and to choose one to use during the study period. Students discussed their experiences at the end of the following class period. Once a week for the following four weeks, we discussed mindfulness experiences and effects on anxiety. Students also turned in anonymous written assignments related to their experiences. At the close of the study period, students completed post-surveys (anxiety and mindfulness) and participated in an audio-recorded class discussion of their experiences and thoughts.

FIGURE 2. THE VICIOUS CYCLE OF MATH ANXIETY



RESULTS

Qualitative

Throughout the study period, participants reported on their use of mindfulness and its effect on their anxiety levels and overall well-being. Kabat-Zinn (1990) explains that mindfulness helps us see clearly enough to make changes that improve the quality of our lives. Initially, most students reported doing mindfulness activities frequently and feeling somewhat better about their ability to do math. Some used the activities just before doing homework and studying for assessments at home. Others reported starting off their day doing the activities and feeling better overall during the day. Still others practiced breathing exercises while en route to school or to prepare for difficulties they knew they would face upon arriving at work. Only a few students reported using the journals even at the beginning of the study. After two weeks, students reported obstacles to being consistent with mindfulness exercises and especially journaling about them. By the final discussion on the last day, the consensus was that although they were well aware of and appreciative of the benefits of mindfulness, they were unable to incorporate it into their lives. Students who even promoted mindfulness among fellow students or coworkers were unable to be consistent in their own pursuit of mindfulness. Even if they were able to practice, the journaling was often forgotten, and students spoke of not always having the journal folder with them.

Quantitative

Only thirteen of twenty students in the first course and fourteen of the eighteen students in the second course returned completed post mindfulness surveys. The following results reflect only the twenty-seven students with complete pre and post mindfulness surveys. Each of these students was enrolled in only one of the courses; the student who was in both classes did not return completed surveys.

The pre- and post-AMARS surveys reflected slight decreases in anxiety levels for most students, several students showed no overall change, and a few students showed slight increases in anxiety. Slightly more than half of the students in the first course showed decreases in test and course anxiety levels (seven and eight students, respectively). Five students in this course reported a decrease in their operational anxiety levels. One student in the course reported high anxiety levels in each of the three categories both before and after practicing mindfulness. This student struggled throughout the course to earn a C. In the second course, all but two students reported an overall decrease in anxiety levels. One of the two students reported no overall change and the second reported an increase of two points. I mention these two students because both students earned great grades throughout the semester and neither reported high anxiety levels in any category.

The pre and post mindfulness surveys reveal that more than half of the students in the first course reported an increase in mindfulness levels of seven to twelve points in four of the five categories—observation, description, awareness, and nonreactivity. On the other hand, at least half of the students in the second course reported a decrease in mindfulness levels in each of the five categories.

It seems that students who have only been in my class one semester reported the most positive mindfulness change. These students were also taking their first mathematics course in their major and perhaps were more inclined to try something new. Students who had been with me for two semesters reported the least improvements in anxiety and mindfulness levels. These phenomena deserve closer examination.

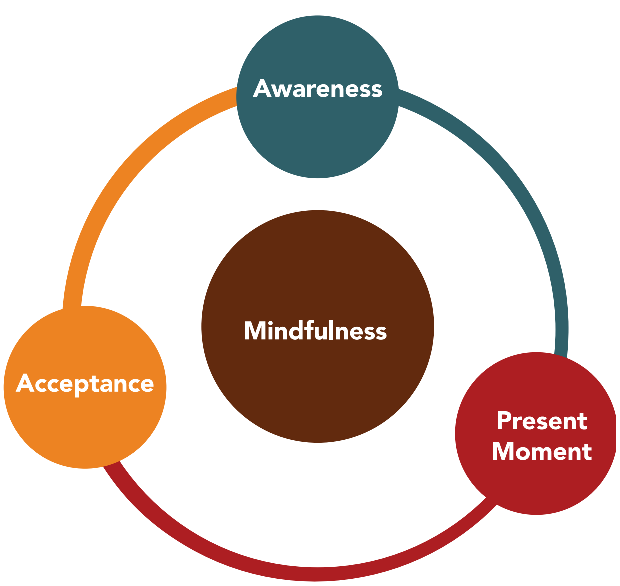
DISCUSSION

Mindfulness is a conscious act of being aware of the present, accepting past mistakes without labeling them or oneself as bad, learning from them, and moving on with life. It has been shown to reduce anxiety levels in students, thus enabling them to become more successful in academic pursuits as well as in other aspects of life (McCloskey 2015). Mindfulness has the potential to help fix the leaky STEM pipeline by enhancing preservice teachers' learning and their subsequent teaching of mathematics and mindfulness to elementary students, which can lead to broader STEM abilities and deeper interest and participation in STEM throughout students' P–16 education. Particularly important, it has the potential to greatly increase STEM participation by underrepresented minorities.

In addition to implementing mindfulness in my classroom activities, I began introducing the concept across campus. In my research on mindfulness activities occurring in my city, I came across scheduled events that I shared with professors in various departments. The information was well received, and some professors from other disciplines attended events. Additionally, I held mindfulness-based stress reduction student workshops for three days during the week before midterms. The workshops all took place in the building where I teach. On the first day, a student counselor in attendance shared his knowledge and experience of introducing mindfulness to students.

Next, I invited the student counselor to take part in introducing mindfulness study to my students. On the first day of the study, he joined both classes to share his knowledge and experience. Later he and I held additional mindfulness workshops to help students study for final exams. This time, to facilitate attendance by more students, we varied the days, times, and locations. He led one of the sessions in his building on Tuesdays, and I led two sessions in two other buildings on Wednesdays and Thursdays. Therefore, the workshops ran for three weeks in three different buildings on campus. We also disseminated information on the mindfulness activities we had been involved in during the campus technology conference.

FIGURE 3. COMPOSITION OF MINDFULNESS



As I make changes to the study for another semester, I will incorporate electronic journaling apps, increased in-class mindfulness activities such as brief breathing exercises before quizzes, other brief mindfulness exercises before learning new topics, simple tools to gauge states of mindfulness before and after the exercises, and virtual mindfulness-related conversations beyond the classroom by using the campus learning management system (Blackboard). I believe that these changes will help students see the power in mindfulness and realize that they can make positive changes in their lives. ▪

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Metacognition:
A Tool for Overcoming Discrimination

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Disparities in American education across all levels can be traced to our nation's history of racial discrimination and injustice. This inequity is rooted in a long history of discriminatory housing practices and outright racism that have helped segregate communities and differentiate education—and career—opportunities for students. Despite legal rulings declaring these practices illegal and laws aimed at enforcing housing equality, cities like St. Louis remain segregated, with Black citizens largely confined to regions of the city with lower rates of homeownership and lower property values. Because the public school districts rely heavily on local real estate taxes for funding, public K–12 schools in these communities tend to be underfunded and underperforming, and many Black students are denied the academic experiences necessary to prepare them for success in college.

The consequences are clear. In St. Louis, Blacks are half as likely as Whites to have a bachelor's degree (19 percent versus 37 percent), and consequently, the median household income for a Black family is roughly half that of a White family ($36,676 versus $66,815). Black unemployment is also roughly three times higher (11.5 percent versus 3.7 percent), and Blacks are almost three times as likely (23.1 percent versus 7.9 percent) as Whites to live in poverty (NAACP 2018). By rendering individuals impoverished and denying them the financial means to revitalize their community and schools or to relocate, their children continue to be denied access to quality education.

Despite lacking the resources of larger institutions of higher education, open-access institutions are experiencing rapid growth and have made strong contributions to the increasing numbers of degrees being granted nationally.

OPEN-ACCESS SCHOOLS BROADEN PARTICIPATION IN STEM

Open-access colleges and universities have become leaders in educating students from low socioeconomic backgrounds and are helping to break the vicious cycle of limited educational access and poverty by opening higher education to students with low ACT or SAT scores. Despite lacking the resources of many larger institutions of higher education, open-access institutions are experiencing rapid growth and have made strong contributions to the increasing numbers of degrees being granted nationally. However, while open-access institutions have found success in recruiting often-overlooked students, they face various challenges in retaining and graduating students who matriculate from public school systems impacted by inequitable funding and policy.

In committing to provide higher education opportunities to all students, open-access colleges and universities must also accept the important responsibility of ensuring that students' investments in their education are rewarded. Students dedicate years of their lives

and substantial amounts of money to their education, and the cost of not succeeding includes student debt, lost time in the workforce, and a reduced opportunity or career progression.

This article discusses how one open-access institution, Harris-Stowe State University (HSSU), fulfills its open-access mandate and core historical mission. HSSU is a historically Black university located in St. Louis, Missouri. In 2011, HSSU began to offer degrees in biology and mathematics. STEM programs have rapidly expanded at HSSU, and it now has more than four hundred students who are STEM majors. At HSSU, we have committed to exploring new approaches aimed at providing quality experiences for underserved students. Specifically, this article discusses efforts to incorporate metacognition into STEM course curricula and student support.

RETHINKING HOW WE SUPPORT ALL STUDENTS

Inequality in educational funding and structure has far-reaching effects on college preparation. Institutions with high Black student enrollment offer fewer rigorous STEM courses such as physics, chemistry, and calculus as compared with schools with lower Black enrollment; Black students have less access than their White peers to accelerated coursework and gifted programs; and Black students are more likely than their White counterparts to have inexperienced or uncertified teachers (US Department of Education Office for Civil Rights 2016). Schools that do not adequately address course content would be expected to also have gaps in other skills students acquire such as how to approach instructors after class, study skills, planning, and self-reflection. These missing skills then become additional barriers to equity that reinforce social stratification paradigms, as some undergraduates arrive on campus with access to unwritten rules of college and some do not.

Traditional approaches grounded in deficit models, including placement into remedial coursework, have been seen as a solution to the issue of academically underserved students. However, these approaches have not proven successful in helping students to attain college degrees and may disproportionately harm Black students. Black students are the most likely group to be placed into remedial courses (Adams et al. 2012), owing in large part to the discriminatory educational practices embedded in K–12 funding and education. Further, these students entering remedial coursework are unlikely to ever pass a credit-bearing class in the subject (Edgecombe 2011). These classes are costly to the students in terms of money and time since they do not count for college credit but must be paid for and completed before advancing in a degree program. Placement into these classes can also reinforce racist stereotypes such as "Black people do not belong in college," causing severe damage to the students' self-conception and their will to persist in college.

METACOGNITION: A TOOL TO PROMOTE EQUITY IN EDUCATION

Upon matriculating into college, students often face novel academic challenges that require them to explore new study methods and learning approaches, assess the personal effectiveness of these approaches, and learn how to apply and adapt the approaches accordingly. The ability to be aware of and analyze one's thoughts and learning processes is referred to as metacognition. This skill can be honed, and interventions to encourage students to engage in metacognitive behaviors have been linked to improved academic performance in higher education settings (Young and Fry 2008).

Developing metacognitive skills can prove particularly helpful for academically underserved students pursuing rigorous STEM degrees. Each year, some incoming first-year HSSU students report that they were never challenged in their high school studies and indicate they do not understand what it means to study or truly engage an academic topic. Thus, students may confuse recognizing vocabulary with a deep understanding of the subject material. Additionally, many first-year students lack robust study skills and have not identified which learning methods are most successful for them personally. Reflection on and self-assessment of these skills and methods can help students overcome educational disadvantages they may have faced previously. Further, by building awareness of study and learning skills and facilitating their development, faculty can enhance STEM educational experiences and broaden participation.

FIGURE 1. SAMPLE POST-TEST REFLECTION ASSIGNMENTS

After Exam One

1. (A) Exam one was on X date. I began seriously studying for exam one on ___. (day of the week, date)
   (B) I estimate that I probably spent ____hours studying for exam one.
   (C) My studying was (check one):
   ___distributed across several days
   ___done in one evening or in a 24- to 48-hour period
2. (A) I studied for exam one by (describe your approaches, techniques, strategies):
   (B) Now that I have seen the grade I earned on exam one, these are the study strategies that I feel worked well for me, and I plan on using them again for exam two:
   (C) Now that I have seen the grade I earned on exam one, these are the study strategies that I feel did not work well for me, and I don't plan on using them again for exam two:
3. Was the exam what you expected? If not how was it different?
4. (A) A compiled list of strategies used by students who have been successful in biology courses is attached. Please review this list. After reading this document, I might try the following new study strategy for exam two:
   (B) The reason I think this may be helpful is:______________________________
   (C) Besides what you already wrote, what else do you plan to do differently for exam two now that you have the experience of taking exam one?

After Exam Two

1. Did you put more time into studying for exam two than you did for exam one? ___yes___ no
2. In the space below, please explain how you were able to put more time into studying for exam two or why you were not able to put more time into studying for exam two.
   ____
   ____
3. Did you follow the study plan you outlined for exam two? ___ yes___ no
4. In the space below, please explain how you were able to follow your study plan or why you were not able to follow your study plan for exam two.
5. Now that you have taken two introductory biology exams, which study strategies will you continue using to prepare for exam three, because they worked well on exam two?
6. I feel these study strategies are effective because ______________________________
   ____

DEVELOPING METACOGNITIVE SKILLS IN INTRODUCTORY BIOLOGY

To help students achieve substantial metacognitive growth, we have committed to restructuring our introductory biology course for majors. In alignment with previous studies (Stanton et al. 2015), HSSU STEM faculty employ metacognition as a classroom tool to assist students in self-reflection and monitoring the success of various study strategies and learning approaches. We have built reflection assignments into students' coursework after their first and second tests to prompt behavior that promotes metacognition. These assignments investigate aspects of student test preparation, such as (1) how much time students dedicate to preparing, (2) how far in advance students begin preparing, and (3) what general plans students use to prepare for the test. We also ask students to reflect on why their specific plans were or were not successful in preparing them for the test (see fig. 1). Lastly, we provide students resources on various study strategies and guide the development of new plans to prepare for the subsequent assessments. This approach can provide the ability to assess our students' metacognitive abilities and provide useful information that will enhance our design of future strategies and environments that support students.

Our experiences have taught us that two conditions must be satisfied to create an environment that fosters metacognitive growth: (1) the material being learned must be perceived as important to know and (2) the material must be sufficiently challenging. To satisfy the first condition, we have dedicated portions of our class period to connecting the course material to issues the students feel are relevant and important to them. Contributing to their communities can be a powerful motivator for some Black scientists (Gibbs and Griffin 2013) and is a component of culturally responsive teaching, so we should work to emphasize the link between understanding basic biology and the ability to contribute in this regard. To satisfy the second condition, we use the Universal Design for Learning approach—a teaching method aimed at meeting the needs of every student in a classroom—where students have multiple ways to acquire and demonstrate knowledge. For instance, we have written challenging tests that contain mostly short-answer questions instead of multiple-choice questions. This approach has been shown to enhance higher-level thinking skills (Stanger-Hall 2012) and can also reduce culturally or linguistically embedded instructor bias in multiple-choice answers, allowing students to pick up on key words and freely demonstrate their knowledge. Additionally, we have increased the number of active learning exercises used in the classroom, which have been demonstrated to help all students thrive in introductory biology courses (Haak et al. 2011).

AN INSTITUTIONAL COMMITMENT TO STEM STUDENT SUCCESS

HSSU has long been committed to pursuing student-centered approaches aimed at making all of our students, and particularly those from underrepresented minority groups, grow as independent thinkers and problem solvers. We offer a variety of resources outside the classroom to assist students in their development, and many of these resources also foster metacognitive growth. For example, we provide a study skills workshop where students can acquire and develop critical skills necessary for metacognition. Tutors are also encouraged to reinforce our message of growth through knowledge, planning, and assessment of learning approaches. Questions such as "What is your plan for doing well in this course?" or "Why do you think that plan did not work well?" can provide crucial prompts that cause students to reflect and begin

this growth-oriented process. Tutors can also contribute to the development of strong study plans if students are unable to do so by themselves.

HSSU is also committed to empowering faculty to develop metacognitive skills so they can better serve students. Faculty must be aware of their own educational practices and pedagogies to actively create an equitable learning environment that builds students' skills and content knowledge. Building awareness of socio-emotional factors that impact education and incorporating concepts such as culturally relevant curricula and pedagogies and Universal Design for Learning practices promote inclusive learning and represent a starting point for building a culture of reflection among faculty. The HSSU Department of Mathematics and Natural Sciences uses a STEM education research journal club to reflect on culturally relevant curricula, discussions on building classroom community, impediments to learning that our students face, student motivation, and pedagogy (including creating active learning environments).

DEVELOPING STEM SKILLS THAT WILL LAST A LIFETIME

At HSSU, our goal is to develop metacognitive skills in our students that can contribute to many different aspects of success as a STEM professional. Introduction to biology is not just content, it is about setting the foundation for a biology degree and career with the potential for a cascading effect on educational outcomes. If students can master the material, learning approaches, and study skills in an introductory course, they will have a better foundation from which to approach all their other courses, leading to sustained academic success. Their metacognitive skills can likely be transferred to their career planning and interaction with peers, and metacognitive interventions have a lasting effect on students from low socioeconomic backgrounds (de Boer et al. 2018).

However, even that does not describe the full potential impact of fostering metacognitive growth. Students in STEM often must navigate an increasingly competitive system of internships, faculty-mentored research experiences, and other activities meant to enhance their competitiveness for STEM graduate programs and jobs. While improved course grades increase student access to such opportunities, content knowledge alone may not be sufficient to guarantee their success in these endeavors. Academically underserved Black students, in particular, may also need to persist through an onslaught of macro- and microaggressions in unwelcoming STEM environments. Building metacognitive reflection into planning and decision-making will aid students in identifying and interpreting the unwritten rules of higher education. Further, recognition, reflection, and planning are also stepping-stones to advocating for changing systems that are not working.

Racism is a complex issue that stems from centuries of targeted subjugation and oppression and thus will not be easily remedied. As educators, we can design approaches to content and classroom environments to promote students' metacognitive skills and enhance students' ability to recognize, navigate, and remove these obstacles. Our students will become the leaders of tomorrow, and it is our responsibility to ensure they have the best opportunities to carry us all forward to a better future. ▪

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Reducing Attrition from STEM Disciplines:
Understanding the Student Athlete's Perspective

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Institutional data show that a significant number of students at Elizabeth City State University (ECSU)—a public, rural Historically Black University—who identify as STEM (biology, chemistry, pharmaceutical science, computer, and mathematics) majors in the first year graduate with degrees in non-STEM disciplines. While this pattern of switching from STEM to other majors is true across all racial groups, it is much greater for African Americans and other underrepresented minorities (Eagan et al. 2011; Mervis 2010; Bettinger 2010; Stinebrickner and Stinebrickner 2011; National Science Board 2014). Sadly, this phenomenon has been identified by STEM educational researchers as a major obstacle for achieving the national goal of sufficiency in STEM graduates (Chen and Soldner 2013).

The findings of this study suggest that inadequate accommodations for students with extenuating educational burdens may be a major reason why some students who are genuinely interested in STEM disciplines walk away from them.

STEM literature asserts that poor academic performance in STEM courses relative to non-STEM courses is one of several reasons why students abandon pursuit of STEM disciplines (Rask 2010; Stinebrickner and Stinebrickner 2011). However, contextual factors such as institutional environments and resources are also known to produce similar outcomes (Fouad et al. 2010; Chang et al. 2011).

The hypothesis of this study is that attrition from a STEM discipline may be due to factors that are totally unrelated to a student's intellectual ability. Identifying such factors and addressing them through cultural and institutional change may reduce attrition, improve retention, and, subsequently, increase the rate of graduation in the discipline. The key finding highlights a need for STEM departments to reassess the academic and cocurricular supports provided to students with extenuating educational burdens.

The conceptual underpinnings of this study are grounded in elements of the Association of American Universities' (AAU) framework for systemic change in undergraduate STEM teaching and learning (2011). Also, through a leadership strategy that operates according to elements of the leadership frames described by Bolman and Gallos (2011)—including structural, political, human resources, and symbolic paradigms—the project stimulated cultural transformation among key stakeholders through advocacy for community purpose, responsibility, accountability, and morality, which are all relevant to the ethos of ECSU.

METHODS

Study participants were ECSU sophomores and juniors who were non-STEM majors but previously had declared a major in biology, chemistry, pharmaceutical science, computer science, or mathematics. Because I was interested in exploring the reasons students depart STEM that are unrelated to academic potential, only students with cumulative GPAs above 2.5 were invited to participate. Eligible students were identified from a master data

sheet from the university's Office of Institutional Effectiveness, Research, and Planning and were invited by email to participate in the study.

To ensure collection of detailed data, interviews were guided by the principles of qualitative research described by Rossman and Rallis (2012), which encourage researchers to allow participants to share rich and detailed narratives from which important themes may emerge. To this end, study participants responded individually to two open-ended questions: one on their reason(s) for leaving the STEM major that they were initially enrolled in and the other on their reason(s) for selecting their current major. Prior to scheduled interviews, potential interviewees received copies of informed consent documents wherein study details and statements ensuring anonymity of participation were carefully documented. Information and notes by which students might be identified were kept confidential. The average length of interviews, which were scheduled at times that were most convenient for participants, was thirty minutes. During interview sessions, the interviewer diligently took comprehensive notes and validated the accuracy of the notes by a read-back technique before the sessions concluded. All interviews were conducted in the faculty researcher's office, although students were given the opportunity to identify alternative locations if they considered this location inconvenient.

Interview notes were carefully reviewed, and responses to the first interview question were collated by themes into groups according to the qualitative research guidelines of Rossman and Rallis (2012). Groups of responses that directly or indirectly referred to the academic rigor of course content as the main reason for attrition were identified and eliminated. Those that pertained to issues with university-based teaching or learning resources were noted and subjected to additional review. Applicable reasons that were cited by more than one interviewee within each or in all the disciplines were recognized as issues to be addressed in postproject recommendations.

RESULTS

Data from the Office of Institutional Effectiveness, Research, and Planning showed that a total of forty-eight students who identified as biology, chemistry, pharmaceutical science, computer information science, engineering, technology, or mathematics majors at the time of admission changed their majors between the fall 2014 and spring 2018 semesters. Ten of these students had inter-STEM changes while the remaining thirty-eight changed to non-STEM majors. Thirty-one of those who changed to non-STEM majors were invited to participate in the study and seventeen were interviewed. Those interviewed provided a total of twelve

TABLE 1. REASONS CITED FOR CHANGING TO A NON-STEM MAJOR

REASONS CITED	NUMBER OF RESPONDENTS WHO CITED REASON	NUMBER OF RESPONDENTS LIKELY TO BE IMPACTED	PERCENT IMPACTED
1. Wanted to study what I liked	9	17	53%
2. Accommodation for student athletes	2	2	100%
3. Hard to understand teacher (accent)	2	17	12%
4. Hard to understand teacher (other reasons)	5	17	29%
5. Pace was very fast/too many credit hours per semester	6	17	35%
6. Not enough professors (one professor teaching most courses)	1	17	6%
7. More peer tutoring (peers explain concepts better)	3	17	18%
8. Testing didn't reflect what was taught	1	17	6%
9. Couldn't see any future for me in the major/No job guarantee	9	17	53%
10. Didn't understand the major well before signing up	3	17	18%
11. Lost initial passion once had for the major	1	17	6%
12. Error—wasn't supposed to be in major in the first place	1	17	6%

reasons why they changed to non-STEM majors (table 1). Four of the twelve reasons (33 percent) were disregarded because they were cited by only one participant and the rest (eight of twelve, or 67 percent), which were each mentioned by at least two participants, were considered relevant. Results also show that all student-athlete participants cited inadequate accommodations as a primary reason for changing to non-STEM majors, arguing that lectures and labs missed during required athletic travel adversely impacted their academic performance and increased their risk of losing athletic scholarships.

DISCUSSION

Many of the reasons provided by participants in this study (table 1) for leaving these STEM majors align well with existing literature. Study participants cited a loss of interest (Chang et al. 2011; Fouad et al. 2010; Thompson et al. 2007), instructor accent (Berrett 2012; Sanchez and Khan 2016; Subtirelu 2015), style of teaching and instructors' inability to explain concepts clearly (Daempfle 2002; Marra et al. 2009; Johnson 2007; Geisinger and Raman 2013), pace of study (Sanabria and Penner 2017; Mervis 2010; Maltese and Tai 2011; Ellis, Fosdick, and Rasmussen 2016), lack of peer tutoring (Preszler 2009; Batz et al. 2015), and academic counseling (Berdahl 1995) as reasons for departing STEM majors. However, a potential lack of adequate and intentional accommodations for students with extenuating educational burdens, such as student athletes, as a possible contributor of STEM attrition has not been studied adequately, making this one of the most important findings of this study.

The findings of this study suggest that inadequate accommodations for students with extenuating educational burdens may be a major reason some students who are genuinely interested in STEM disciplines walk away from them. These are students who have circumstances that do not qualify as disabilities or clinical conditions that are accommodated under the provisions of the Individuals with Disabilities Education Act. However, they are personal burdens that are indispensably interwoven with their individual lives that present unavoidable challenges for learning within contexts of traditional formats of education. Extenuating educational burdens may manifest as excessive tardiness or absence from lectures and labs, poor student engagement, or failing grades.

In this study, two of the seventeen participants identified as student athletes. Both had to leave a STEM discipline because, according to one of them, "I keep missing lectures and labs, and the only way to catch up with what I missed in lectures is to look at the information on Blackboard, ask some of my friends, or go to office hours. Neither of these and sometimes all of them are not enough."

Student athletes are one particular group of students with essential non-academic responsibilities that qualify as extenuating burdens to education. Many of them are on athletic scholarships with stringent terms of performance and expectations for both athletics and academics. They are required to participate fully in trainings, athletic travel, and competitions while maintaining a certain level of academic standing. Participation in athletic responsibilities sometimes contributes to missing lectures or labs, encroaches on time to study and other essential components of a successful STEM education, contributes to poor test grades, and threatens athletic scholarship eligibility. The interdependency of the pressures student athletes face is the reason adequate accommodations in support of academic success are essential to retention and graduation.

CONCLUSION

It is imperative to call the attention of STEM departments to the subtle contributors of attrition that are often missing from major dialogues on the subject, including inadequate accommodation for students who truly deserve it (student athletes, working students, students with children, etc.). Some might argue that the small number of students who responded in this study render it statistically insignificant, while they point to anecdotes of student athletes who are successful in STEM (Neale, Grant, and Sachdev 2012). However, it is still noteworthy because the stereotypical presumption is that STEM disciplines and student athleticism are incompatible (Sailes 1993), and there is little scientific literature on strategies for attracting and retaining student athletes in STEM disciplines (Neale, Grant, and Sachdev 2012). Given the very structured nature of traditional methods

of education used in STEM disciplines that often require presence and active participation of students, it is conceivable that the academic performance of students with extenuating educational burdens who are pursuing STEM disciplines could be adversely impacted in the absence of thoughtful accommodation plans. Adequate testing accommodation is the main consideration behind such concepts as assistive technologies, extended time, language interpreters, or reading aloud (Lin and Lin 2016). It meets the educational needs of all students, aligns perfectly with student-first and student-centered paradigms, and is a practical expression of commitment to student success.

While STEM instructors may make varying concessions to individuals with student-athlete circumstances such as exceptions to turn in assignments late, opportunities to make up exams or labs, and excused absences, this finding challenges the assumptions that STEM departments are doing enough to accommodate all students. I therefore recommend that STEM departments design, implement, and periodically assess intentional strategies for supporting students with various types of extenuating educational burdens and acknowledge their efforts as a practical approach to increasing STEM retention and graduation rates. The solutions that we seek may be hiding in plain sight. ▪

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Using Adaptive Learning Courseware as a High-Impact Practice to Improve Students' Learning Outcomes in General Chemistry II at an HBCU

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The Clark Atlanta University (CAU) Department of Chemistry offers general chemistry as a high-enrollment foundational course for STEM majors, the majority of whom are biology majors. Two of the authors have been coteaching general chemistry (Chem I and Chem II) for several years. Despite employing various pedagogical approaches to improve teaching and learning, trying to understand why these classes yield low pass rates—Chem I varies between 40 and 65 percent and Chem II has a rate of around 70 percent—has been emotionally draining at the end of each semester. In this article, we present the development, implementation, and findings from a pilot of a redesigned Chem I course that incorporated adaptive learning courseware (ALC) as part of our efforts to improve learning, retention, and graduation rates of STEM majors.

CAU is a Historically Black College and University (HBCU) that offers bachelor of science and master of science degrees in biology, chemistry, computer science, mathematics, and physics, and doctoral degrees in biology and chemistry. With an enrollment of approximately four thousand students, CAU is the largest private institution among the HBCUs in the state of Georgia. Sixty-one percent of our undergraduate students are from low-income families making $48,000 or less, 70 percent are eligible for Pell Grants, and 35 percent are first-generation students.

CAU, like most institutions for higher education, struggles with low retention rates of undergraduate STEM majors. General chemistry is one of the key courses that pose a significant barrier to success for STEM majors. Though CAU has averaged a pass rate of approximately 70 percent in Chem II over the past three spring semesters, Chem I historically has much lower pass rates (43 percent in fall 2015, 64 percent in fall 2016, and 47 percent in fall 2017). Therefore, it is critical that we continue to assess the quality of our instructional delivery and wraparound support services and examine new approaches to improve students' learning outcomes. CAU chemistry students have continuously expressed the need for active learning and real-time assistance in identifying areas where they are having challenges with problem solving. The size of classes, the inordinate amount of time required of the instructor(s), the shortage of qualified tutors and teaching assistants, and the cost for such assistance make it nearly impossible to provide adequate real-time personalized interaction for our students.

Digital learning can overcome these limitations. Students today are digital natives, and higher education must embrace the differentiation of instruction for individual students that digital learning enables. Digital courseware is now becoming increasingly available as online homework systems become more sophisticated and more advanced with "adaptive learning" (adaptive-responsive) technology that can provide instructions tailored to each student's needs. In fact, adaptive learning is accepted as one of the three components of the Persistence Framework, the benchmark among best practices for increased retention of STEM majors (Graham et al. 2013). Digital and adaptive learning technology

is being implemented at many predominately White institutions, as demonstrated by the Personalized Learning Consortium of the Association of Public and Land-Grant Universities (2018). HBCUs must also place themselves at the forefront in leading this digital movement to improve student learning outcomes and increase retention and graduation rates, particularly for African American STEM students.

CONCEPTUAL FRAMEWORK

It is against this background that we conducted an active learning project (ALP) with support from the Center for the Advancement of STEM Leadership, which is funded by the National Science Foundation, to introduce ALC in our general chemistry sequence and measure its impact on learning as well as on students' perceptions of the learning platform. This ALP is part of an institutional initiative called Course Redesign with Technology (CRT), which is supported by the CAU Office of Academic Affairs to integrate innovative digital and adaptive courseware into the curricula to increase student learning, retention, and degree completion rates. The conceptual framework for this ALP is grounded in the three elements of the Association of American Universities Framework for Systemic Change in Undergraduate STEM Teaching and Learning: (1) pedagogy, (2) scaffolding, and (3) culture change (2018). The implementation of ALC as part of the CRT provided scaffolding, an evidence-based technique representing the pedagogical underpinning of the ALP. Scaffolding refers to the support necessary to first incubate and then sustain this evidence-based teaching. Concurrent with the development of this ALP, course redesign with ALC was also undertaken in core courses in biology and mathematics.

All elements of Bolman and Gallos's (2011) four frames of leadership—structural, human resource, political, and symbolic—were employed in the development, implementation, and institutionalization of this ALP. In this phase of the project, the political and symbolic frames were paramount for addressing faculty and student buy-in. The political frame required us to be compassionate leaders working with an intensely political aspect of academic life as advocates, power brokers, and strategists who engaged in setting agendas, building coalitions, and managing conflicts. Having been introduced to adaptive learning pedagogy based on artificial intelligence, we were easily convinced that it warranted exploration for enhancing student learning. However, some colleagues remained skeptical and viewed this as a futile effort in implementing a pedagogical approach that they assumed has not been proven to be effective. We decided that careful execution of a well-designed project was an important first step toward successfully maneuvering in this political minefield and simultaneously demonstrating symbolic leadership. Following our commitment to redesign Chem II, we established collaboration and communication with our colleagues who were redesigning courses in biology and mathematics in order to build a strong STEM coalition. Increasing student engagement was also crucial to earn their buy-in. We communicated to students the importance of the adaptive-learning component of their course for improving their learning outcomes and that the courseware would become a portion of their graded assignments.

Adaptive Learning Courseware

Online learning platforms have now altered and augmented learning. However, despite approximately 80 percent of US households owning at least one desktop or laptop computer (File and Ryan 2014; Pew Research Center 2017), educational technology has not met its potential for improving educational outcomes (i.e., test scores), especially in mathematics (National Center for Education Statistics, n.d.; Program for International Student Assessment 2015; Jackson and Kiersz 2016). Yet, there is an encouraging shift on the horizon for two reasons. The first is that educational technology is increasingly able to interact with students in sophisticated ways; the second is the experience of a growing number of schools, like the Khan Lab School, which is not just bolting technology onto the existing way of doing things but is also using new software to change how pupils and teachers spend their time (Hamer 2014; Office of Educational Technology 2012).

Colleges and universities must make changes in instructional delivery by including ALC to increase student retention of knowledge and skills, which will decrease the number of students who fail to master foundational STEM concepts. Newer programs use machine learning to find student-specific patterns of strengths and deficiencies. Key vendors include Assessment and Learning in Knowledge Spaces (ALEKS), Knewton, CogBooks, and DreamBox Learning. These companies use AI techniques to deliver personalized instruction, replacing the one-size-fits-all traditional learning model.

Knewton, used in our Chem II course, is an adaptive learning platform that powers digital education based on a proficiency model that is used to "infer each student's knowledge state" (Binger 2018). This is accomplished by combining a "knowledge graph," time-tested psychometric models, and additional pedagogically motivated models. The foundation for the proficiency model is an educational testing theory known as Item Response Theory (IRT). One important aspect of IRT is that it accounts for network effects (the system learns more about the content and the students as more people use it), leading to continually better student outcomes. In addition, it incorporates features like temporality (older responses count the same as newer responses), instructional effects (subject matter content read in the system), and multiple concepts (and their interrelationships) in the knowledge graph.

THE INTERVENTION

Chem I and II are coordinated across years, sections, and instructors. Both are four-credit-hour courses comprising lectures, recitation, homework problems, and laboratories. In the spring 2018 semester, we piloted the redesigned Chem II by incorporating Knewton in one of two sections of the course. There was a common syllabus for both sections, no change in course content, and a common final exam. The Chem II class met three days per week for fifty minutes for traditional lectures and once a week for a ninety-minute recitation during which students engaged in problem-solving exercises under the guidance of a professor and at least one teaching assistant. Fifty-one students enrolled in the pilot section, forty-four of whom completed the course. Thirty Knewton assignments were generated spanning six topical areas worth 10 percent of students' final grades.

METHODOLOGY

We used a quasi-experimental, interrupted-times series design in which grades were compared between students who used Knewton (Chem II in spring 2018) and students who did not use it in the three prior semesters (Chem II in spring 2015, 2016, and 2017). The study was approved by the CAU Institutional Review Board (IRB number-HR2017-11-760-1). To examine the relationship between mastery attained in Knewton and final grades in the course, the researchers calculated a Pearson correlation coefficient since the scatterplot revealed a linear association between the two variables. Finally, a confidential web-based survey was administered during the last week of the semester to capture students' attitudes and perceptions of the adaptive learning intervention. The student perception survey included eleven Likert-type statements and five free-response questions.

FINDINGS

Differences in Grade Distribution

Figure 1 compares outcomes among Chem II students for the past four spring semesters. The spring 2018 pass rate (70.6 percent) was similar to the average (70.3 percent) of the prior three spring semesters. Among students passing the course, there was a significant increase in the percentage of Bs earned (55.6 percent) in the redesigned course compared to the baseline courses (an average of 11.1 percent) and a concomitant decrease in the percentage of Cs (33.3 percent in spring 2018 compared with 82.9 percent in the baseline courses).

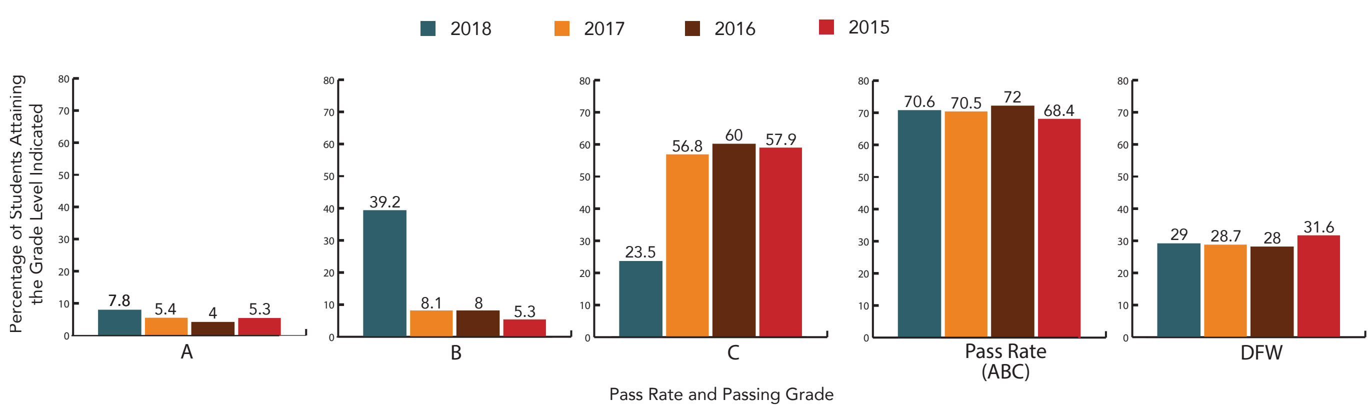
The Relationship between Mastery Attained in Knewton and Final Grades

Students averaged 13.4 hours engaging in the Knewton adaptive-learning platform during the semester and, as shown in figure 2, there was a strong correlation between mastery attained in Knewton (defined as students attaining a 90 percent correct response rate on a series of questions in an individual assignment) and students' final course grades (Pearson correlation coefficient $r(42) = 0.77$, $p < 0.05$). This is consistent with students' survey responses, in which 47 percent agreed that Knewton helped them earn a better grade in Chem II than they would have received without access to the system.

Students' Perceptions of Knewton

There was a 98 percent response rate for the end-of-semester survey. Most respondents were first-year students and biology majors, and 72 percent were female. Forty-nine percent of respondents indicated that they generally enjoy chemistry, 47 percent found the questions and activities in Knewton to be interesting, and 46 percent indicated that they enjoyed the material that they were studying in Knewton. Forty-seven percent indicated that they spent more time studying for Chem II than for Chem I because they were able to use Knewton. Fifty-four percent indicated that they understood the material in Chem II because they used Knewton, and 72 percent indicated that the questions in Knewton were relevant to what they were learning in the classroom. Of the thirty-seven respondents to the question, "What do you think was the purpose of Knewton in this course," students

FIGURE 1. STUDENT GRADES IN CHEM II OVER FOUR SPRING SEMESTERS



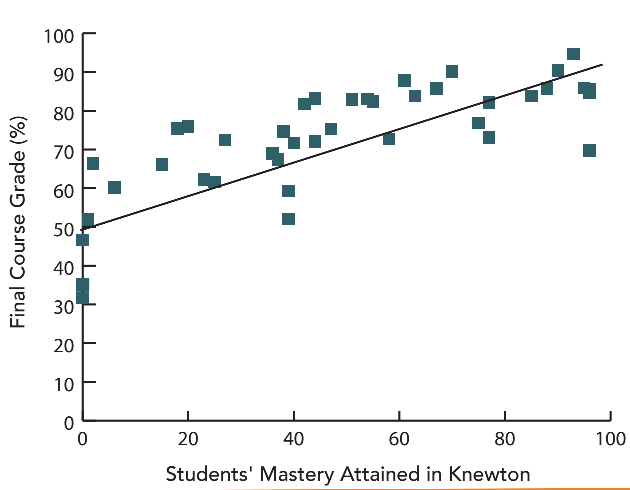
indicated that it was to assist in getting a better understanding (sixteen respondents), expanding knowledge (three respondents), or serving as a study aid and providing extra practice (thirteen respondents) for the course material. Twenty-six students indicated that Knewton was beneficial to their learning, whereas nine indicated that it was not, for various reasons (but mainly because of the extended time that was often required to complete the assignments). In general, the feedback indicates that Knewton helped in understanding and learning but that it takes an extended time to complete and attain mastery of assignments.

DISCUSSION

Our course redesign with ALC did not produce an increase in the percentage of students passing the course; however, it led to great progress toward mastery of Chem II concepts by students successfully completing the class. Most students were initially dismissive of the use of Knewton in the redesigned Chem II, and they preferred to focus on completing CANVAS-based assignments to which they had become accustomed in Chem I in fall 2017. Full engagement with Knewton gradually increased and was driven by the instructor's frequent reminders that it contributes significantly to the final grade. Ultimately, students developed a positive response to Knewton and indicated that, had it been available for Chem I, they would have utilized it more consistently and effectively.

Based on the results of this pilot course, the Department of Chemistry implemented redesigned Chem I and Chem II courses incorporating ALC in fall 2018. Chem I students engage with the system an average of 43.5 hours (a 225 percent increase) versus the 13.4 hours in the piloted course. Knewton has improved the analytics available to faculty, which allows increased personalized responses to students on designated topics and adjustments to classroom lectures and recitation sessions to better address students' areas of deficiency. We are now training the staff in our living and learning centers (campus housing) on how to use the ALC analytics so that they can encourage their residents—our students—to further engage with the ALC toward improving student learning outcomes, retention, and degree completion rates. ▪

FIGURE 2. FINAL COURSE GRADE VERSUS MASTERY ATTAINED IN KNEWTON



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Implementing a Corequisite Algebra Gateway Course

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Dillard University, a private liberal arts institution located in New Orleans, has a mission "to produce graduates who excel, become world leaders and are broadly educated, culturally aware and concerned with improving the human condition" (Dillard University, n.d.). The university serves approximately 1,290 students, 91 percent of whom are African Americans and 75 percent of whom are women. Over the years, Dillard has taken a leadership role in national STEM higher education reform to enhance the quality and competitiveness of undergraduate STEM education for African Americans. These efforts include, at their core, a group of dedicated faculty members from various STEM disciplines at Dillard working in partnership on programs to provide contemporary instructional processes and enriching research experiences for Dillard students who major in STEM.

One example of this partnership exists within and among the faculty of the Dillard mathematics program. Often used as a gateway course for STEM majors, College Algebra holds an important position in the mathematics field. However, in many US colleges and universities, nearly 60 percent of all entering first-year students require remediation (Grubb et al. 2011). The vast majority of the required remediation is in the area of mathematics. Because of this need for further preparation to successfully study college-level math, which may consume two or three semesters of additional coursework, there is a high drop-off of students who initially intended to pursue a STEM major and career. As a result, remedial math has now become a filter from, rather than a pipeline to, STEM careers.

There are several factors that influence remedial math education, and thereby also influence undergraduate STEM enrollment. The first is the national research, which has increasingly shown that the standardized tests used as math placement tools are poor analysts of student ability (Attewell et al. 2006; Belfield and Crosta 2012). Second, there still exists disproportionate number of students of color and low-income students in remedial courses based on these tests (Witham et al. 2015). Placement into these courses often serves as a deterrent for students to pursue degrees in STEM majors due to the extended time to degree. In contrast, reforms that enable students to avoid or accelerate remediation are producing large gains in the completion of college-level courses and narrowing achievement gaps for students of color. However, a more significant consequence of remedial placement could be the ancillary effect on students' sense of self-efficacy and legitimacy as college students (Crisp, Nora, and Taggart 2009).

To address this troubling trend, the state higher education systems in Tennessee, California, and Texas have embraced a paradigm shift to incorporate remediation into entry-level mathematics courses (Rodriguez et al. 2018; Denley, n.d.). Such programs are academic bridges for unprepared students to improve their college readiness. One strategy state legislatures and institutions are adopting is the corequisite remediation model. This model has shown great success in getting students to complete degrees because it allows students to enroll in credit-bearing classes while also providing academic support in conjunction with their regular courses (Edgecombe and Bickerstaff 2018). In Tennessee, for example, 55 percent of students who were enrolled in a corequisite

mathematics course in the fall of 2015 earned credit in one semester, compared to 12 percent of students who earned a gateway credit after one year in the previous prerequisite model (Denley, n.d.). The success rate for minority students increased from 6.7 percent to 42.6 percent in one semester in the corequisite math model. Georgia, Indiana, Colorado, and West Virginia have also adopted the corequisite remediation model and demonstrated similar results as Tennessee in both math and English courses (Complete College America, n.d.).

Likewise, Dillard, through its association with the Center for the Advancement of STEM Leadership and support from an HBCU-UP Grant Award (both funded by the National Science Foundation), continues to embark upon several initiatives aimed at addressing the persisting underrepresentation of African Americans receiving baccalaureate and graduate degrees in STEM disciplines. More specifically, Dillard implemented a curriculum revision of gateway STEM courses, especially in mathematics, that will enhance and update content and pedagogical methods.

METHODS

Leadership

To develop and implement this work, we used the human resource frame of Bolman and Gallos's framework of leadership (2011). Leaders using the human resource frame combine the skills of a servant, catalyst, and coach.

From the beginning of this project, it was clear that the success of this work would require setting attainable goals, achieving collaboration from several stakeholders, and breaking down silos that prevent shared knowledge. During the 2017–18 academic year, several university personnel assisted with the planning of the new course design. The effort was led by the faculty of the mathematics department, who worked with the following individuals and groups: chairperson and program coordinators of the School of STEM, dean of University College, director of the Office of Admissions, and the university registrar.

The mathematics faculty were responsible for evaluating the existing content of the remedial course to identify the specific competencies that were being addressed in order to integrate these components into the redesigned college algebra course. Since University College is responsible for the advisement, registration, and matriculation of incoming first-year students, the college served as a liaison on academic matters related to general education courses. Additionally, the University College dean served as the chairperson of both the university retention and general education committees and provided a unique perspective on the impact of these courses on retention, persistence, and graduation. The admissions office was critical in the administration of placement exams. The registrar ensured that the new course and testing processes complied with university policy related to course changes.

It was also important, as leaders of this effort, to remain objective in order to identify team members' emotions and deal with what was driving them, while at the same time not letting unconscious biases create unrealistic views and affect anyone's decisions. Team members were constantly reminded of the importance of their role and the underlying main goal—students' success. Creating a positive work environment by showing gratitude and recognizing milestones of the project was essential to building trust and patience among team members.

Key administrators, such as STEM program coordinators, the STEM chairperson, and the dean of arts and sciences were included on the development team to ensure that the curricular review and approval processes were followed and that shared governance was maintained during the processes. They also assisted in the management of potential conflicts and reminded stakeholders of our institutional goals and priorities.

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Course Design

The team chose to design a corequisite course, MAT 121A College Algebra Integrated, which provided students who scored below the placement cutoff scores on the ACT and SAT with just-in-time support focused on essential intermediate algebra concepts needed for success in the college algebra course. MAT 121A is a four-credit course that meets seventy-five minutes on Monday, Wednesday, and Friday and is capped at thirty students per section. The ACCUPLACER exam was incorporated as part of the course design as an additional placement tool for validating students' proper placement in the corequisite course.

The procedure for learning in this course includes the instructor guiding students through important concepts, especially difficult problems, study

strategies, and in-class quizzes, and active problem-solving. Intermediate algebra concepts that were reviewed included simplifying algebraic expressions, simplifying integer and rational exponents, factoring polynomials, solving a variety of equations, graphing techniques, writing equations of lines, introducing functions and relations, complex fractions, and rational numbers.

MAT 121A also incorporated MyLab Math, an online interactive and educational system designed by Pearson Education as a homework management system. MyLab Math includes several learning aids and automated feedback that reinforce skills generated according to each student's performance in web-based activities such as embedded tutorials, practice exercises, multimedia aids, and other resources. Students can work at their own pace, measure their progress, and learn from their mistakes without fear of being judged. Course faculty can use MyLab Math to monitor the progress of students and provide early intervention to those who are falling behind. Students are also required to attend the math tutoring lab, which provides an environment conducive to active learning and additional instructional interaction. Also, the Instructure Canvas Learning Management System was used for course announcements, the posting of course syllabi, and homework assignments.

While the course coordinator was responsible for creating all MyLab Math homework assignments, the overall evaluation of student outcomes in the course was uniform across all sections and based on four categories: exams (50 percent), the final exam (25 percent), homework (15 percent), tutoring assistance (10 percent), and class participation.

IMPLEMENTATION

In summer 2018, a pilot study was conducted using a cohort of twenty-five incoming first-year students who participated in the Emerging Scholars Program (ESP). ESP is a six-week residential summer program designed to increase the number of students who successfully matriculate through the undergraduate curriculum by enhancing their reading, writing, and analytical and critical-thinking skills. The program also provides tutoring, academic counseling, and mentoring throughout students' first year and beyond. ESP usually calls for students who do not meet the required ACT or SAT scores for placement into MAT 121 College Algebra to enroll in the developmental math course, MAT 109; however, during summer 2018, twenty-five ESP students were enrolled in the corequisite algebra course MAT 121A. The pilot was very successful, as every student earned a C or better. Of those students, ten enrolled in the subsequent required math course, MAT 122 Pre-Calculus, during the fall 2018 semester with eight passing with a grade of C or better.

MAT 121A was fully implemented in fall 2018 with 140 students enrolled in five sections. Seventy-eight percent of the students completed the course, 80 percent earned a passing grade (C or better), and 2 percent withdrew from the course. In comparison, for students who took MAT 121 (without the intermediate algebra review; 178 students in seven sections) during the same semester, 92 percent of the students completed MAT 121 and 78 percent earned a passing grade.

CONCLUSION

Implementation of MAT 121A shows promising results in its early stage. Future studies will focus on collecting and analyzing data to determine whether the following anticipated outcomes of MAT121 were met: (1) improved retention; (2) increased completion rates of entry-level, credit-bearing college courses; (3) improved college completion rates; and (4) significant cost savings for both students and the institution. We must also identify the psychosocial factors that might contribute to a student's lack of success in the course. Data obtained from this study will allow STEM faculty to better assess student retention in a methodical format and allow the math faculty to measure gaps between students enrolled in the corequisite course and students enrolled in the traditional college algebra course.

In terms of pedagogy, the development of MAT 121A required mathematics faculty members to make learning more interactive by incorporating technology. It also required a shift to a more collaborative effort in teaching and learning, focusing more on faculty-student and student-student interactions in the classroom. Students' engagement will help them understand that course content is not just a series of discrete content areas and skills, but rather includes knowledge and skills that are constructed and scaffolded.

Collectively, these interventions will improve the teaching and learning environment not only for STEM majors but also for the broader community of all university students who take STEM courses to fulfill general education requirements. Currently, the English program is exploring a corequisite model for its gateway courses. However, despite the success of Historically Black Colleges and Universities (HBCUs) in training African American students, changes are needed to reposition them for continued growth. It is imperative that HBCUs find innovative strategies to increase student success in critical gateway courses and to improve retention and graduation rates. There is no doubt that corequisite courses will be sustained at Dillard University. Celebrating 150 years of heritage and academic excellence, Dillard University remains steadfast in its mission of training well-prepared graduates. ▪

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Overcoming Advising Barriers to Retain STEM Majors

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The lack of STEM graduates needed to fill the coming jobs requiring science and engineering skills has been well-documented (PCAST 2012). Higher education institutions have implemented an array of interventions to retain students as STEM majors, not only to address this need but also with an eye to adding diversity to the STEM workforce. The University of the Virgin Islands (UVI), a small land-grant HBCU with campuses on two islands separated by forty miles of water, has had success with not only graduating STEM majors but also preparing many students to go on to earn graduate and professional degrees (Sanchez 2018). To achieve this goal, UVI's College of Science and Mathematics (CSM) has instituted interventions aimed at retaining students and strengthening their skills. These include peer-led team learning in foundational mathematics courses, original research projects in classes in multiple disciplines, flipped classrooms and other active engagement strategies, proactive advising, and the very successful Emerging Caribbean Scientists program, an umbrella for the numerous grants and opportunities for students (seminars, scholarships, research support for students and faculty, and more).

Finally, they found that the successful implementation and scaling of this work requires "both bottom-up and top-down leadership often epitomized by shared or distributed models of leadership."

Student persistence as STEM majors and time to degree completion continue to be challenges, particularly persistence after the second year. Research has repeatedly cited advising as a critical component of any retention strategy (Darling 2015; White 2015), yet data from several surveys at UVI (National Survey of Student Engagement 2015; Mills and Bellew 2016) indicate student dissatisfaction with advising. Faculty have also expressed frustration with the process. In an internal study, Kimarie Engerman (2013) surveyed both faculty and students on the St. Thomas campus in all schools and colleges about their attitudes toward advising, characterization of the advising experience, suggestions for improvement, and best practices at peer institutions. The data indicated specific points of dissatisfaction such as advisor availability, unprepared students, and policies occasionally circumvented (prerequisites waived without advisor knowledge, personal identification numbers needed for registration given to students without advisor consent, etc.).

As a result of Engerman's study, the university formed an advising committee comprised of faculty representatives from each of the university's schools and colleges and staff members from UVI's Center for Student Success (CSS). They were charged with developing an advising plan, and the university

also invested in AdvisorTrac software, which was used to manage advising. The plan, based on the findings from Engerman's study, was completed in April 2015 and sent to the provost; it was then distributed to the deans to be implemented in the schools and colleges. The plan was partially successful, as some elements were implemented, particularly in the CSS, where they have worked diligently to advise new first-year and sophomore students, reach out to students needing more support, and answer questions promptly regarding the current advising software. Paradigms (or plans of study) for all majors are posted on UVI's website, although not all have been updated; administrative assistants have begun assigning advisors to new students prior to registration; faculty are present at new student registration; and faculty and CSS staff are gradually working together more. Problems still exist, as the plan was not implemented evenly across the university. Key interventions, such as consistent training for advisors, early contact with new students, and the development of backup advisement plans, were not done consistently. Also, the AdvisorTrac software had technical issues and few users.

Recognizing the importance of advising, the current president implemented a different advising software and overall approach, joining the Student Success Collaborative (www.eab.com) and using data analytics software to examine all aspects of student life to aid in retention. This software, referred to as BucsConnect at UVI, serves as a connector to different resources involved in advising and student success, including CSS, Access and Enrollment Services, financial aid, faculty (as advisors and as course instructors), and students. A new advising task force convened in January 2018 and, using the previous advising plan as a foundation, updated and adapted the previous advising plan to create the new advising plan. The plan was distributed to stakeholders for feedback, suggestions were incorporated and vetted, and the plan was approved by the full faculty in April 2018.

The current challenge is fully implementing the plan in each school and college, including the CSM, which faces some unique challenges. Unlike

the other schools and colleges, only the computer science and applied math degrees can be completed on both campuses, necessitating the physical relocation of many students who begin on St. Croix to the St. Thomas campus to complete degrees in other STEM majors. It is not uncommon for students from the St. Croix campus to transfer to an institution on the United States mainland instead—or to change their major to avoid relocating to St. Thomas.

This issue—and potentially others—was not explored in Engerman's original 2013 study, which was conducted only on the St. Thomas campus. The author's 2018 study, which built on the one conducted by Engerman, focused on CSM across both campuses to identify potential barriers to successfully implementing the new advising plan. The goal was to use the data gathered in Engerman's 2013 study as a baseline of the CSM landscape prior to developing the college-specific advising elements and fully implementing the new advising plan; the same data will be collected after implementation to assess its impact.

As noted in Kezar, Gehrke, and Elrod's study (2015), attempts to implement STEM interventions at scale often fail due to implicit theories of change held by individuals they called "change agents" that are not accurate or do not reflect the reality of what is needed for a change to be institutionalized. Kezar, Gehrke, and Elrod also identified implicit theories of change—both generally and specifically for STEM—that were detrimental to achieving the desired change. To successfully implement the advising plan, this study was designed to address some of these implicit theories of change. One common implicit theory of change noted by Kezar, Gehrke, and Elrod (2015) is "the challenge of change agents believing they can jump directly to a strategy or intervention without much exploration of the problem or issue." This was a driving force for the 2018 study described here: If there are underlying issues not dealt with by the new advising plan, its full implementation will not achieve the benefits the

university seeks. Kezar, Gehrke, and Elrod (2015) also indicated that campus politics play a role in the change process: "Change agents assumed if they were armed with data about why students were not succeeding, then others on campus would be persuaded. They did not anticipate or prepare for politics." Finally, they found that the successful implementation and scaling of this work requires "both bottom-up and top-down leadership often epitomized by shared or distributed models of leadership." However, they found that unsuccessful change agents tended toward only one or the other.

METHODOLOGY

STEM majors and CSM faculty were surveyed on both campuses to gain a more complete and up-to-date view of barriers to successfully implementing the advising plan in CSM. The Engerman survey, with small modifications specific to CSM and STEM majors, was administered electronically to both students and faculty; it assessed attitudes and perceptions toward advising and also asked for recommendations for improvements of the academic advising process. The anonymous, voluntary survey included a mix of closed and open-ended questions. Open-ended responses were coded to identify broad themes and issues (mirroring Engerman's study) to detect changes that might affect implementation of the advising plan and identify any modifications that may be needed as we finalize the college-specific portion of the plan. The survey responses will guide the implementation strategy for the advising plan, as they potentially allowed us to avoid the detrimental results of erroneous implicit theories of change.

RESULTS

While almost half (48.5 percent) of CSM faculty completed the survey, only 11.8 percent of CSM majors responded. Of student respondents, similar numbers of first-year, sophomore, and junior students responded, with a larger number of seniors participating. Biology, marine biology, computer science, and applied mathematics were well-represented among the respondents; smaller numbers of students from physics, chemistry, and mathematics participated (one to three students each, though this mirrors the proportion of these majors in CSM). Of the faculty respondents, six were from biological sciences, six were from chemical and physical sciences, four were from mathematics, and one was from computer sciences. Not all indicated years of service; the range of those who did was three to twenty-two years.

Despite differences in the populations surveyed (the 2013 survey included all majors at only one campus, while the 2018 survey included only STEM majors at both campuses), overall attitudes toward advising remained very similar; more faculty than students found advising pleasing and rewarding. Overall ratings of academic advising services were similar between faculty and students in 2018, with 75 percent or better of both groups rating advising as moderately or highly effective. This is higher than 2013 (45 percent or better rated advising moderately or highly effective), but whether that is due to changes in academic advising that were already underway or to the current survey's focus on a single college is not clear.

Faculty and students characterized many aspects of the academic advising experience differently. While both groups ranked giving/receiving advice and answers on curricular requirements highly, many faculty (81 percent) felt that their role giving advice and guidance on careers and options after graduation was also an important aspect of advising. However, only approximately 30 percent of students characterized those aspects as part of the advising experience. These differing characterizations were reflected in what each group said was the most rewarding aspect of advising. Students' comments most often mentioned help in selecting classes and developing a graduation plan—the courses and their sequence needed to graduate—followed by a smaller portion responding to advice in their field and career. When asked about the most rewarding aspect of advising, the theme that faculty mentioned most was assisting students in reaching their dreams or goals (i.e., seeing them succeed). That was followed by personal interaction or encouraging students.

When asked about the most rewarding aspect of advising, the theme that faculty mentioned most was assisting students in reaching their dreams or goals (i.e., seeing them succeed). That was followed by personal interaction or encouraging students.

The open-ended questions also asked for the most frustrating or dissatisfying aspects of academic advising. The most common theme for both faculty and student responses ultimately revolves around time: not being able to contact or fit into the advisor's schedule, students not making appointments, not enough time with the advisor or student, not enough advisors, or advisors keeping track of too many advisees. Faculty expressed frustration that students only wanted their PIN (i.e., just want to be able to register online) and had a lack of understanding of the importance of academic advising; this would also include students registering for classes against what they were advised. Students, on the other hand, were frustrated with recommended classes not being offered and little help to find a solution. Another concern raised more than once was that advisors don't take into consideration what students say. However, an equal number noted that their advisors listen to their interests, perhaps indicating differences in the advisors' approach or training.

There was also substantial overlap between student and faculty suggestions for improvement for the advising process. Both students and faculty recognized the need to make advising and/or advisors more accessible: suggestions included "more hands on deck"; adding "super advisors" for each department with release time from teaching; staggered registration or a shorter, specific block of time for advising prior to registration; identifying a neutral space to meet; and implementing an earlier start in the fall for the spring registration process. Faculty recommended that students meet with their assigned advisors, whereas students indicated the desire to choose or change advisors—or even have multiple advisors. A few comments from both faculty and students cited the need for an assigned faculty advisor from the very start (i.e., orientation), as well as multiple and even mandatory meetings. Both wanted more information in a timely manner, although the type of information requested by each group varied. Evaluation of advisors and training were also brought up in comments by both students and faculty.

CONCLUSION

All the open-ended responses generally mapped to those in the 2013 Engerman study, and more importantly, were either addressed by the university-wide advising plan or will be addressed as the elements of the CSM-specific portion of the plan are developed. One issue raised in the survey that is not currently addressed in the advising plan is the transition of students who start on St. Croix and transfer to the St. Thomas campus to complete their degrees. Several former St. Croix students expressed a great deal of dissatisfaction with the advising transition, with several noting that they still worked with their initial St. Croix advisor. Discovering this and determining how to facilitate the transition of CSM majors from one campus to the other might have been missed without the survey.

This survey forms part of a collaborative approach to finalizing and implementing an advising plan that works. To broaden participation in STEM nationally, we need to broaden participation internally, ensuring all groups and stakeholders who are affected by a change have true input and ownership. In line with Bolman and Gallos's frames of leadership (2011), both the political and the human resource frames speak to this development process: respect for and navigation among the stakeholders, as well as fostering the collaboration needed for the success of the new advising plan. Once the college-specific elements are developed and the full plan is put into practice, the survey will be administered again to help assess the effectiveness of CSM's advising plan. The results will be used to address remaining issues, drawing on the structural frame of leadership. Our overarching goal is for every student to have a strong relationship with his/her advisor. Outcomes include more students meeting with their advisors, reduced time to degree, and more seamless transitions for students transferring between campuses. Most importantly, we anticipate far greater retention and graduation of students at UVI as STEM majors. ▪

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HBCUs and Black STEM Student Success

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In 2016, the National Science Foundation's Historically Black Colleges and Universities-Undergraduate Program (HBCU-UP) announced a call for applications for HBCUs to become Broadening Participation Research Centers, with the expectation that those selected would "represent the collective intelligence of HBCU STEM higher education and serve as national hubs for the rigorous study and broad dissemination of the critical pedagogies and culturally sensitive interventions that contribute to the success of HBCUs in educating African American STEM undergraduates" (National Science Foundation 2016). The first such participant is the Center for the Advancement of STEM Leadership (CASL), with a mission to "substantially broaden the participation of students who have been marginalized from US STEM higher education" (Center for the Advancement of STEM Leadership, n.d.).

CASL intends to use findings from studying HBCUs to generate new knowledge at the intersection of leadership development and efforts to broaden participation in STEM. One of CASL's innovative and groundbreaking components is the Leadership Development Program that provides emerging HBCU leaders (CASL fellows) with the tools to think deeply about the role HBCUs can play in this work. While many articles in this journal make the case that HBCUs can have a significant role in meeting the nation's demands for a well-prepared STEM workforce, I would like to emphasize an even greater mission that these historic institutions have been carrying out. They are the institutions that educate Black students in the United States and prepare them for the next step in their careers by acknowledging the links between the lived experiences of Black students with their success as STEM students.

Melvin Hall, Northern Arizona University professor and CASL's director of strategic initiatives, refers to this role of HBCUs as "cultural context" and calls the HBCU environment "Camelot" (Center for the Advancement of STEM Leadership, n.d.). From my own (yet to be published) research, a participant described the HBCU where he studied physics as providing a "dome of security and safety." In contrast, he recounted that when he attended a predominantly white institution, he constantly needed to be guarded and employ "his body sense," an act that made him tense, defensive, and unable to listen. As I searched for an understanding of what makes HBCUs successful in educating Black STEM students, I realized that at the core lies the fact that HBCUs let Black students live their best and authentic lives.

As I searched for an understanding of what makes HBCUs successful in educating Black STEM students, I realized that at the core lies the fact that HBCUs let Black students live their best and authentic lives.

We can hardly expect the 102 HBCUs that make up 3 percent of US institutions of higher education and enroll 9 percent of Black students (National Center for Education Statistics 2018) to carry the burden of redressing the marginalization of Black scientists and engineers within the US STEM enterprise. That said, a report by the American Institutes for Research shows that a third of Black STEM PhD recipients earned their undergraduate degrees at HBCUs (Upton and Tanenbaum 2014). HBCUs embody the best practices for educating students who are marginalized in other learning environments, and it is critical that we look to these schools to learn how to best educate all STEM students. The Center for the Advancement of STEM Leadership is at the vanguard of contributing to the body of knowledge on how leadership of STEM faculty and

administrators is linked to the success of Black students in STEM. CASL acknowledges that leadership does not only happen at the level of deans, provosts, and presidents but with faculty members as leaders in classrooms and labs. The results of the action learning projects presented in this issue of *Peer Review* range from innovative approaches to fostering the career advancement of faculty (such as increasing research capacity and addressing issues related to tenure, promotion, and career development) to ways that students can learn better (such as course-based research experiences, adaptive learning courseware, mindfulness to reduce math anxiety, and metacognition to support racial equity). Critically, much of the work reflects a realization that, in order to broaden the participation of Black students in STEM, we must first place Black students at the center of what we do as educators.

The work of the CASL fellows, guided by the philosophy of CASL to be at the "Soul of Leadership," reflects the work of so many HBCU faculty. Guiding frameworks that use the context of HBCUs have been largely missing from the literature on leadership, as well as on STEM undergraduate education reform. I am excited that this issue of *Peer Review* leads the way in introducing this groundbreaking work to the STEM education community. ▪

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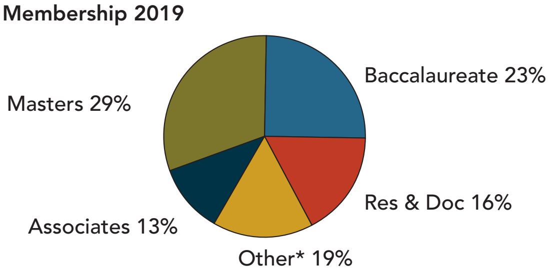
AAC&U is the leading national association dedicated to advancing the vitality and public standing of liberal education by making quality and equity the foundations for excellence in undergraduate education in service to democracy. Its members are committed to extending the advantages of a liberal education to all students, regardless of academic specialization or intended career. Founded in 1915, AAC&U now comprises 1,400 member institutions—including accredited public and private colleges, community colleges, research universities, and comprehensive universities of every type and size.

AAC&U functions as a catalyst and facilitator, forging links among presidents, administrators, faculty, and staff engaged in institutional and curricular planning. Through a broad range of activities, AAC&U reinforces the collective commitment to liberal education at the national, local, and global levels. Its high-quality programs, publications, research, meetings, institutes, public outreach efforts, and campus-based projects help individual institutions ensure that the quality of student learning is central to their work as they evolve to meet new economic and social challenges. Information about AAC&U can be found at www.aacu.org.

AAC&U Membership 2019



*Specialized schools, state systems and agencies, and international affiliates