USC Rossier School of Education

CENTER FOR URBAN EDUCATION

Statement on
BROADENING PARTICIPATION IN STEM

Before the
HOUSE SUBCOMMITTEE ON RESEARCH AND SCIENCE EDUCATION
of the SCIENCE AND TECHNOLOGY COMMITTEE

By
Alicia C. Dowd, Ph.D.
Associate Professor and Co-Director
Center for Urban Education, Rossier School of Education
University of Southern California

March 16, 2010

Chairman Lipinski, Ranking Member Ehlers, and members of the Committee, thank you for this opportunity to inform your deliberations concerning the issues of diversity in science, technology, engineering and mathematics (STEM). I am honored to share my research findings and recommendations with you. The committee has taken up the issue of broadening diversity in STEM fields in an era of urgent need to improve the nation's infrastructure, environmental sustainability, security, and manufacturing. Currently we are experiencing a loss of talent from STEM, as each year African American, Latina and Latino, and American Indian students start their college studies as STEM majors, but then leave those fields at high rates. The National Science Foundation's (NSF) role in addressing these problems is under review. You have asked me to address, in particular, the challenges of increasing the participation of Hispanic students in STEM fields.

In this testimony, I first describe the context of higher education for Hispanic students, who attend community colleges and Hispanic Serving Institutions (HSIs) more than other students. I then discuss the value of NSF funding in two broad categories: (1) student services, academic support programs, and curricular reform; and (2) scholarships and fellowships. While recognizing the value of expanded student services and academic programming, I raise concerns that current approaches do not address the fundamental problem of the negative racial climate in STEM classrooms and programs. In conclusion, my recommendations emphasize the need for consortium based and interdisciplinary collaboration in curriculum reform, particularly in mathematics education. I also call for the adoption of more robust and comprehensive evaluation standards to evaluate the impact of NSF funding on diversity in STEM.

In making these recommendations, I draw on findings from a three-year NSF-funded study (STEP-Type 2) called *Pathways to STEM Bachelor's and Graduate Degrees for Hispanic Students and the Role of Hispanic Serving Institutions*, for which I serve as principal investigator. This study involved statistical analyses of college financing strategies and the impact of debt on graduate school enrollment; interviews with ninety faculty, administrators, and counselors at Hispanic Serving Institutions; and the development of instruments to assess institutional capacity for expanding Hispanic student participation in STEM. I also draw on my experiences as an educational researcher and methodologist, a review panel member for research

proposals submitted to the NSF and the Institute for Education Sciences (IES), and as co-director of the Center for Urban Education (CUE) at the University of Southern California. CUE's mission is to conduct socially conscious research and develop the tools needed by institutions of higher education to produce equity in student outcomes.

Hispanic Students in Higher Education and STEM[1]

Two types of institutions play a much greater role in the education of Hispanic students in comparison to students of other racial-ethnic groups: community colleges and Hispanic Serving Institutions (HSIs,) which are defined by the federal government as institutions with 25% or more Hispanic full-time equivalent student enrollment. More than half of all Hispanic college students enrolled in postsecondary education attend a community college. In 2006, the enrollment of Hispanic students in U.S. community colleges was 932,526, which compares with 903,079 Hispanic students enrolled in four-year institutions. Hispanic college students are enrolled in HSIs in such large numbers that approximately half of all Latina and Latino undergraduates enrolled in four-year universities can be found at just a fraction (10%) of four-year universities. As a result, a large proportion (40%) of the bachelor's degrees awarded to Hispanic students in all fields of study are awarded by HSIs.

In 2006-2007, 265 institutions of higher education were classified as Hispanic Serving Institutions (HSIs). Almost half of these were community colleges. The other half were divided between public and private not-for profit four-year universities (with a small number of private not-for profit two-year institutions). Hispanic students and Hispanic Serving Institutions are heavily concentrated in the Southwestern states, where over half of the HSIs are located (see Figure 1). However, several states outside the Southwest are also home to HSIs, including Florida, Illinois, and New York, and fifty-one HSIs are located in Puerto Rico. More institutions will be classified as HSIs in other states as the Hispanic population continues to grow. Although approximately 40% of the bachelor's degrees awarded to Hispanic students in all fields of study are awarded by HSIs, this proportion is lower in STEM fields. Only 20% of the

[1] For further information, data sources, and references, see *Benchmarking the Success of Latina and Latino Students in STEM to Achieve National Graduation Goals* by Alicia C. Dowd, Lindsey E. Malcom, and Estela Mara Bensimon (December, 2009, USC Center for Urban Education) and *Improving Transfer Access to STEM Bachelor's Degrees at Hispanic Serving Institutions through the America COMPETES Act* by Alicia C. Dowd, Lindsey E. Malcom, and Elsa E. Macias (forthcoming March 2010, USC Center for Urban Education).

bachelor's degrees awarded to Hispanic students in STEM fields are awarded by HSIs. Only a small percentage of Hispanic STEM baccalaureates (6.5%) earn the bachelor's degree at an HSI after having earned an associate's degree.

In her analysis of NSF's National Survey of Recent College Graduates (NSRCG)[2] for our study of Latino Pathways to STEM Degrees, Professor Lindsey Malcom of the University of California Riverside found that Latino community college transfers who first earn associate's degrees have lower access to STEM bachelor's degrees at academically selective and private universities than their counterparts who do not earn an associate's degree prior to the bachelor's. These transfer students who held associate's degrees were more likely to graduate from Hispanic Serving Institutions (32.1% with an associate's degree compared to 16.8% without one) and from public four-year institutions (83% as opposed to 62.9%). However, they were less likely to graduate from academically selective institutions (42% with an associate's degree compared to 59% without one) or from a research university (25.3% as opposed to 43.5%).

The analysis also showed differences in the fields of study in which students earned their bachelor's degrees. HSIs had greater success than non-HSIs in graduating Latinos in several STEM fields of critical importance in the workforce, particularly computer science and mathematics. However, transfer students who first earned associate's degrees were less likely to earn degrees in those fields of study at HSIs.

These figures would change if we used a different definition of transfer students (for example those who transferred after the equivalent of one year of study, or 30 credits), but they illustrate that certain pathways to STEM bachelor's degrees are not as readily accessible for students who start out in community colleges. Notably, those institutions that provide the greatest access to graduate degrees (academically selective and research universities) are least accessible to Latina and Latinos who earn associate's degrees. As a result, the proportion of STEM doctoral degrees awarded to Hispanic students (estimated at less than 5%) severely lags the proportion of Hispanics in the U.S. population (around 15%). Our study indicates that access to STEM

[2] For details, see Malcom, L. E. (2008). *Accumulating (dis)Advantage? Institutional and financial aid pathways of Latino STEM baccalaureates.* Unpublished dissertation, University of Southern California, Los Angeles. CA.

bachelor's and graduate professions can be expanded for Hispanic students by improving access to STEM bachelor's and graduate degrees through transfer from community colleges.

Expanded transfer access is necessary because although Hispanic participation in STEM fields has risen, it has not kept pace with Hispanic population growth. Growth in the number of bachelor's degrees awarded to Hispanic students has occurred primarily in non-science and engineering fields. From 1998 to 2007, there was a 64% increase in the number of non-science and engineering bachelor's degrees awarded to Hispanic students, as compared to an increase of only 50% in science and engineering degrees awarded to Hispanic students.

Furthermore, most of that 50% growth occurred primarily in the social sciences and psychology rather than in the biological sciences, engineering, computer sciences, and other fields categorized as STEM fields. The lower participation of Hispanic students in STEM is not due to lack of interest. A recent report by UCLA's Higher Education Research Institute demonstrates that Hispanic students enter college with the same aspirations to earn STEM degrees as students of other racial-ethnic backgrounds.[3]

Although the number of STEM bachelor's degrees awarded to Hispanic students grew over the past decade, the rate of growth in the number of STEM degrees awarded at other levels (associate's, master's and doctoral) was quite flat. Approximately 6,000 associate's degrees were awarded to Hispanics in science and engineering fields in 2007, a relatively low number given the large population of Hispanics enrolled in community colleges. These figures reflect the fact that many community college students from all racial-ethnic groups are placed in remedial mathematics classes at community colleges. There is considerable variation by state, but it is not uncommon for the rate of remedial placement to be as high as 50% at community colleges and in some colleges that figure can reach as high as 90%. Remedial instruction in mathematics is also common at the four-year level, but the rates of remedial placement are lower, nearer to 20% or 30%. Improving teaching and learning in mathematics instruction is therefore a high priority for increasing the numbers of STEM degrees awarded to Hispanic students.

[3] Hurtado, S., Pryor, J., Tran, S., Blake, L.P., DeAngelo, L., & Aragon, M. (2010). *Degrees of Success: Bachelor's Degree Completion Rates among Initial STEM Majors*. Los Angeles, CA: Higher Education Research Institute, UCLA.

National Science Foundation (NSF) Support for Diversity in STEM

Student Services, Academic Support Programs, and Curricular Reform

NSF currently funds special programs at community colleges and four-year institutions that aim to increase the number of students earning STEM degrees by providing enhanced student services and academic advising. Typical strategies focus on recruitment, orientation, faculty and peer mentoring, and intrusive advising to inform students if they are running into trouble academically or to guide them in making good academic choices. These strategies are primarily designed to reduce the difficulties of navigating college by providing students with information and extra support. Other programs go farther by offering learning experiences designed to better engage students in scientific study, such as through intensive summer research programs, learning communities, and supplemental instruction. A subset of the student services and academic support programs place a particular emphasis on increasing the numbers of students from underrepresented racial-ethnic groups in STEM.

The value of these special programs is supported by research that indicates such approaches are "best practices" for keeping students in college. However, the most common program designs implemented by NSF grantees are not informed by studies of the racial climate of STEM classrooms and programs. Recent research documents that racial stigma and discrimination create significant barriers to the participation of underrepresented racial-ethnic groups in STEM. A sampling of recent studies and reports illustrates this point:

- A literature review issued in 2009 documenting the "Talent Crisis in Science and Engineering" points to "traditions and stereotypes" that create low expectations, bias, and race discrimination as a primary cause of the loss of talent in STEM fields.[4]
- A book published in 2009 titled "Standing on the Outside Looking In: Underrepresented Students' Experiences in Advanced Degree Programs" captures the experiences of African American, Latina, and Latino graduate students of color. It documents hostile learning environments and experiences of marginalization and exclusion based on race

[4] Sevo, R. (2009). The talent crisis in science and engineering. Retrieved February 1, 2009, from SWE-AWE: http://www.engr.psu.edu/AWE/ARPResources.aspx

and ethnicity, class, gender, and language among students of color in STEM fields and Latinas in doctoral and professional programs in the health sciences.[5]

- A report issued in 2010 on "Diversifying the STEM Pipeline: The Model Replication Institutions Program" raises concern about the lack of "buy in" among faculty and senior leadership at participating campuses towards the goal of increasing access and success in STEM education for minority and low-income students.[6]
- A research article published in 2009 emphasizes that African American students participate in mathematics education with an acute awareness of the dynamics of race and racism in their lives. Successful students embrace a mathematics identity and an identity as African Americans, but this often comes only through a great deal of struggle and perseverance.[7]

Programs that do not address the fundamental problem of the negative racial climate in STEM fields are, therefore, unlikely to have a substantial impact to increase diversity.

There is a second problem that limits the potential of such interventions. They are not primarily designed to transform STEM education at its heart: in the classroom and the core curriculum. They tend to be program based and therefore seldom bridge the boundaries of different disciplines and types of institutions. There is a risk that the improvements in mentoring, advising, supplemental instruction, and laboratory instruction that may be brought about by the special programs that have been funded will remain on the periphery and not have a broader impact on STEM education.

Through the case study component of the USC Center for Urban Education's (CUE) study of Latino Pathways to STEM Degrees, researchers under the leadership of Professor Estela Mara Bensimon, co-director of CUE and co-principal investigator of this NSF-funded study,

[5] Gasman, M., Perna, L. W., Yoon, S., Drezner, N. D., Lundy-Wagner, V., Bose, E., et al. (2009). The path to graduate school in science and engineering for underrepresented students of color (pp. 63-81) and González, J. C. (2009) Latinas in doctoral and professional programs: Similarities and differences in support systems and challenges. In M. F. Howard-Hamilton, C. L. Morelon-Quainoo, S. M. Johnson, R. Winkle-Wagner & L. Santiague (Eds.), *Standing on the outside looking in: Underrepresented students' experiences in advanced degree programs* (pp. 103-123).

[6] *Diversifying the STEM pipeline: the Model Replication Institutions Program* (n.d.). Washington, D.C.: Institute for Higher Education Policy (IHEP).

[7] Martin, D. B. (2009). Researching race in mathematics. *Teachers College Record*, *111*(2), 295-338.

interviewed ninety faculty, administrators, and counselors at three universities and three community colleges, all of which were Hispanic Serving Institutions. Many of these individuals were employed by or affiliated with NSF-funded programs designed to improve diversity in STEM fields. These respondents often described and shared data with us showing programs intensively focused on a small number of Hispanic students relative to the entire Hispanic student body. As often as not, those we interviewed worked in isolation and were not part of robust networks of faculty and administrators engaged in changing the STEM curriculum. For some the isolated nature of the work led to a sense that the goal of improving Hispanic student participation and degree completion in STEM fields was not supported by the college leadership. These results led us to question whether interventions through special programs can be adequate to the task of substantially increasing the number of Hispanic students being awarded STEM degrees.

This committee has already heard testimony on February 4, 2010 from Dean Karen Klomparens of Michigan State University and Professor Robert Mathieu of the University of Wisconsin at Madison regarding the importance of creating active learning in STEM education and providing faculty with the know-how (through professional development) to bring about active learning. I endorse their testimony and note that in regard to diversity issues in STEM, active learning and "real world" problem-solving approaches hold promise to reduce the sense of alienation of underrepresented racial-ethnic groups too often experience in STEM fields. Studies show that students of color value the opportunity to serve communities and address social problems through their college coursework.

However, as important as active learning and real world problem solving is, even this solution is not sufficient in and of itself to substantially improve diversity in STEM fields. Active learning can be incorporated without attention to the root problem of the racial discrimination, stigma, and alienation experienced by underrepresented students in STEM fields. NSF has played an important role in supporting experimentation in the STEM curriculum. Future funding will be valuably invested by ensuring that curricular innovation and reform occurs in the core curriculum and with the majority of faculty members involved. Such initiatives will also need to

directly engage and be designed to tackle the problems of racial discrimination experienced by too many students who then depart STEM.

Scholarships and Fellowships

Current NSF funding invests considerably in research and graduate fellowships for undergraduate and graduate students, including students from underrepresented racial-ethnic groups, in STEM fields. Many studies indicate that targeted financial aid is extremely important and that grants of this type improve students' persistence and degree completion in college. Scholarships and fellowships also reduce students' need to borrow for postsecondary education at the undergraduate and graduate level.

This is of particular importance when we consider diversity in STEM because debt can have a more negative impact on underrepresented students. An analysis by Professor Lindsey Malcom of the University of California Riverside of NSF's National Survey of Recent College Graduates (NSRCG), conducted as part of the CUE's study of Hispanic student pathways to STEM degrees, found that cumulative undergraduate debt among STEM bachelor's degree holders (measured in relative terms in comparison with the typical amount of debt at the graduate's institution) had a more negative effect on graduate school enrollment right after college among Hispanic STEM baccalaureates than among students of other racial-ethnic backgrounds. We do not interpret these findings as a sign of risk aversion among Hispanic students, as some analysts have inferred, because the Hispanic STEM bachelor's degree holders in the study tended to have a higher amount of debt than the typical graduate in their graduating class. The findings suggest a reluctance to incur more debt for graduate or professional study, which is a typical financing pattern except for those students who receive graduate fellowships. They illustrate the importance of scholarships and fellowships in improving Hispanic student participation in STEM fields and professions. They also provide support for policies that offer student loan forgiveness to students who work in socially valued professions such as mathematics education and clinical health care.

Recommendations

Summary

Through NSF funding, we have made valuable investments in the development of student services and academic support programs to help students navigate the complexities of college and the STEM curriculum. However, a broader strategy is required to reduce the negative campus climates experienced by Hispanic students and other racial-ethnic minorities. This is because stereotypes of underrepresented students—representing them as unable to succeed or disinterested in STEM—are pervasive in society, schools, and postsecondary education. The "treatment" of special programs in relation to the overall problem is insufficient because they tend to take place at the margins rather than the core of higher education.

This is not to say that special advising and student services programs are not part of the necessary remedy—they are. The work in this area has identified workable strategies for providing students with additional information, support, and direction. However, the next generation of studies and experimental programs must explore models of even more fundamental organizational change in terms of curriculum design, assessment of student learning, and faculty and administrator rewards.

Areas for Future NSF Support

The area in greatest need of pedagogical innovation is remedial and basic skills mathematics instruction. Community college students in particular must experience success in mathematics to gain the competencies needed to earn degrees in biological, agricultural and environmental sciences, and in engineering, which are fields with limited transfer access for transfer students who earn their bachelor's degrees at HSIs.

To encourage diversity and active learning in STEM, we must invest in bold experiments in curriculum and pedagogical reform that are informed by the principles of culturally responsive pedagogy. Priority should be given to initiatives that include a focus on integrating mathematics education in real world problem solving. These experiments should involve people from multiple scientific, social science, and educational research disciplines. As well as being interdisciplinary, they should be "intersectoral," bringing faculty, administrators and counselors

from different types of institutions into close collaboration. **Consortia involving community colleges, four-year comprehensive institutions, and research universities in regional service areas are needed to improve transfer access for Hispanic students from community colleges to STEM bachelor's and graduate degrees.**

Few observers of American politics and society would disagree that racial issues are among the thorniest in the U.S. Yet, to broaden participation among racial-ethnic groups underrepresented in STEM requires attention to the underlying racial dynamics of STEM education. We cannot fix problems of diversity without acknowledging the problems of racial marginalization and stigma and stating the intent to fix them. Toward that end, a body of research knowledge has emerged that provides concrete and practical steps faculty can take to introduce culturally responsive pedagogies in classrooms and other instructional settings.

A powerful tool for shaping the objectives and methods adopted by recipients of NSF funds is the Program Solicitation (or request for proposals.) A valuable first step in broadening participation in STEM fields would be to convene a panel of experts in culturally responsive pedagogy alongside scientists and social scientists to develop the language for a program solicitation. Their charge would be to write **a Program Solicitation that makes the study of the racial dynamics of instructional environments in STEM a central component of curriculum and pedagogical reform.**

The criteria for award decisions should also support the mission focus of proposals from HSIs that propose specifically to develop the Hispanic *serving* capacity of their institution (and similarly the mission focus of historically black colleges and universities and tribal colleges). This can be indicated by staffing, hiring, professional development, and evaluation criteria that involve a critical mass of Hispanic faculty and administrators in program implementation and a large proportion of Hispanic students on a campus (or located in institutional service areas) in program participation.

Evaluation

Campuses will be able to achieve more widespread involvement in STEM reform by engaging STEM faculty at the department and college levels in self-assessment of their educational practices and beliefs regarding the causes of student success and lack of success. Reflective practices are needed to comprehend the complexities underlying student experiences of racial stigma and discrimination.

The methods of benchmarking can be used to create a more comprehensive evaluation system that measures program effectiveness and cost-effectiveness, student outcomes, faculty development, and changes in organizational policies. There are three valuable strategies, which are called performance, diagnostic, and process benchmarking.[8] Each has a different application and can be used together for a more robust measurement and implementation design:

- **Performance benchmarking** is used to establish baseline performance and to set and evaluate progress towards improvements in student transfer and degree completion.
    - Data collected at the program proposal stage should demonstrate the capacity to observe the progress of cohorts of students at key curricular milestones and transitions and to disaggregate data by racial-ethnic groups.
    - Data collected for program evaluation should compare the progress of students enrolled in the program or affected by the initiative in comparison to a group that was not involved.
- **Diagnostic benchmarking** involves assessing one's own campuses practices against established standards of effective practice, as documented in the research and professional literature.
    - The principles of culturally responsive pedagogy provide standards for diagnostic benchmarking for curriculum and instruction.

[8] For further information, see Dowd, A. C., & Tong, V. P. (2007). Accountability, assessment, and the scholarship of "best practice." In J. C. Smart (Ed.), *Handbook of Higher Education* (Vol. 22, pp. 57-119): Springer Publishing.

    - The sociological concept of "institutional agents," as developed by the sociologist Ricardo Stanton Salazar[9] and applied in the context of STEM postsecondary education in collaboration with researchers at the Center for Urban Education, provides diagnostic standards for administration, counseling, and mentoring specifically designed to provide support to students from racial-ethnic minority groups.
- **Process benchmarking** involves closely investigating the changes in organizational policies, procedures, and practices that are needed to implement effective practices in a particular campus context with fidelity.
    - Self-assessment instruments have been developed by the Center for Urban Education[10] and other organizations to assist campuses in observing the racial-ethnic dimensions of instructional and administrative practices. The outcome of process benchmarking is data-informed decision making for ensuring program effectiveness.
    - **Process benchmarking is particularly valuable when it is carried out within consortia where trust develops over time so that participating campuses become willing to share their data and engage collaborators in problem solving.** Strategies that are effective at one campus may not work at all on another because of differences in resources, personnel, and institutional culture, so the capacity for data-informed problem solving is necessary.

Campuses will benefit from resources to develop their evaluation capacity prior to implementing large-scale programmatic or curricular reform. One valuable way to acquire this capacity is by serving as a peer evaluator to a partnering institution in a peer group.

[9] Stanton-Salazar, R. D. (2001). *Manufacturing hope and despair : the school and kin support networks of U.S.-Mexican youth*. New York: Teachers College Press.

[10] See Bensimon, E. M., Polkinghorne, D. E., Bauman, G. L., & Vallejo, E. (2004). Doing research that makes a difference. *Journal of Higher Education, 75*(1), 104-126; and Dowd, A. C. (2008). The community college as gateway and gatekeeper: Moving beyond the access "saga" to outcome equity. *Harvard Educational Review, 77*(4), 407-419.

By using these three types of benchmarking procedures, campuses can evaluate instructional effectiveness in producing greater diversity in STEM and increasing the number of Hispanic students who are awarded STEM degrees. In sum, these are strategies for organizational learning, professional development, and pedagogical innovation. **For too long, our approach to improving diversity in STEM has been overly focused on the "demand" side of the problem, on "fixing" presumed student deficits through attempts to improve their aspirations, motivation, or willingness to succeed. In contrast, these recommendations focus on fixing the "supply" side of the problem by improving the quality of STEM education.** Research conducted at the Center for Urban Education demonstrates that the most important starting point for broadening participation in STEM is to reframe the lack of diversity as problems of institutional practices and practitioner knowledge,[11] which unwittingly create a negative racial climate harmful to students from racial-ethnic minority groups.

[11] See Bensimon, E. M. (2007). The underestimated significance of practitioner knowledge in the scholarship of student success. *The Review of Higher Education, 30*(4), 441-469; and Bensimon, E. M., Rueda, R., Dowd, A. C., & Harris III, F. (2007). Accountability, equity, and practitioner learning and change. *Metropolitan, 18*(3), 28-45.

Figure 1 Hispanic Serving Institutions by State, 2006-2007