ARTICLE
Cultivating Diversity and Competency in STEM: Challenges and Remedies for Removing Virtual Barriers to Constructing Diverse Higher Education Communities of Success

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The need to increase the number of college graduates in Science, Technology, Engineering, and Mathematics (STEM) disciplines is a national issue. As the demographics of the United States' population grow increasingly more diverse, the recognition that students of color are disproportionately under-represented among those individuals successful at completing STEM degrees requires exigent and sustained intervention. Although a range of efforts and funding have been committed to increasing the success of under-represented minority (URM) students at primarily white, or majority, institutions, widespread progress has been slow. Simultaneously, Historically Black Colleges and Universities and Minority Serving Institutions have demonstrated disproportionate successes in graduating URM students with STEM degrees and those that proceed to completing graduate-level degrees in the sciences. The differential successes of particular institutions with promoting the achievement of diverse individuals in obtaining academic STEM degrees suggest that with committed and strategic leadership, advancements in creating academic communities that promote the success of a diverse range of students in STEM can be achieved in part through assessing and mitigating environmental barriers that impede success at majority institutions. In this paper, we address issues related to the engagement of URM students in majority settings and describe some efforts that have shown success for promoting diversity in STEM and highlight continuing issues and factors associated with cultivating diversity in academic STEM disciplines at majority institutions. Recommended efforts include addressing academic assistance, professional and cultural socialization issues and institutional environmental factors that are associated with success or lack thereof for URMs in STEM.

Key words: diversity; higher education; minority achievement; pipeline; STEM degrees; under-represented minorities (URM)

OVERVIEW
Many academic institutions continue to confront the challenges of addressing the educational and workforce needs of an increasingly diverse population. However, most struggle with identifying the appropriate strategies and/or interventions necessary to actively recruit, engage and educate students from under-represented groups. While creative and visionary leadership appears critical in these efforts, several other factors arise as common themes in successful academic models. Some of these factors include: recruitment, a critical mass of individuals from similar backgrounds or similar racial/ethnic or sociocultural origins, orientation effectiveness, environmental accommodations, mentoring, faculty buy-in, and partnerships. Achieving successful outcomes could depend on any number of these. Further, the inherent challenges associated with meeting diversity goals are correlated with perceptions of social, cultural, ethnic, as well as intellectual competencies, among others. As such, efforts to find remedy undoubtedly will require committed engagement, leadership and strategic assessment of such issues, while developing models for effectively managing environmental barriers and support systems. Here, we take a relatively broad view of this very complex issue and address issues of engagement and overcoming obstacles in majority settings. We probe the real and perceived challenges facing under-represented minorities in such settings and consider what is needed to overcome these. Whereas increasing the numbers of diverse individuals that are represented at majority institutions continues to be a major issue, there is a growing need to highlight specific issues/factors worth considering when contemplating potential remedies and approaches to increasing student diversity in academic training programs.

Diversity in the Sciences: Roles of Minority Serving Institutions and Predominantly White Institutions
Progress with increasing the numbers of students graduating in Science, Technology, Engineering and Mathematics (STEM) disciplines is slow in the United States. Whereas a national need exists to increase STEM graduates overall, the issue that the number of students of color that are successful at completing degrees in STEM is far behind the proportion of these individuals in the national population, presents an even greater challenge in terms of making the needed progress. This is especially pertinent given the changing demographics of the U.S. population. As the nation considers ways to make needed progress in increasing the number of students graduating in STEM

disciplines, there are current positive trends with students of color in STEM that need to be considered. Notably, African-American students at Historically Black Colleges and Universities (HBCUs) are more likely to major in biological or physical sciences than those at majority institutions (Fryer and Greenstone, 2010). HBCUs and Minority Serving Institutions (MSIs) also continue to produce the largest number of under-represented minority (URM) students with STEM degrees, including those continuing on to advanced education in the sciences (Clewell et al., 2010) and those that go on to earn doctorates in STEM disciplines (Stage and Hubbard, 2009). The disproportionate success of these institutions with URM students in the sciences may be due to a number of variables, including sustained, active engagement of the students, as well as the increased numbers and commitment of available mentors of color in these institutions.

The practice of comprehensive engagement of students of color may be an institutional characteristic of HBCU and MSI environments, which seem to function better for URM students than predominantly white institutions (PWIs) in terms of institutional mentoring programs and/or initiatives for promoting student success. This engagement may come in the form of increased access to faculty members in academic settings, including classes and seminars, as well as informal settings and interactions that occur outside of classes. To the contrary, significant effort and funding have been put towards increasing the success of URM students in the sciences in majority institutions, yet widespread progress has been slow.

Efforts to Improve the Pipeline of URM Students in STEM

Numerous efforts have been initiated to improve the numbers and success of students of color majoring in STEM disciplines at majority institutions. These efforts have ranged from those at the institutional level, i.e., housed at a single institution, to inter-institutional partnerships to national efforts for promoting diversity in STEM. Some of these efforts target high-achieving URM students, whereas others more broadly target URMs at different academic achievement levels.

Institution-level Efforts for Increasing Recruitment, Retention, and Achievement of URM students in STEM. A great number of programs have been developed to address the issue of promoting the success of URM students in STEM disciplines at individual PWIs, though program assessment, numbers or data have been disseminated scarcely (Koenig, 2009). For those that have been described in the literature, several are broadly directed at students of color of different academic achievement levels (Barlow and Villarejo, 2004; Dirks and Cunningham, 2006; Howard Hughes Medical Institute, 2008; Koenig, 2009), whereas others target primarily high-achieving students of color (Summers and Hrabowski, 2006; Johnson, 2007; Koenig, 2009; Maton et al., 2009).

The Biology Undergraduate Scholars Program (BUSP) at the University of California at Davis (Barlow and Villarejo, 2004), Biology Fellows Program at the University of Washington (Dirks and Cunningham, 2006) and Biology Scholars Program at the University of California, Berkeley (Koenig, 2009), are all programs broadly open to students of color that aim to promote the retention and success of these students. These programs provide academic support, financial support, mentoring, community building and promote or require student participation in research (Barlow and Villarejo, 2004; Dirks and Cunningham, 2006; Koenig, 2009). Students in these programs were reported to perform better academically, to have increased retention and have significantly improved odds of graduating than non-participants (Barlow and Villarejo, 2004; Dirks and Cunningham, 2006; Villarejo et al., 2008; Koenig, 2009). Results from a follow-up study of BUSP students at UC Davis indicated that part of the impact of student research participation on encouraging a pursuit of careers in science among BUSP participants that graduated is correlated with research participants having access to more mentors/advisors than those that did not participate in undergraduate research (Villarejo et al., 2008). Furthermore, BUSP students appear to benefit from both academic assistance, as well as programmatic attention to cultural and professional socialization (Ovink and Veazey, 2011).

The Meyerhoff Scholars Program at the University of Maryland, Baltimore County (UMBC; Summers and Hrabowski, 2006; Koenig, 2009; Maton et al., 2009) and the Minority Arts and Sciences Program at the University of Colorado, Boulder (Johnson, 2007) target high-achieving African Americans or other students of color to increase the number of under-represented students in science and engineering. Key components of such programs that result in institutional success include recruiting a reasonably sized pool of students or critical mass, encouraging a sense of community, substantial financial support, student orientation, active faculty support, and early engagement in research (Summers and Hrabowski, 2006). These programs have increased the likelihood of graduating for URM students in the sciences at these campuses (Summers and Hrabowski, 2006; Johnson, 2007; Maton et al., 2009). Furthermore, compared to similarly prepared and similarly performing students, Meyerhoff students were much more likely to enroll in graduate level STEM programs (Summers and Hrabowski, 2006; Maton et al., 2009). A related program at the graduate level was initiated at UMBC with funding from NIH through the Minority Biomedical Research Support – Initiative for Maximizing Student Diversity (MBRS-IMSD) program and is also leading to gains in the numbers of under-represented students admitted to UMBC's graduate programs (Summers and Hrabowski, 2006; Rutledge et al., 2011). The Meyerhoff MBRS-IMSD program includes a "Summer Bridge Program," which brings entering doctoral students to campus the summer prior to their first year of studies to support the building of networks and a transitional period to adapt to the graduate school environment (http://www.umbc.edu/meyerhoff/graduate/program_history_statistics.html). Whether the programmatic impact is direct and/or due to environmental changes

at the institution, the number of PhDs awarded to URMs in STEM disciplines has increased greatly since the establishment of the graduate Meyerhoff program (Rutledge et al., 2011).

Some institutions have bridge programs that bring undergraduate students to the institutions during the summer prior to their freshman year. One such program at Mount Holyoke College provides early exposure to research for incoming freshman (HHMI, 2008). Shorter versions of this summer bridge program, referred to as "boot camps," have also been initiated at some institutions, including Louisiana State University, which has a one-week program called Biology Intensive Orientation for Students (HHMI, 2008). Preliminary analysis of this program suggests that student participants in the boot camp program are retained at a rate twice as high as non-participants (HHMI, 2008).

Inter-institutional Partnerships for Increasing Diversity.
Institutional diversity partnerships are generally established on the basis of leveraging the strengths of HBCUs' success with producing a large proportion of students of color who complete degrees in STEM majors with the fiscal and infrastructure resource bases of large majority institutions. The goal is to promote the successful transition and persistence of URMs in graduate-level STEM programs. One such program, i.e., the Fisk-Vanderbilt Masters-to-PhD Bridge Program, is a joint program between Vanderbilt University and Fisk University for increasing participation of individuals from under-represented groups in the physical sciences (and recently expanding into the biophysical sciences; http://www.vanderbilt.edu/gradschool/bridge/). This program exemplifies partnership between a PWI (Vanderbilt) and a research active HBCU (Fisk) in close physical proximity. A key component of this program is the joint student mentoring from the institution where the M.S. is being completed and the institution where the Ph.D. will be pursued (Stassun et al., 2010; Stassun et al., 2011). Close collaborative activities between the two institutions allows students to transition into the PWI for doctoral level studies better prepared for the effort needed for successful completion of the doctoral program to which they are admitted (Stassun et al., 2010; Stassun et al., 2011). One of the predicted factors contributing to students' success in the doctoral programs is the early and sustained relationship with a faculty mentor in the PhD program (Stassun et al., 2010). The Fisk-Vanderbilt Masters-to-PhD Bridge Program provides sustained engagement of students and sustained mentoring, two key components contributing to students being retained in and succeeding in doctoral programs. It is suggested that these efforts likely lower transition barriers to the PWI environment for URM students. One of the significant features of the program is the extensive mentoring – peer mentoring, faculty buy-in in the form of co-mentoring (i.e., mentors at both institutions), administrative mentoring to help the students navigate the logistics and/or bureaucracy of the institutions, and at least biannual meetings with the program's steering committee to gauge student progress

(Stassun et al., 2011).

Another institutional partnership program that has been described was initiated between Indiana University School of Medicine (IUSM) initially with the HBCU, Jackson State University, and later expanded to include the Hispanic Serving Institution (HSI) California State University, Dominguez Hills (Gibau et al., 2010). This partnership program provides financial support for URMs to conduct master's level research with a mentor at the home HBCU or HSI and then to engage in a summer research experience at the majority institution (Gibau et al., 2010). This "bridging" of students was designed to allow the students to have hosts at both the home and majority institution prior to encouraging these students to apply for doctoral level studies at IUSM (Gibau et al., 2010). This partnership has resulted in a large number of the participating students entering Ph.D. programs at IUSM or elsewhere (Gibau et al., 2010). Although this program did not have the benefit of the sustained interaction between mentors afforded by the close proximity of the partnering institutions involved in the Fisk-Vanderbilt Masters-to-PhD Bridge Program described above, the introduction of the students to mentors and the majority institution environment prior to their enrolling as doctoral students was likely a critical factor for easing the transition of the URM students from an MSI environment to one of a PWI.

An additional partnership between an HBCU, Elizabeth City State University (ECSU), and a PWI, The University of New Hampshire (UNH), has also been described (Williams et al., 2011). This affiliation between geographically disparate institutions consists of reciprocal exchange of students and faculty and shared partnership principles or goals that has resulted in a number of externally funded collaborative grants (Williams et al., 2011). Although a systematic evaluation of the program has not been conducted, an enhanced recruitment of URM students at UNH has been observed (Williams et al., 2011).

National Efforts for Enhancing Diversity in STEM.
A number of national academic consortium programs that are utilized by numerous universities as a recruitment tool to promote access to education and careers in STEM for URM students have emerged. These consortia include university partners that are majority institutions and HBCU, HSI or other MSI institutions. One such program, The Leadership Alliance (http://www.theleadershipalliance.org), provides support for undergraduate research involvement and presentations at a national symposium, financial and professional development support for doctoral students and continuing professional development and mentoring support to URMs through advancement in academic environments. The National GEM consortium, i.e., National Consortium for Graduate Degrees for Minorities in Engineering and Science, Inc. (http://www. gemfellowship.org/), also seeks to promote participation and graduation of URMs at the graduate level in STEM. GEM activities include graduate level internship and fellowship programs, mentoring networks, the Future Faculty and Professionals Symposium for future and junior faculty members, and a symposium to encourage URM

undergraduates to pursue graduate level education in STEM disciplines. The National Physical Science Consortium (NPSC; www.npsc.org/) promotes the attainment of graduate degrees in the physical sciences and engineering with a specific focus on recruiting URMs. NPSC's primary activity is a graduate fellowship program. The National Action Council for Minorities in Engineering (NACME; http://www.nacme.org/) is a consortium aiming to advance the success of URM students in STEM, primarily engineering. NACME provides funding for URM students mostly in engineering, at the undergraduate and graduate levels. The Committee on Institutional Cooperation (CIC; http://www.cic.net/Home/Students/SROP/Home.aspx) sponsors a Summer Research Opportunities Program (SROP) that is intended to serve as a gateway or recruitment avenue to increase the number of URM students who pursue graduate education at CIC member institutions.

While such consortium efforts have value, these "outsourced" diversity efforts cannot and should not replace direct, institutional-driven diversity efforts. The direct links to such consortia, while apparently stacking the deck or priming the pipeline with qualified minority candidates, largely benefit the PWIs in the alliance – and minimize the need for major recruiting efforts and/or screening on the part of these institutions. The need for personalized recruitment efforts that take into account unique benefits and challenges at a particular institution in regards to recruiting, retaining and successfully graduating URM students remain critical for long-term, sustained success at a broad range of institutions.

What Benefits are Current Programs Offering to URM Students?

Science identity building and self-efficacy development, together with participation in science research programs are characteristics attributed to high-achieving students participating in diversity promotion programs as positive contributors to their goals of pursuing graduate education and a career in scientific research (Hurtado et al., 2009). However, some students from under-represented minority groups struggle because of the absence of social identity in the PWI environment due to perceived or real questions about their intellectual abilities, aptitude for scientific research, and lack of community understanding and support (Hurtado et al., 2009; Malone and Barabino, 2009; Ovink and Veazey, 2011). In a study on factors impacting the persistence of undergraduate women of color in STEM disciplines, Espinosa (2011) reported that involvement in research programs and engagement in peer discussion related to course content are among factors contributing positively to persistence in STEM. All of the programs described above address these issues to differing degrees and with differing levels of success.

Environmental Barriers to Successful Completion of STEM Degrees by URM Students at PWIs

Mismatch between students from HBCUs and the environment of PWIs (majority institutions) can impede success in science. Many URMs at PWIs are matriculating in a relatively foreign environment and thus experience large environmental transition challenges (Malone and Barabino, 2009; Gibau et al., 2010; Brown, 2011).

URM students from HBCUs often enter majority institutions to face climates that are very different from the supportive, nurturing environments generally characterized by both lower student-faculty ratios and high student-faculty interactions in which they matriculated and studied as undergraduates (Kim and Conrad, 2006). Thus, these students are virtually stuck between two environments – alternating socially and academically – and attempting to meet academic demands while struggling to find social identity. Such issues related to race and institutional climate, which has been termed "institutional inhospitality" (Elliott et al., 1996), can result in a need to ease students' transitions into an institution to improve the students' chances for success (Treisman, 1992). This is clearly not an issue related to any perceived intellectual inadequacy of the students of color, as white students likewise do not perform well in environments that are a mismatch for the ways in which they are accustomed to operating, i.e., a lower success of white students at institutions with large percentages of students of color in regards to graduation rates has been reported (Oseguera, 2006).

For students of color transitioning from HBCU or MSI campuses to majority institutions, these students often try to operate as they did in the HBCU or MSI environment, and in doing so, sometimes communicate openly and honestly in hopes of finding support. However, this can often be interpreted as communicating uncertainties and struggles that get them labeled in the eyes of some faculty members at majority institutions as individuals who are not adjusting or performing well or possibly may be incapable of adjusting or performing. At worst, their core academic or intellectual ability is questioned. The PI at the majority institution often interprets the "open communication" or "search for support" by the student as them not having the aptitude to persist and succeed in the PWI environment or in the sciences. The transitional stressors can lead to a slow start or worse yet, the student failing to succeed in the program, which may represent a major leak in the URM STEM pipeline. The recognition of these issues make it necessary to determine specific methods that can be used to ease the environmental transition for these students and to determine how to make environmental accommodations that allow successful transitions, retention and degree completion. Most programs address interventions for academic transitions (i.e., tutoring, academic support, research experiences), but little to no attention is given to interventions for "environmental transitions" or to address the barriers that contribute to the creation or development of such transition problems.

"Virtual barriers" reflect the atmosphere being created at many PWIs, e.g., those instances where the goal is solely minority "representation" without the associated intellectual credibility being ascribed to the URM students. The students that have been accepted into these institutions have been accepted because they were deemed qualified and capable. Thus, we need to address the question of

why these students are then largely not able to thrive and succeed in such majority environments. A thorough assessment should include PWIs becoming more introspective rather than finding fault externally, i.e., attributing failure to incoming student deficiencies. Such a response is characteristic of "environmental protectionist" principles and has not resulted in increased productivity or success. Despite historically limited resources to HBCUs and MSIs, they are far more successful in producing URM doctoral degrees; many of whom go on to thrive as productive professionals in majority institutions. This represents an incongruity in outcomes and suggests that there are "best practices" for URM research training that can be learned and/or adopted from the HBCUs and other MSIs.

Identifying Institutional Barriers that Impede the Progression and Success of URM Students in STEM

Hurtado et al. (1998) identified specific institutional parameters that impact the environment experienced by individuals in the academic community, including structural diversity, the psychological climate and the behavioral climate. Structural diversity is the numerical representation of different groups, which is determined by historical institutional practices of inclusion or lack thereof (Hurtado et al., 1998). Structural diversity is the most common parameter addressed in university diversity and outreach efforts (Hurtado et al., 1998; Hurtado et al., 2008; HHMI, 2008). The psychological climate largely describes how individuals making up an institution view and experience interactions among diverse groups (Hurtado et al., 1998). Individuals from different groups often experience the psychological climate of a single institution very differently (Hung et al., 2007). This dimension of institutions is less attended to in terms of evaluation and interventions. However, campus administrators, leaders, and faculty members can become "deliberate agents of socialization" (Hurtado et al., 1998, pg. 291) to impact in positive ways the psychological climate of their institutions.

Although the findings of many studies of programs for increasing diversity hint at such psychological climate issues, e.g., the extra support that comes from having a research mentor has been shown as being as important to students' success as the active research experience (Villarejo et al., 2008), little has been done to investigate this directly. Much of what is communicated to students and the programs that are supported financially focus on research and academics – i.e., getting students involved in hands on research experiences and reinforcing strong grades and test scores. Whereas these are viewed as critical components for getting admitted to and succeeding in professional or graduate programs, these are only a part of what is needed to succeed in majority environments. To succeed in these environments, in the short term, URMs need to be able to adjust to the very different learning environments or forms of support/mentoring that are available (or lacking) as compared to those to which they were accustomed, and which directly contributed to their success in completing undergraduate studies and matriculating into advanced degree programs. Furthermore, in the long term, institutions need to evaluate and adjust the cultural climates to support all of the individuals represented in the community if the goal truly is to equitably support the success of all community members (Crowley et al., 2004; Whittaker and Akers, 2009).

As students at HBCUs report higher motivation to achieve and more strongly value education (Caldwell and Obasi, 2010) and HBCUs continue to produce a large percentage of the students who go on to successfully complete PhDs (Clewell et al., 2010), we need to assess which environmental factors at these institutions result in such success with students of color in STEM. This is particularly important given that these environments do not have the same resources and infrastructure or support for infrastructure. Whether it is the environmental accommodations, support, mentoring, or other factors, we must determine which particular aspects contribute to success and determine whether they are transferable to other types of institutions to increase performance of students of color in STEM in these environments.

Institutional cultures and climates, including a dearth of diversity among faculty members, present barriers to URMs persisting in STEM disciplines and attaining degrees (National Research Council, 2011). It has been determined that institutional or environmental influences, i.e., campus specific factors, have an early impact on students' careers and directly influence whether these students complete their degrees (Padilla et al., 1997). Thus, it is imperative that we pay critical attention to transitions. There have been calls for institutions to address issues of support and inclusion, as well as institutional efforts to ease the transition of URMs during matriculation to majority research institutions (NRC, 2011). In a recent National Research Council report, areas that were identified that must be addressed in programs to increase success of URMs in STEM disciplines include the following: summer research programs and experiences, professional development, academic support and social integration and mentoring (NRC, 2011). While recent reports indicated the need to address institutional climate issues (e.g., NRC, 2011), specific institutional characteristics that must be addressed are not identified explicitly. However, many of the successful programs described or referenced above may be working in large part by lowering or removing virtual barriers to success for students of color at particular institutions. Research programs may function to offset the impact of such virtual barriers by helping students build a community, i.e., a critical mass of like-minded individuals, for support (e.g., see Byars-Winston et al., 2011; Ovink and Veazey, 2011). The community of support should encompass peer support, as well as support from the larger institutional community that would not only include the students, but also support of mentors, advisors, and institutionalized support and engagement of the institution's core leaders. One suggested path to promoting communities of success is the development of inter-institutional collaborative partnerships, such as those described above, which leverage impactful institutional factors at different

institutions for promoting the representation and performance of individuals from diverse groups (Montgomery and Montgomery, 2012). Such inter-institutional programs have been reported to provide clear paths for decreasing transitional barriers to institutions and may provide unique forums for identifying virtual barriers to successful transition and achievement of URM students at majority institutions through extensive interactions between students and faculty from different institutional types (Williams et al., 2011).

Extensive personalized faculty engagement with students adds to an institutional culture of support while maintaining high scientific standards – often not a common attribute of large, more selective institutions and yet vitally important for African-American students, in particular (Hurtado et al., 2011). At PWIs, the numbers of faculty members of color continue to be disproportionately low, particularly in STEM disciplines. Thus, the available mentors of color in these environments are extremely limited and the demands on those available to assist students of color matriculating in these institutions are high. There exists a need for these under-represented faculty members to be supported and rewarded in their efforts to engage in mentoring, to serve as role models and actively engage in outreach and recruitment activities. These faculty members often engage in such activities, but more often than not these are not rewarded in regards to efforts that count towards advancement, tenure and/or promotion. The need for institutions to provide support and recognize the time devoted by individuals to participate in these efforts in a way that is acknowledged and rewarded at the institutional level and beyond has been recognized both by individual URM faculty members (Hayes, 2010) and larger groups looking at needed interventions (Gilligan et al, 2007; Merchant and Omary, 2010; Hurtado et al., 2011).

Interventions for Reducing or Removing Institutional Barriers to Success

Some evaluations of programs that promote persistence of undergraduates in science majors have indicated that the impact is likely through altering the environment experienced by these students rather than on improvement of their academic skills (Johnson, 2007). A survey of multiple programs supports this view with program participation being associated with increased degree completed but not higher GPAs (Gándara and Maxwell-Jolly, 1999). Some assessments investigating the role of race and/or ethnicity on persistence of students of color mention institutional racism or barriers (e.g., Elliott et al., 1996), yet few look at ways to identify or ameliorate institutional barriers, while others have begun initial efforts to query issues of the environment that may impact, positively or negatively, the success of increasing and retaining a diverse pool of students (Gibau et al., 2010).

Successful navigation of academic environments generally requires a cohort for peer-to-peer exchange of practical knowledge about the institutional environment (Padilla et al., 1997). This observation supports a continuing need for promoting structural diversity at institutions. However, the need extends beyond increasing

just numerical representation of individuals from diverse groups. Padilla et al. (1997) present a model for assessing barriers in a particular university environment to facilitating individual student adjustment or institutional interventions to assist in successful transitions of students to academic training environments. They identify a range of barriers including the following: (1) discontinuity barriers, which address issues for transitioning to college environments; (2) lack-of-nurturing barriers, which can relate to limited mentoring in the academic environment or from the family or community of origin; (3) lack-of-presence barriers, which are related to structural deficits in the numbers or environmental integrations of students, staff, or faculty from under-represented groups in an academic environment; and (4) resource barriers, which are primarily related to financial deficits (Padilla et al., 1997). Applying this model to students in the sciences and for students' transitioning to graduate level studies to understand factors that impede successful adjustment of URM students, particularly those who have performed well at the undergraduate level in different academic environments, would be immensely useful.

Unlike majority students who often find "cultural continuity" between their communities of origin and the campus environment, students of color often find a discontinuity between these environments at PWIs (Padilla et al., 1997; Brown, 2011). White students, especially white males, by the virtue of the large numbers of available mentors are likely to benefit from informal interactions that arise from regular contact with mentors of similar racial/ethnic or sociocultural origins who identify with them personally and socially. In fact "cultural continuity" is a type of benefit that may be one of the continuing important roles for HBCUs and other MSIs.

Majority institutions seeking to address environmental barriers need to consider and determine how such historically assimilated benefits that arise due to histories of inclusion of some groups and exclusion of others result in unequal benefits or detriments to specific groups (Hurtado et al., 1998; Bauer-Dantoin and Ritch, 2005). In fact, many programs that have shown achievement for improving success of students of color at PWIs function by purposeful instigation of environmental parameters that may be intrinsically, or historically, integrated into institutional environments for majority students. By purposeful and sustained engagement, mentoring and environmental integration of URM students, these majority institutions are following MSI/HBCU traditions, even though not classified as such. In this regard, one program associated its success with under-represented students by the program's attention to "developing" scientists, in a sense of putting more time and resources into students who have a great desire to excel at the doctoral level in the sciences, even though their preparation was not the very top tier (Gibau et al., 2010). This type of student development has arguably been done for years for white students.

Continuing Obstacles to Increasing Diversity in STEM

Impacts of highly successful programs look at easily identifiable or quantifiable factors, including academic

supports, funding, engagement in research, graduation rates or progression to graduate programs in STEM, yet these studies cannot control easily for the impact that these successful programs have on the environment or the extent that program-related changes that occur in the environment contribute significantly to success of training and developing URM students in STEM. Some researchers have started to understand that identifying virtual barriers or environmental contributors to the success of URMs in STEM is vitally important (Crowley et al., 2004; Bauer-Dantoin and Ritch, 2005; Gibau et al., 2010; Brown, 2011; Ovink and Veazey, 2011). Increasing diversity by increasing representation without addressing virtual barriers is likely to increase transitional issues for URMs or how the environment supports or deters their success (Hurtado et al., 1998; Hurtado et al., 2008). Major areas where additional work is needed include efforts to understand the types of environmental interventions that will most positively transform institutional climates for the increasingly diverse populations of students that they serve. These efforts may include the creation of learning communities in which diverse members of the institution address the academic and social integration of URM students. It will be critical as a part of such efforts to highlight early engagement and empowerment of faculty members with the capacity to deliver quality mentoring and skill in recognizing students' challenges and problems. Some efforts aimed at increasing the efficacy of faculty mentoring for supporting the success of URM students in scientific research have emerged (Ramirez and Tonidandel, 2009; Byars-Winston et al., 2011; Wilson et al., 2012).

Effective Support Systems for URM Students

Requirements for long-term interventions in areas that impact an institutional climate or address virtual barriers include the following: (1) Institutional participation support and imaginative, proactive leadership (Hurtado et al., 1998; Hurtado et al., 2008; Maton et al., 2009); (2) Faculty participation and measures to address faculty attitudes, particularly access to minority mentors, especially for students of color who are experiencing HBCU to PWI transitions and a need for increased socialization of these students (Treisman, 1992; Hurtado et al., 1998; Hurtado et al., 2008; Gibau et al., 2010; Williams et al., 2011); (3) Development of learning communities to promote community engagement in comprehensive academic and social integration of URM students (Dodson et al., 2009; Williams et al., 2011); and (4) Studying climates to definitively identify institutional or virtual barriers (Elliott et al., 1996; Hurtado et al., 1998; Hurtado et al., 2008). All of these will require iterative evaluation/assessment and intervention to promote long-term transformation of higher education communities into equitable communities of success for all community members.

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