Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads

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Committee on Underrepresented Groups and the Expansion of the Science and Engineering Workforce Pipeline; Committee on Science, Engineering, and Public Policy; Policy and Global Affairs; National Academy of Sciences, National Academy of Engineering, and Institute of Medicine

Summary

A TRANSFORMATIONAL MOMENT

Our ability to meet the challenges and achieve the opportunities of our time depends in large measure on our science and engineering (S&E) enterprise. Yet, while our S&E capability is as strong as ever, the dominance of the United States in these fields has lessened as the rest of the world has invested in and grown their research and education capacities. *Rising Above the Gathering Storm* documented this global leveling and argued that the United States was at a **crossroads:** For the United States to maintain the global leadership and competitiveness in science and technology that are critical to achieving national goals today, we must invest in research, encourage innovation, and grow a strong, talented, and innovative science and technology workforce.[1] *Gathering Storm* resonated strongly in both the executive and legislative branches of government, resulting in the American Competitive Incentive Act, the America COMPETES Act, and substantial appropriations through the American Recovery and Reinvestment Act of 2009.

The importance of S&E to the United States has been documented in a series of reports over more than half a century. Nevertheless, critical issues for the nation's S&E infrastructure remain unsettled. Among them, America faces a demographic challenge with regard to its S&E workforce: Minorities are seriously underrepresented in science and engineering, yet

[1] Institute of Medicine, National Academy of Sciences, and National Academy of Engineering. 2007. *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. Washington, DC: The National Academies Press.

they are also the most rapidly growing segment of the population. *Gathering Storm* provided compelling recommendations for sustaining and increasing our knowledge workforce as part of a larger plan to sustain the nation's scientific and technological leadership. These workforce recommendations focused on improving K-12 STEM education as well as providing incentives for students to pursue S&E education at the undergraduate and graduate levels.[2] We fully support these recommendations, but they are insufficient to meet the emerging demographic realities. The United States stands again at the **crossroads**: A national effort to sustain and strengthen S&E must also include a strategy for ensuring that we draw on the minds and talents of all Americans, including minorities who are underrepresented in S&E and currently embody a vastly underused resource and a lost opportunity for meeting our nation's technology needs.

Citing the need to develop a strong and diverse S&E workforce, U.S. Senators Edward Kennedy, Barbara Mikulski, Patty Murray, and Hillary Clinton requested in November 2006 a study of underrepresented minority participation in S&E. The U.S. Congress later included this request as a mandate in the 2007 America COMPETES Act, charging the study committee to explore the role of diversity in the STEM workforce and its value in keeping America innovative and competitive, analyze the rate of change and the challenges the nation currently faces in developing a strong and diverse workforce, and identify best practices and the characteristics of these practices that make them effective and sustainable.

AMERICA'S SCIENCE AND ENGINEERING TALENT AT THE CROSSROADS

Broad Participation Matters

A strategy to increase the participation of underrepresented minorities in science and engineering should play a central role in our approach to sustaining America's research and innovation capacity for at least three reasons:

1. *Our sources for the future S&E workforce are uncertain:* For many years, the nation relied on an S&E workforce that was predominantly male and overwhelmingly white and Asian. In the more recent past, as the proportion of the S&E workforce that is white and male has fluctuated, we have seen gains for women in some fields and an increasing reliance on international students in others. Non-U.S. citizens, particularly those from China and India, have accounted for almost all growth in STEM doctorate

[2] Ibid. pp. 5-7, 9-10.

awards and in some engineering fields comprise the majority of new doctorates. Yet, we are coming to understand that relying on non-U.S. citizens for our S&E workforce is an increasingly uncertain proposition.

2. *The demographics of our domestic population are shifting dramatically:* If the uncertainty about the future participation of international students suggests that we need to ensure that we draw on all demographic sources, the dramatic changes in the demographics of the domestic population, especially the school-age population, suggest that the problem is all the more urgent: *Those groups that are most underrepresented in S&E are also the fastest growing in the general population.*

3. *Diversity is an asset:* Increasing the participation and success of underrepresented minorities in S&E contributes to the health of the nation by expanding the S&E talent pool, enhancing innovation, and improving the nation's global economic leadership.

Dimensions of the Problem

The S&E workforce is large and fast-growing: more than 5 million strong and projected by the U.S. Bureau of Labor Statistics to grow faster than any other sector in coming years. This growth rate provides an opportunity as well as an obligation to draw on new sources of talent to make the S&E workforce as robust and dynamic as possible. But we start from a challenging position: Underrepresented minority groups comprised 28.5 percent of our national population in 2006, yet just 9.1 percent of college-educated Americans in science and engineering occupations (academic and nonacademic), suggesting the proportion of underrepresented minorities in S&E would need to *triple* to match their share of the overall U.S. population.

Underrepresentation of this magnitude in the S&E workforce stems from the underproduction of minorities in S&E at every level of postsecondary education, with a progressive loss of representation as we proceed up the academic ladder. In 2007, underrepresented minorities comprised 38.8 percent of K-12 public enrollment, 33.2 percent of the U.S college age population, 26.2 percent of undergraduate enrollment, and 17.7 percent of those earning science and engineering bachelor's degrees. In graduate school, underrepresented minorities comprise 17.7 percent of overall enrollment but are awarded just 14.6 percent of S&E master's degrees and a miniscule 5.4 percent of S&E doctorates.

Historically, there has been a strong connection between increasing educational attainment in the United States and the growth in and global leadership of the economy. Consequently, there have been calls—from the College Board, the Lumina and Gates Foundations, and the administration—to increase the postsecondary completion rate in the United

States from 39 percent to 55 or 60 percent. The challenge is greatest for underrepresented minorities: In 2006 only 26 percent of African Americans, 18 percent of American Indians, and 16 percent of Hispanics in the 25- to 29-year-old cohort had attained at least an associate degree.[3] The news is even worse in S&E fields. In 2000, as noted in *Gathering Storm,* the United States ranked 20 out of 24 countries in the percentage of 24-year-olds who had earned a first degree in the natural sciences or engineering. Based on these data, *Gathering Storm* recommended efforts to increase the percentage of 24-year-olds with these degrees from 6 percent to at least 10 percent, the benchmark already attained by several countries.[4] But again, the statistics are even more alarming for underrepresented minorities. These students would need to *triple, quadruple,* or even *quintuple* their proportions with a first university degree in these fields in order to achieve this 10 percent goal: At present, just 2.7 percent of African Americans, 3.3 percent of Native Americans and Alaska Natives, and 2.2 percent of Hispanics and Latinos who are 24 years old have earned a first university degree in the natural sciences or engineering.[5]

Recent data from the Higher Education Research Institute (HERI) at UCLA show that underrepresented minorities aspire to major in STEM in college at the same rates as their white and Asian American peers, and have done so since the late 1980s. Yet, these underrepresented minorities have lower four- and five-year completion rates relative to those of whites and Asian Americans. That a similar picture previously was seen in data in the mid-1990s signals that, although we have been aware of these problems for some time, we, as a nation, have made little collective progress in addressing them.

Fixing the Problem

No single career pathway or pipeline exists in STEM education. Students start from diverse places, with different family backgrounds and schools and communities with different resources and traditions. There also is substantial variation in K-12 mathematics and science education across schools, districts, and states. STEM courses, moreover, serve varied purposes for students on different tracks.

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[3] Ryu Mikyung. 2008. *Minorities in Higher Education*. Washington, DC: American Council on Education.

[4] IOM, NAS, and NAE. 2007. *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. Washington, DC: The National Academies Press.

[5] National Science Foundation, Women, Minorities, and Persons with Disabilities in Science and Engineering, http://www.nsf.gov/statistics/wmpd/ (accessed March 27, 2009); and U.S. Census Bureau, Population estimates, http://www.census.gov/popest/national/asrh/NC-EST2007-asrh.html (accessed March 27, 2009).

Although a set of pathways may be difficult to describe in detail, the ingredients for success in STEM are the acquisition of knowledge, skills, and habits of mind; opportunities to put these into practice; a developing sense of competence and progress; motivation to be in, a sense of belonging to, or self-identification with the field; and information about stages, requirements, and opportunities. These ingredients require attention in some measure for all students at every stage along the STEM educational continuum. However, there are issues that are specific to underrepresented minorities, in general and in STEM, focused on preparation, access and motivation, financial aid, academic support, and social integration.

Preparation

The education children receive from preschool through high school is foundational and critical. For STEM, quality preparation is a prerequisite for later success. From "A Nation at Risk" 25 years ago to current debates over reauthorization of the No Child Left Behind Act, interventions have been a subject of contention. Yet today, the nation remains faced with many of the same issues it has grappled with for years: failing schools, inequitable distributions of resources across schools, achievement gaps, and increasing demand for skilled workers in science, technology, and other knowledge-intensive fields. Moreover, substantial growth in the nation's Hispanic population has increased pressure on our nation's schools by increasing the number of nonnative English speakers.

Researchers offer many explanations for the persistent achievement gaps while recognizing that there are many interrelated factors. They agree that family and community differences, school context, low expectations, and lack of exposure to role models, information about career opportunities, and advanced courses affect minority students' success in mathematics and science. Although there is considerable disagreement over solutions such as school choice, testing, and teacher pay, there is substantial agreement about the need for strong preschool programs, more qualified mathematics and science teachers in predominantly minority and low-income schools, and challenging high school curricula that prepare underrepresented minorities for college.

Access and Motivation

The S&E workforce in the United States is drawn primarily from among our nation's undergraduates who complete at least a bachelor's degree. Undergraduate enrollment of underrepresented minorities has increased substantially over the past three decades and at a rate faster than for whites. As a result, they now comprise 26.2 percent of all undergraduates. While

this falls short of their proportion in the college age population (33.2 percent), this increase in their numbers and proportions nonetheless represents a significant national achievement.

However, we must do much more to attract and retain underrepresented minorities, low-income students, and first-generation undergraduates who aspire to a major in STEM. Specifically, we can do the following: (1) improve college awareness activities for prospective college students, (2) focus on college admissions policies that support the postsecondary matriculation of qualified underrepresented minority students, (3) raise awareness of STEM careers through K-12 activities, improved counseling for science and mathematics, and activities that promote STEM, and (4) promote STEM outreach that specifically targets underrepresented minorities.

Affordability

College affordability is an issue for all students, especially as tuition continues to increase above the rate of inflation, and is affected by federal, state, and institutional policies. Financial support that meets student need is strongly correlated with student attendance and persistence. For underrepresented minorities in STEM, financial support can come from a range of programs, including need-based financial aid programs (e.g., Pell Grants), general programs supporting underrepresented minorities (e.g., Gates Millennium Scholarships), financial aid that targets students in STEM (e.g., SMART Grants), and programs that target underrepresented minorities in STEM (e.g., NIH's MARC program). While some financial assistance may be need-based, programs that target underrepresented minorities in STEM are necessary. Researchers have shown that financial incentives are most effective in reducing attrition among low-income and minority students when provided in conjunction with academic support and campus integration programs.

Academic and Social Support

A study of undergraduate persistence by the National Center for Education Statistics (NCES) found that although women were less likely to major in STEM than men, they had similar or higher persistence rates. By contrast, they found that underrepresented minorities majored in STEM at the same rate as others, but their completion rate was lower, a finding recently corroborated by HERI. NCES concluded that underrepresented minorities faced greater barriers to persistence and completion. Other researchers note also that the culture and climate of institutions, including the diversity of faculty, impact the entire process from entry to graduation.

Several practical steps can be taken to increase the completion of minorities: Make student success a priority, track student achievement, identify "choke points" such as course availability, make course transfer easier, and ensure that courses are structured to properly support students. Only higher education institutions can address these issues and only they can ensure the academic and social support necessary for underrepresented minority students in STEM. To address issues of self-confidence and inclusion that are profoundly salient, institutions can play a pivotal role, through formal and informal actions, to encourage persistence through:

- Strong leadership from trustees and regents, the president, provost, deans, and department chairs;
- A campus-wide commitment to inclusiveness;
- A deliberate process of self-appraisal focused on campus climate;
- Development of a plan to implement constructive change; and
- Ongoing evaluation of implementation efforts.

THE JOURNEY BEYOND THE CROSSROADS

Principles

Six principles have informed the development of our recommendations to move "beyond the crossroads" to the implementation of actions designed to increase the participation and success of underrepresented minorities in STEM education. Given how long it takes to realize gains from educational reform, the national effort must be urgent, sustained, comprehensive, intensive, coordinated, and informed:

1. The problem is *urgent* and will continue to be for the foreseeable future.
2. A successful national effort to address underrepresented minority participation and success in STEM will be *sustained*.
3. The potential for losing students along all segments of the pathway from preschool through graduate school necessitates a *comprehensive* approach that focuses on all segments of the pathway, all stakeholders, and the potential of all programs, targeted or nontargeted.
4. Students who have not had the same degree of exposure to STEM and to postsecondary education require more *intensive* efforts at each level to provide adequate preparation, financial support, mentoring, social integration, and professional development.
5. A *coordinated* approach to existing federal STEM programs can leverage resources while supporting programs tailored to the specific mis-

sions, histories, cultures, student populations, and geographic locations of institutions with demonstrated success.

6. Evaluation of STEM programs and increased research on the many dimensions of underrepresented minorities' experience in STEM help ensure that programs are well *informed,* well designed, and successful.

Institutional Roles

The diversity of American higher education institutions is a competitive advantage in the global knowledge economy as different types of institutions address the varied needs of students who find themselves at different places in their educational journey with a range of life and career goals. This institutional diversity could be, but is not yet, effective in addressing the varied needs of the nation's underrepresented minority students in STEM. For our recommended action to be successful, every institution of higher education should take steps to address the problem of underrepresented minority participation in STEM. Currently, only a small number of institutions are doing so. They are diverse and can be found among all institutional types and categories; they are successful because they are doing something special to support the retention and completion of underrepresented minority undergraduates in the natural sciences and engineering. Their actions can be replicated, and when they are, with a focus on both numbers and quality, it will pay off significantly:

- **PredominantlyWhite Institutions:** The best way to increase the **retention** of underrepresented minorities in STEM is to replicate programs of the successful PWIs at *a very large number* of similar institutions, especially large state flagships.
- **Minority-Serving Institutions:** MSIs have a legacy of recruiting, retaining, and graduating a disproportionate number of minorities, especially at the undergraduate level. With additional support, MSIs can expand their effectiveness in recruiting, retaining, and graduating an increased number of minorities, especially at the baccalaureate level.
- **Community Colleges:** To facilitate and increase the successful transfer of underrepresented minorities in STEM to four-year institutions, an increased emphasis on and support for articulation agreements, summer bridge programs, mentoring, academic and career counseling, peer support, and undergraduate research at two-year institutions are recommended.

Leadership

Leadership is key to the successful transformation of institutions and the development of sustainable programs:

- **Sectoral Leadership:** Leadership in identifying and articulating minority participation and success as an institutional goal is essential at all levels for all stakeholders: the federal government, state and local governments, employers, philanthropy, professional societies, educational institutions, programs, faculty, and students.
- **Institutional Leadership:** At each higher education institution, the academic leadership—regents, trustees, presidents, provosts, deans, and department chairs—should articulate underrepresented minority participation as a key commitment to set a tone that raises awareness and effort. Faculty buy-in is essential. Institutional leaders also should be more aggressive in investing in the development of underrepresented minority teachers, faculty, and administrators who can serve as role models and leaders.
- **Programmatic Leadership:** A champion at the program level providing leadership dedicated to long-term improvement is typically critical to the success of underrepresented minority programs at the undergraduate and graduate levels.

Program Development

The literature on best practices for increasing minority participation in STEM education provides guidance for the development and execution of the policies and programs that are designed to change the academic culture and sustain programs so as to encourage student retention, persistence, and completion. Below are key elements for developing a program that are necessary to transform goals into reality.

- **Resources and Sustainability:** The development of programs to stimulate student interest and success in STEM, in general and for programs that target minorities, requires substantial and sustained resources.
- **Coordination and Integration:** Coordination and integration of efforts can make the aggregate of individual programs greater than the sum of their parts.
- **Focus on the Pipeline, Career Pathways, and Transition Points:** A corollary to coordination and integration is programs and strategies that focus on career pathways and critical pipeline transition points.
- **Program Design:** A successful program may be innovative or replicative and will draw on the lessons of best and worst practices in program development and implementation, but it will be tailored to its particular institutional and disciplinary context.
- **Program Execution:** Even if a program is well designed, well resourced, and appropriately targeted, without proper execution it has little chance of full success.

- **Program Evaluation:** Whether a program meets or exceeds organizational goals is subject to examination. Programs designed to increase the participation of underrepresented minorities benefit themselves and others by engaging in ongoing, constructive evaluation.
- **Knowledge Sharing:** A corollary to the importance of program evaluation is the dissemination of information about practice derived from these evaluations and other research.

Program Characteristics

While many strategies for academic support and social integration apply equally to students in STEM fields regardless of their racial or ethnic background, for underrepresented minority students these can be critical for opening doors of opportunity. Proven, intensive interventions for underrepresented minorities in STEM include:

- **Summer Programs:** Summer programs that include or target minority middle and high school and undergraduate students provide experiences that stimulate interest in these fields through study, hands-on research, and the development of a cadre of students who support each other in their interests.
- **Research Experiences:** At the undergraduate and graduate level, engagement in rich research experiences allows for the further development of interest and competence in and identification with STEM and enhances academic competitiveness.
- **Professional Development Activities:** Opportunities for undergraduate and graduate students to engage in networking, participation in conferences, and presentation of research provide opportunities to develop and socialize students within a discipline and profession.
- **Academic Support and Social Integration:** Success may also hinge on the extent to which undergraduate and graduate students participate in activities—such as peer-to-peer support, study groups, social activities, tutoring, and mentoring programs—that can promote academic success and social integration.
- **Mentoring:** Engaged mentors can provide undergraduate and graduate students with information, advice, and guidance and support generally and at critical decision points.

Students should also have access to proper facilities and equipment, and course curricula should be formulated to encourage student learning and progress—something that seems self-evident, except that many introductory courses in the sciences have traditionally sought to "weed out" students rather than encourage them.

Recommendations and Implementation Actions

A successful national effort to increase the participation and success of underrepresented minorities in STEM will be urgent, sustained, comprehensive, intensive, coordinated, and informed. It will also cut across all educational stages and stakeholder groups. With these principles in mind, the committee has developed six broad recommendations followed by implementation actions that should be taken by specific stakeholders. Following the six broad recommendations, we propose two top priorities that should serve as the near-term focal point for national policies for broadening participation.

Preparation

Recommendation 1: ***Preschool through Grade 3 Education***
Prepare America's children for school through preschool and early education programs that develop reading readiness, provide early mathematics skills, and introduce concepts of creativity and discovery.

Recommendation 2: ***K to 12 Mathematics and Science***
Increase America's talent pool by vastly improving K-12 mathematics and science education for underrepresented minorities.

Recommendation 3: ***K-12 Teacher Preparation and Retention***
Improve K-12 mathematics and science education for underrepresented minorities overall by improving the preparedness of those who teach them those subjects.

Postsecondary Success

Recommendation 4: ***Access and Motivation***
Improve access to all postsecondary education and technical training and increase underrepresented minority student awareness of and motivation for STEM education and careers through improved information, counseling, and outreach.

Recommendation 5: ***Affordability***
Develop America's advanced STEM workforce by providing adequate financial support to underrepresented minority students in undergraduate and graduate STEM education.

Recommendation 6: ***Academic and Social Support***
Take coordinated action to transform the nation's higher education institutions to increase inclusion of and college completion and success in STEM education for underrepresented minorities.

Top-Priority Actions

Out of the recommendations and implementation actions that span the entire educational system and full spectrum of stakeholders, we have identified two areas of highest priority for near-term action. We chose them because we believe they can have the most immediate impact on the critical transition points in the STEM education pathway for underrepresented minorities.

Priority 1: Undergraduate Retention and Completion: We propose, as a short-term focus for increasing the participation and success of underrepresented minorities in STEM, policies and programs that seek to increase undergraduate retention and completion through strong academic, social, and financial support. Financial support for underrepresented minorities that allows them to focus on and succeed in STEM will increase completion and better prepare them for the path ahead. This financial assistance should be provided through higher education institutions along with programs that simultaneously integrate academic, social, and professional development.

The success of such an effort is made possible by the existence of a cadre of qualified underrepresented minorities who already attend college, declared an interest in majoring in the natural sciences or engineering, and either did not complete a degree or switched out of STEM before graduating. An increase in the STEM completion rate for these students may, by example, increase interest in STEM on the part of younger cohorts and also increase the number of underrepresented minorities who may consider graduate education in STEM.

Financial support for underrepresented minorities that allows them to focus on and succeed in STEM will increase completion and better prepare them for the path ahead. This financial assistance should be provided through higher education institutions along with programs that simultaneously provide academic support, social integration, and professional development. Given the scale of the problem, an effort to double the number of underrepresented minorities who complete undergraduate STEM degrees is a near-term, reasonable, and attainable down payment on a longer-term effort to achieve greater parity overall.

Priority 2: Teacher Preparation, College Preparatory Programs, and Transition to Graduate Study: We propose also an emphasis on teacher prepara-

tion, secondary school programs that support preparation for college STEM education, and programs that support the transition from undergraduate to graduate work.

We note the particular importance at the K-12 level of teacher preparation and secondary school programs that support preparation for college STEM education. Secondary school programs that ensure students have access to advanced courses and proper academic advising will support the goal of undergraduate persistence and completion by ensuring that matriculating freshmen are fully prepared for college study.

At the other end of the undergraduate years, programs that support the transition from undergraduate to graduate work are likewise important. The transition of underrepresented minorities to graduate work at top research universities where they can contribute to research and leadership in our nation's science and engineering enterprise is also critical. A significant proportion of new graduate students who are supported through portable fellowships, research assistantships, or institutional grants should be underrepresented minorities in order to increase their overall representation and to move greater numbers into top graduate programs.

EXPANDING UNDERREPRESENTED MINORITY PARTICIPATION

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Acknowledgment of Reviewers

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Academies' Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the process.

We wish to thank the following individuals for their review of this report: Betsy Ancker-Johnson, General Motors Corporation (retired); Carlos Castillo-Chavez, Arizona State University; Daryl Chubin, American Association for the Advancement of Science; Henry Frierson, University of Florida; Adam Gamoran, University of Wisconsin-Madison; Juliet Garcia, University of Texas at Brownsville; Tuajuanda Jordan, Howard Hughes Medical Institute; Shirley Malcom, American Association for the Advancement of Science; Douglas Medin, Northwestern University; Samuel Myers, University of Minnesota; Helen Quinn, SLAC National Accelerator Laboratory; Joan Reede, Harvard University; Isiah Warner, Louisiana State University; and Herman White, Fermi National Accelerator Laboratory.

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by Georges C. Benjamin,

American Public Health Association, and Mary E. Clutter, National Science Foundation (retired). Appointed by the National Academies, they were responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

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Workforce Pipeline

Contents

TABLES

FIGURES

BOXES