POLICY FORUM

SCIENCE EDUCATION

Replicating Meyerhoff for inclusive excellence in STEM

Undergraduate diversity is fostered across many contexts

By **Mariano R. Sto. Domingo[1], Starlette Sharp[2,3], Amy Freeman[2], Thomas Freeman Jr.[4], Keith Harmon[5], Mitsue Wiggs[5], Viji Sathy[6,7], Abigail T. Panter[6,7], Leticia Oseguera[8], Shuyan Sun[1], Mary Elizabeth Williams[9], Joseph Templeton[10,11], Carol L. Folt[12], Eric J. Barron[13], Freeman A. Hrabowski III[14], Kenneth I. Maton[1], Michael Crimmins[11], Charles R. Fisher[9], Michael F. Summers[15,16]**

Ethnic minorities comprise rapidly growing portions of the populations of most developed countries (*1*) but are underrepresented in fields of science, technology, engineering, and mathematics (STEM) (*2*, *3*). Efforts to increase diversity in the STEM workforce, important for developing more effective approaches to group problem-solving (*4*–*6*), have been under way in the United States for decades, but widespread impact remains relatively low (*3*). The Meyerhoff Scholars Program (MYS) at the University of Maryland, Baltimore County (UMBC), provides a promising model for increasing retention and academic performance of underrepresented minority (URM) undergraduates in STEM and for preparing those undergraduates to pursue and succeed in graduate and professional programs (*7*, *8*). Although MYS is nearly 30 years old and outcomes for African-American STEM majors have been extensively documented [see (*7*, *8*) and references therein], no other majority university [not meeting the definition of being a minority-serving institution (MSI) (*9*)] has achieved similar outcomes (*10*). We describe here some promising early indicators that an interinstitutional partnership approach can help enable MYS-like outcomes at majority universities with different URM compositions, geographies, and institutional sizes and cultures: The University of North Carolina at Chapel Hill (UNC) and Pennsylvania State University at University Park (PSU).

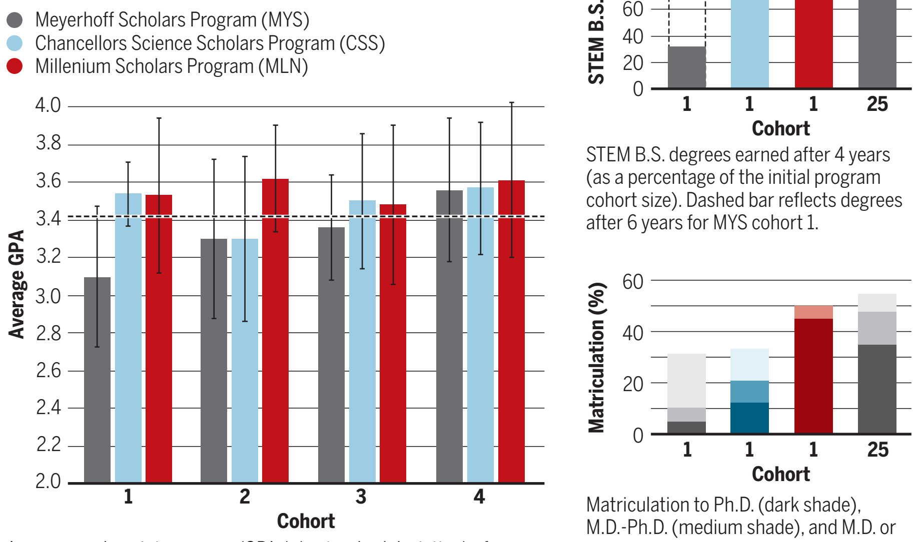
MYS includes students of all ethnicities and backgrounds who are interested in issues of diversity and inclusion in STEM. Since its inception (1989 through summer 2018), 70.8% of the 1490 STEM undergraduates who enrolled in MYS have been URM. Most of the 879 URMs from the first 26 cohorts were retained in the program through graduation and earned science or engineering bachelor's (B.S.) degrees (739 students, 84.1%), and most of these graduates (560 students, 75.8%) matriculated to graduate or professional programs (47.7% Ph.D., 13.9% M.D.-Ph.D., 19.1% master's, and 19.3% medical or other professional programs). Qualified students [selection metrics included high-school grade point averages (GPAs), standardized college entrance exam scores (SAT), prior research experience, expressed interest in research careers in STEM, and interviews with faculty, staff, and students, among others] who declined MYS offers and attended other universities were half as likely to graduate with a STEM degree and approximately five times less likely to pursue or complete STEM graduate degrees (*8*, *11*). UMBC is the top undergraduate school of origin of African-American M.D.-Ph.D. recipients in the United States and the second-ranked school of origin of African-American STEM Ph.D. recipients (behind Howard University, an MSI) (*12*).

PARTNERING INSTITUTIONS

UMBC is a medium-sized High Research (Carnegie classification) university with a diverse student body (~11,000 undergraduates: 17.2% African American, 7.1% Hispanic, and 29.0% total URM; ~2500 graduate students) and a long-standing African-American president. PSU and UNC are Carnegie Very High Research universities with historically non-URM leadership. UNC has a larger, but less diverse, student body (~19,000 undergraduates: 7.9% African American, 7.2% Hispanic, and 15.6% total URM; ~8500 graduate students). From 2002 to 2011, UNC produced an average of 99 graduates per year who went on to earn STEM Ph.D. degrees, of whom six per year, on average, were African American (*10*). PSU is geographically more isolated and has a much larger and even less diverse student body (~41,000 undergraduates: 4.7% African American, 6.8% Hispanic, and <15% total URM; ~14,500 graduate students). Although PSU was among the top five U.S. schools of origin of B.S. undergraduates who earned STEM Ph.D. degrees from 2002 to 2011 (averaging 193 Ph.D. degrees per year), only four of these individuals per year, on average, were African American (*10*). There was a prevailing sense among some leadership that the institution was too isolated, homogeneous, and underprepared for a MYS-like program to be effective. Despite their low numbers, UNC and PSU ranked

Comparisons with Meyerhoff

Different institutional contexts exhibit some similar trends.



Average grade point averages (GPAs) (± standard deviation) of STEM-retained cohorts. Dashed line indicates MYS 26-year average.

STEM B.S. degrees earned after 4 years (as a percentage of the initial program cohort size). Dashed bar reflects degrees after 6 years for MYS cohort 1.

Matriculation to Ph.D. (dark shade), M.D.-Ph.D. (medium shade), and M.D. or professional programs (light shade) (as a percentage of the entering cohort).

GRAPHIC: A. KITTERMAN/SCIENCE

among the top 20 majority schools of origin of African-American B.S. recipients who went on to earn STEM Ph.D. degrees (*10*).

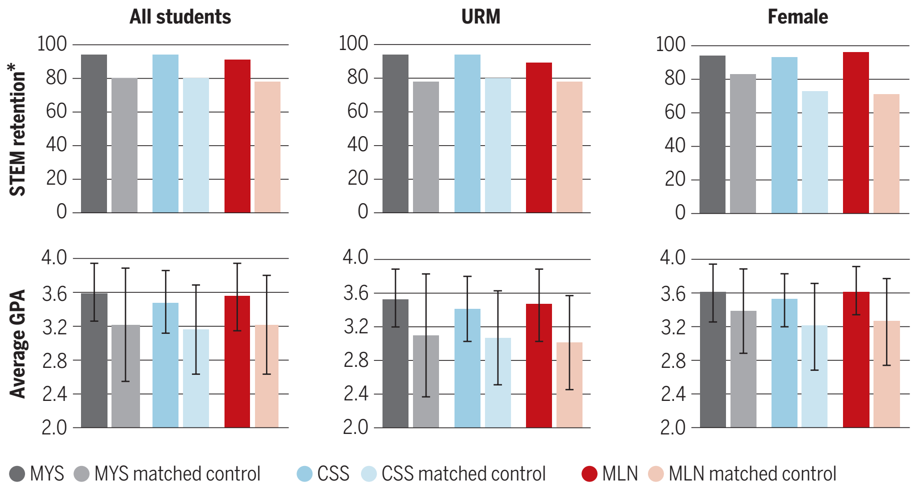
PARTNERSHIP ACTIVITIES

Initial historical assessments of institutional STEM student demographics, academic performance, and retention at PSU and UNC identified disparities for minority students and were critical drivers for broadening support and instituting new programs: The Millennium Scholars Program (MLN) at PSU and the Chancellors Science Scholars Program (CSS) at UNC. Both were designed to replicate or closely adapt all major components of the Meyerhoff program, including (i) establishment of key administrators and senior faculty as program champions; (ii) allocation of space and funding for staff, scholarships, activities, and assessment; (iii) recruitment of diverse staff who can serve as effective mentors and bridge cultural divides; (iv) targeted student recruitment and selection activities; (v) cohort building, including intensive prematriculation summer education and mentoring activities (summer bridge); (vi) early placement in research labs and summer internships; (vii) intensive academic advising and counseling; (viii) community service; and (ix) regular summative and formative program evaluations. Like MYS, MLN and CSS are strength-based programs that include students interested in URM issues in STEM regardless of gender, ethnicity, or background.

Student applicants to all three programs were selected on the basis of academic merit, STEM research and social justice interests, and prematriculation interviews. Some component details varied slightly, owing to differences in resources, campus cultures, and degree offerings, but in all cases, the variations were designed to maintain intended component outcomes. Examples include differences among academic requirements for program admission and retention (GPA requirements ranging from 3.2 to 3.5 among programs), on-campus housing requirements (ranging from freshman and sophomore only to 4 years of required on-campus housing), and approaches to social justice education (a component of cohort-building and mentoring; activities included differing combinations of seminars, workshops, coursework, and/or student debates). Some components evolved over time; for example, the early MYS cohorts (including cohorts 1 to 4) received full tuition and housing support, whereas more recent cohorts (including cohorts 25 to 28) received tiered awards based on academic merit. MLN scholars received full tuition and housing support, and CSS scholars received partial tuition and housing support.

Programs' impacts on student outcomes

Average STEM retention rates and average GPAs (± standard deviation) of MLN and CSS cohorts 1 to 4 and MYS cohorts 23 to 26, compared with demographically, academically, and interest-matched institutional noncohort control groups. Outcomes are shown for all students, underrepresented minorities (URMs), and females.



*Retention is defined as the number of STEM-retained students divided by the initial size of the program cohort or nonprogram control group.

The partnership included several weeks of faculty and staff training at UMBC, with additional training at UNC and PSU. MLN and CSS faculty and staff were embedded in portions of the MYS student selection and summer bridge events at UMBC. Staff also met biweekly by video conference to discuss programmatic issues, evaluation team members met monthly to develop and implement evaluation plans, and faculty leadership met regularly by phone and in person to address administrative goals. Summer retreats were held that involved participants from all three campuses. The Howard Hughes Medical Institute hosted annual staff and leadership meetings, and an external advisory board comprising experts in inclusive practices participated in local institutional events aimed at raising awareness.

STUDENT OUTCOMES

Most program students on all three campuses majored in biology, chemistry, computer science, mathematics, physics, statistics, or a combination of these areas. MLN and MYS included more engineering majors than CSS (35, 27, and 4%, respectively; see tables S1 to S5), and MYS and CSS included a small number of students in other STEM-intensive majors (psychology and neuroscience, geological sciences, and interdisciplinary STEM studies) (14 and 22.5%, respectively).

Comparisons with Meyerhoff

Initial cohort sizes and growth closely paralleled those of MYS cohorts 1 to 4, and minority participation in CSS and MLN grew from ~65% (cohort 1) to ~80% (cohort 4), which exceeds present-day MYS URM participation (~72% for cohorts 25 to 28; see fig. S1B) [throughout this paper, statistical significance was established by Student's t tests and chi-square test analyses, as appropriate, with $P < 0.05$ as the threshold; see figure captions and supplementary material (SM) for statistics and other details]. STEM retention rates of the CSS and MLN cohorts were also similar to those of MYS (fig. S1 and tables S6 and S7). Notably, the average GPAs of the first MLN and CSS cohorts significantly exceeded that of MYS (see the first figure, top; MYS versus MLN: $t = 3.8$, $P < 0.001$; MYS versus CSS: $t = 4.57$, $P < 0.001$), and the 4-year STEM graduation rates for the first CSS and MLN cohorts (67 and 80%, respectively) also exceeded that of MYS cohort 1 (31%) (MYS versus MLN: $\chi^2 = 7.4$, $P < 0.05$;

GRAPHIC: A. KITTERMAN/*SCIENCE*

[1]Department of Psychology, University of Maryland, Baltimore County (UMBC), 1000 Hilltop Circle, Baltimore, MD 21250, USA. [2]Millennium Scholars Program, Pennsylvania State University (PSU), University Park, PA 16802, USA. [3]Department of Curriculum and Instruction, PSU, University Park, PA 16802, USA. [4]Chancellor's Science Scholars Program, University of North Carolina, Chapel Hill (UNC), Chapel Hill, NC 27559, USA. [5]Meyerhoff Scholars Program, UMBC, 1000 Hilltop Circle, Baltimore, MD 21250, USA. [6]Department of Psychology and Neuroscience, UNC, Chapel Hill, NC 27559, USA. [7]Office of Undergraduate Education, College of Arts and Sciences, UNC, Chapel Hill, NC 27559, USA. [8]Department of Education Policy Studies, PSU, University Park, PA 16802, USA. [9]Office of the Dean of Science, PSU, University Park, PA 16802, USA. [10]Office of the Chancellor, UNC, Chapel Hill, NC 27559, USA. [11]Department of Chemistry, UNC, Chapel Hill, NC 27559, USA. [12]Department of Biology, UNC, Chapel Hill, NC 27559, USA. [13]Office of the President, PSU, University Park, PA 16802, USA. [14]Office of the President, UMBC, 1000 Hilltop Circle, Baltimore, MD 21250, USA. [15]Department of Chemistry and Biochemistry, UMBC, 1000 Hilltop Circle, Baltimore, MD 21250, USA. [16]Howard Hughes Medical Institute, UMBC, 1000 Hilltop Circle, Baltimore, MD 21250, USA. Email: summers@umbc.edu

MYS versus CSS: $\chi^2 = 3.9$, $P < 0.05$) and were similar to present-day MYS 4-year graduation rates (72%) (see the first figure, bottom left). Furthermore, the percentage of CSS cohort 1 students who matriculated to Ph.D. and M.D.-Ph.D. programs after 4 years (21%) compares favorably with that of MYS cohort 1 (10%) ($\chi^2 = 0.24$, $P = 0.62$), and MLN cohort 1 matriculation outcomes (50% to Ph.D. or M.D.-Ph.D. programs) greatly exceeded those of MYS cohort 1 ($\chi^2 = 5.39$, $P < 0.05$) and were similar to present-day outcomes (48%) (see the first figure, bottom right). This reflects a key advantage of the partnership. At the time MYS was initiated, UMBC had a poor history of URM performance in STEM—only one African-American UMBC graduate had earned a STEM Ph.D. in the 25-year history of the university, and black students held sit-ins to protest perceptions of racism. It took several years to test and implement MYS activities and to achieve broader faculty buy in. By contrast, lessons learned at UMBC were immediately implemented at UNC and PSU, and the MYS performance history stimulated early faculty and administrative buy in.

Comparisons with institutionally matched control groups

To further test program efficacies, MYS, MLN, and CSS student outcomes were compared with institutionally matched nonprogram student samples identified on the basis of similar ethnicity, gender, academic interest, and entering academic credentials (high school GPA and SAT scores; see SM for details). In all cases, average cohort STEM retention (91 to 94%) and average cohort GPA for STEM-retained students (3.48 to 3.59) were substantially greater for program participants regardless of URM or gender status (noncohort retention = 78 to 80%, GPA = 3.15 to 3.22; retention statistics: $\chi^2 = 8.7$ to 23.3, $P < 0.01$; GPA statistics: $t > 5.7$, $P < 0.001$; table S8) (see the second figure). URM program participants exhibited a substantial GPA benefit (~3.45 versus ~3.05 for matched noncohort URM students; $t > 4.6$, $P < 0.001$), and GPAs of female program participants (~3.55) were also considerably higher than those of female nonparticipants (~3.28) ($t > 4.5$, $P < 0.001$ for all comparisons) (see the second figure).

KEYS TO SUCCESS

Partnership activities and efficacy were evaluated on the basis of confidential interviews with university administrators, faculty, and program staff (see SM). The following factors were considered most important for program success:

1. **Commitment to the entire MYS model**
   MYS student surveys indicate that some programmatic components are foundational for all students (for example, summer bridge and community building), whereas others differentially affect students, apparently owing to differences in background, culture, and preparation (*11, 13*). To ensure broadest impact, all MYS elements were replicated or closely adapted by MLN and CSS.

2. **Sufficient and sustained administrative support**
   MLN and CSS programs were initiated with considerable institutional resources ($0.5 million year 1 state and institutional funding) that expanded to $2.0 million (UNC) and $2.6 million (PSU) by year 4, both exceeding present-day MYS state and institutional expenditures ($1.5 million). (MYS relies more heavily on grants and contracts.) (see fig. S2). MLN and CSS were made explicit Capital Campaign targets in 2017, leading to endowments of $7.1 million and $15.5 million, respectively, after only 2 years of fundraising. Notably, upon upper-administrative turnover, both institutions recruited new leaders (including a new chancellor at UNC and president at PSU) who expanded programmatic support. These activities conveyed strong campus-wide messages that inclusive excellence is an institutional priority—not only of on-campus leadership but also of the governing boards that provide institutional oversight.

3. **Recruitment of full-time program staff**
   Early traction was critically dependent on the ability of the program director to develop and maintain strong relationships with a range of constituents, including administrators, potential donors, faculty, parents, students, and partnering colleagues. Staff were empowered by direct access to the upper administration. Students benefited from program staff with similar experiences navigating issues of ethnicity and culture.

4. **Immersive up-front interinstitutional training and sustained guidance**
   Faculty and staff on both campuses indicated that training at UMBC was critical for understanding and developing MYS-like student activities and mentoring approaches. Biweekly staff meetings provided guidance and technical support and helped MLN and CCS staff respond to student and programmatic needs.

5. **Breadth of faculty participation**
   Faculty leadership across participating departments and colleges on both campuses played important roles in developing and championing the programs. Faculty were integrated in a wide range of programmatic activities, including student recruitment, summer bridge, fundraising efforts, program administration, and workshops to raise awareness about ethnicity and gender issues in STEM. They engaged students in early (year 1) and sustained research experiences and explored pedagogical practices that appear to differentially affect URM learning and academic performance (*14*).

CONCLUSIONS

We have shown that MYS can be adopted at institutions that are much different from UMBC, with outcomes immediately matching or exceeding MYS. Future assessments will determine if retention and performance of nonprogram URMs improve at UNC and PSU as institutional climate and expectations evolve, as occurred at UMBC (*7*). Stimulated by these outcomes, new parterships with the University of California, Berkeley, and the University of California, San Diego, have been initiated to assess the feasibility of long-distance interinstitutional mentoring, and mechanisms to support additional partnerships are being explored.

Strategies for improving URM persistence in different settings and among students with different levels of preparation have been described (*15*). Approaches that leverage lessons learned from successful programs with immersive interinstitutional partnering could serve as a general paradigm for expanding inclusive excellence in STEM. ■

REFERENCES AND NOTES

1. D. A. Coleman, *Popul. Dev. Rev.* **35**, 449 (2009).
2. Danish Technological Institute, "Does the EU need more STEM graduates?" Final report (European Commission, Brussels, 2015).
3. H. A. Valantine, F. S. Collins, *Proc. Natl. Acad. Sci. U.S.A.* **112**, 12240 (2015).
4. A. W. Woolley *et al.*, *Science* **330**, 686 (2010).
5. L. Hong, S. E. Page, *Proc. Natl. Acad. Sci. U.S.A.* **101**, 16385 (2004).
6. R. B. Freeman, W. Huang, *Nature* **513**, 305 (2014).
7. M. F. Summers, F. A. Hrabowski III, *Science* **311**, 1870 (2006).
8. K. I. Maton *et al.*, *CBE Life Sci. Educ.* **15**, ar48 (2016).
9. See https://www2.ed.gov/about/offices/list/ocr/edlite-minorityinst.html.
10. National Science Foundation (NSF), "2014 survey of earned doctorates" (NSF InfoBrief 13-323, NSF, Washington, DC, 2016), tables 6 and 8.
11. K. I. Maton, S. A. Pollard, T. V. McDougall Weise, F. A. Hrabowski, *Mt. Sinai J. Med.* **79**, 610 (2012).
12. F. A. Hrabowski III, P. H. Henderson, *Issues Sci. Technol.* **35**, 67 (2019).
13. K. I. Maton *et al.*, *J. Women Minor. Sci. Eng.* **15**, 15 (2009).
14. S. L. Eddy, K. A. Hogan, *CBE Life Sci. Educ.* **13**, 453 (2014).
15. M. Estrada *et al.*, *CBE Life Sci. Educ.* **15**, es5 (2016).

ACKNOWLEDGMENTS

The authors acknowledge financial and programmatic support from the Howard Hughes Medical Institute. Program and institutional staff who assisted with data collection and program operation are acknowledged in the supplementary materials.

SUPPLEMENTARY MATERIALS

science.sciencemag.org/content/364/6438/335/suppl/DC1

10.1126/science.aar5540

Science

Replicating Meyerhoff for inclusive excellence in STEM

Mariano R. Sto. Domingo, Starlette Sharp, Amy Freeman, Thomas Freeman Jr., Keith Harmon, Mitsue Wiggs, Viji Sathy, Abigail T. Panter, Leticia Oseguera, Shuyan Sun, Mary Elizabeth Williams, Joseph Templeton, Carol L. Folt, Eric J. Barron, Freeman A. Hrabowski III, Kenneth I. Maton, Michael Crimmins, Charles R. Fisher and Michael F. Summers

Science **364** (6438), 335-337.
DOI: 10.1126/science.aar5540

ARTICLE TOOLS	http://science.sciencemag.org/content/364/6438/335
SUPPLEMENTARY MATERIALS	http://science.sciencemag.org/content/suppl/2019/04/24/364.6438.335.DC1
REFERENCES	This article cites 13 articles, 4 of which you can access for free http://science.sciencemag.org/content/364/6438/335#BIBL
PERMISSIONS	http://www.sciencemag.org/help/reprints-and-permissions