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**BROADENING  
PARTICIPATION IN  
STEM**  
A CALL TO ACTION



## **Broadening Participation in STEM**

The Broadening Participation in STEM project is an effort led by the American Institutes for Research® (AIR®), with consultation from the Institute for Higher Education Policy (IHEP). The goals of our work are to examine the data and research on mechanisms designed to stimulate undergraduate science, technology, engineering, and mathematics (STEM) degree attainment, particularly among underrepresented minorities, women, and persons with disabilities; and to solicit recommendations and feedback from a wide range of STEM experts and stakeholders—including representatives from minority-serving and majority-serving institutions, professional associations, federal government agencies, corporations, foundations, and student groups—to improve our nation’s return on investments in STEM education at the undergraduate level.

**October 2012**

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## EXECUTIVE SUMMARY

Domestic science, technology, engineering, and mathematics (STEM)<sup>1</sup> degree production is not keeping pace with the demand for STEM talent. As a nation, our STEM education and workforce development infrastructure have realized a poor return on investment. Women, racial and ethnic minorities and persons with disabilities are underrepresented in the STEM disciplines. They represent the largest untapped STEM talent pools in the United States. According to U.S. Census estimates, women represent a larger proportion of the U.S. population than men, and projections indicate that 54 percent of the population will be a member of a racial or ethnic minority group by 2050. Given the shifting demographic landscape, failing to broaden participation in STEM—that is, failing to cultivate these pools of potential STEM expertise—is a waste of our domestic human resources and, therefore, imposes an opportunity cost on national security interests, the U.S. economy, and our quality of life.

To respond to this challenge, the *Broadening Participation in STEM* project is an effort led by the American Institutes for Research® (AIR®), with consultation from the Institute for Higher Education Policy (IHEP). Our principal charge was to solicit the perspectives of a wide range of national STEM education experts and stakeholders on the state of undergraduate STEM degree production. We also analyzed national STEM bachelor's degree attainment trends between 1989 and 2009, and conducted a literature review of the scholarship on the promising practices associated with broadening the participation of historically underrepresented groups in undergraduate STEM education.

We convened roundtable discussions in Washington, DC on three occasions in the spring of 2011. These listening sessions were designed to gather input from representatives from minority-serving and non-minority-serving institutions, professional associations, federal agencies, corporations, foundations, and student groups. The representatives and thought leaders who participated in these sessions provided judicious observations and counsel on ways to improve our STEM education and workforce development infrastructure. Among their many concerns, they relayed that:

- The current definition of success in broadening participation in STEM is too narrow; we need to move beyond simple degree completion rates to more sophisticated measures.
- The role of two-year institutions, Tribal Colleges and Universities (TCUs) and other minority-serving institutions (MSIs) should not be diminished; different types of institutions play different but equally valuable roles in producing STEM talent.
- There is a pervasive culture of attrition in the STEM disciplines.
- Federal funding is concentrated in well-resourced, four-year institutions at the expense of other types of institutions in need of capacity-building that educate a critical mass of underrepresented minorities (e.g., two-year institutions, MSIs).
- STEM-degree production and workforce needs are not aligned.

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<sup>1</sup> In this study, STEM includes the natural and physical sciences, technology, engineering and mathematics. The social and behavioral sciences were not examined.

- Higher education is not promoting STEM literacy for all.
- STEM education is largely preparing students to be employees while neglecting their development as entrepreneurs.
- Federal agencies need better data with which to make funding decisions.

Reflecting on this feedback, our trend analyses and literature review activities, this report details the key issues our nation should consider and the steps we should collectively take if we want to improve our position as a global leader in STEM innovation. Specifically, this report responds to the following six critical policy questions which are detailed below:

1. **To what extent are women and racial and ethnic minorities underrepresented in STEM?**
2. **How have minority-serving institutions contributed to STEM degree production over time?**
3. **What STEM talent development models, mechanisms and practices are most promising for underrepresented groups?**
4. **What indicators should be used to measure the success of efforts to broaden participation in STEM at the undergraduate level?**
5. **What role(s) should higher education play to broaden participation in STEM?**
6. **What role(s) should federal funders play to support higher education's capacity to broaden participation in STEM?**

***To what extent are racial and ethnic minorities and women underrepresented in STEM?*** Our analyses indicate that national STEM bachelor's degree-completion trends between 1989 and 2009 were not promising for any U.S. demographic group including Whites and Asian/Pacific Islanders:

- **Blacks, Hispanics, and women are underrepresented in the domestic pipeline to STEM.** While the number and share of bachelor's degrees earned in STEM by underrepresented minorities and women has increased over time, this growth did not keep pace with population growth, undergraduate enrollment, overall bachelor's degree attainment, and projected STEM labor market growth rates.
- **The percentage of bachelor's degrees earned in a STEM discipline has not realized considerable growth over time for any demographic group including Whites.** Among Asian/Pacific Islanders, the percentage of bachelor's degrees earned in a STEM discipline has actually *declined* over time.
- **When disaggregated by STEM discipline, the trend data indicate pronounced degree-completion gaps between Whites and racial and ethnic minorities, between men and women, and between White women and White men.** For example, the biological sciences and the agricultural sciences are the only STEM disciplines in which women have reached parity and surpassed men in terms of the number and proportion of bachelor's degrees earned. A sizable gender gap persists in engineering and the computer sciences; and unlike their minority peers, there is a substantial degree-attainment gap between White women and White men in the physical sciences, computer sciences, engineering, and the earth, atmospheric, and oceanic sciences.



**How have Minority-Serving Institutions contributed to STEM degree production over time?** Our trend data demonstrate that MSIs, such as Historically Black Colleges and Universities (HBCUs), TCUs, and Hispanic-Serving Institutions (HSIs) have played an especially important role for Blacks and American Indians, respectively. HBCUs and TCUs have an historical mission to target Black and American Indian students in higher education. HSIs are more recent in the higher education landscape to have a federal designation; many HSIs have revised their missions with specific language that targets Hispanic students.

- **Although non-MSIs produce a greater number of Black and American Indian/Alaska Native STEM graduates, HBCUs produce a larger percentage of STEM degrees among Black students, and TCUs have steadily increased their production of American Indian/Alaska Native STEM graduates while the percentage of STEM degrees among American Indian/Alaska Natives at non-MSIs has remained virtually unchanged.**
- **HSIs produce Hispanic STEM graduates at comparable levels to non-MSIs.**

**What STEM talent-development models, mechanisms, and practices are most promising for underrepresented groups?** Our review of the literature revealed that many programs and interventions, large and small, have been implemented to increase the number of underrepresented minorities and women who successfully progress through the STEM pipeline. Key strategies employed by these programs include:

- **Undergraduate research opportunities**
- **Pre-college summer bridge and academic enrichment programs**
- **Academic supports such as tutoring and mentoring**
- **Student community-building efforts such as peer-support networks**
- **Institutional capacity building such as facility development**
- **The improvement of the physical infrastructure for STEM instruction and research**
- **Curricular reform**
- **Cross-campus collaborations and partnerships**

Data on the effectiveness of these strategies show varying degrees of success. However, our review found that participation in programs with one or more or a combination of these strategies was positively associated with broadening participation outcomes, such as achievement, retention, degree completion, graduate enrollment, and pursuit of a STEM career. Although the existing evidence is hampered by methodological issues and gaps, the findings involving these widely used practices are fairly consistent across studies, suggesting that a foundational knowledge base that warrants further exploration as we continue efforts to increase the representation of underrepresented groups in STEM.

**What indicators should be used to measure the success of efforts to broaden participation in STEM at the undergraduate level?** Key recommendations shared by stakeholders included:

- Move beyond STEM degree completion as an indicator of success (e.g., persistence/retention/attrition rates, course-completion rates, skill development, dispositional and attitudinal measures);
- Include indicators that account for the contribution of two-year institutions to STEM degree production;
- Evaluate STEM degree-program quality, including instructional quality and the value of an earned degree;
- Establish *institutional baselines* to account for the unique context and starting point of each institution (e.g., student demographic characteristics, student academic preparedness, mobility and transfer rates, the proportion of nontraditional students, teaching capacity, research infrastructure, faculty development needs and history of funding) and using these institutional baseline data to create an *institution profile* against which funders can set expectations and evaluate programs; and
- Group institutions with similar baselines and establishing benchmarks for each grouping against which funders can measure progress and make fair comparisons between institutions.

**What role should higher education play to broaden participation in STEM?** Key recommendations shared by stakeholders included:

- Expand the capacity of two-year institutions to remediate academically underprepared students for STEM coursework and successfully transfer students to four-year STEM degree programs;
- Ameliorate the competitive, gate-keeper culture of STEM, especially in introductory courses;
- Develop relational pedagogy to improve student outcomes;
- Engage students in STEM research throughout their undergraduate experience;
- Strengthen student support services;
- Improve within-institution community building;
- Provide faculty development in the areas of mentoring, cultural competence, fostering student engagement, community engagement, and formative assessment to support instruction;
- Establish new and strengthen existing STEM summer institutes and summer bridge programs;
- Align STEM degree production with workforce needs;
- Counsel students on their STEM employment and career prospects;
- Make introductory STEM courses accessible to non-STEM majors;
- Improve STEM literacy in the public policy and business arenas by requiring STEM-literacy coursework for STEM majors;
- Teach students how to create their own jobs instead of simply preparing them for employment;

- Promote cross-fertilization of faculty and course development across STEM and non-STEM disciplines; and
- Train STEM students to be creative and innovative thinkers.

**What role should federal funders play to support higher education's capacity to broaden participation in STEM?** Key recommendations shared by stakeholders included:

- Fund more research and evaluation to collect evidence on promising practices to inform funding decisions;
- Fund dissemination efforts to better inform policymakers, faculty, and program developers of promising practices in undergraduate STEM education;
- Provide grants to build the capacity of under-resourced and teaching institutions;
- Provide grants to support faculty recruitment and development for struggling STEM departments;
- Provide and/or fund technical assistance (e.g., STEM instructional program design, student retention, cross-campus collaboration);
- Capitalize on the unique strengths of two- and four-year institutions by enabling cross-dissemination and cross-institution partnership development opportunities;
- Provide more funding opportunities that respond to the specific goals of two-year institutions (e.g., remediation, transfers to four-year programs, certificate programs, preparation for employment, support for nontraditional students, community outreach, and community building);
- Require higher education administrators to certify their understanding that continued funding is predicated on their institution's ability to provide evidence of progress toward improving the retention, learning, research opportunities, and degree production for underrepresented groups;
- Provide incentives for the use of measures of teacher effectiveness at the undergraduate level, especially in introductory courses;
- Provide funding to support targeted partnerships:
  - *Across institution types and levels (e.g., a local research consortium consisting of a research institution, a community college, and a teaching college),*
  - *Between similar types of schools (e.g., small HBCUs, HSIs, TCUs),*
  - *Across departments within a single institution, and*
  - *With industry and small business to provide research and internship opportunities for students.*
- Improve the marketing of STEM careers to students;



- Establish a comprehensive national reporting system to track student progress through the pipeline to STEM, from cradle to career, that includes two-year and for-profit institutions;
- Conduct routine needs assessments to prevent duplicative programming, encourage coordination and collaboration, and fill funding gaps across federal funding agencies by determining:
  - *The roles, goals, and funding programs offered by the various funding agencies,*
  - *STEM labor-market and policy needs,*
  - *Incentives to encourage students to pursue training in the disciplines for which the need is greatest as well as disincentives for saturated disciplines,*
  - *Outreach activities of the various agencies, and*
  - *Federal policies and federally-funded mechanisms that support or present barriers to career advancement in each of the STEM disciplines.*
- Engage more federal employees in K–16 outreach activities as role models, mentors, and guest teachers; and
- Increase internship and research collaboration opportunities within federal research laboratories.

This report closes with an open letter to the nation in which we state that broadening participation in STEM is a critical national priority and a shared responsibility. To reform our STEM education and workforce development infrastructure at the undergraduate level, our nation needs the political will and the support of its citizenry to carry out such recommendations for change.

# TABLE OF CONTENTS

|   |           |
|---|-----------|
| <b>ACKNOWLEDGMENTS</b>  | <b>3</b>  |
| <b>EXECUTIVE SUMMARY</b>  | <b>4</b>  |
| <b>TABLE OF CONTENTS</b>  | <b>10</b> |
| <b>INTRODUCTION</b>   | <b>1</b>  |
| <b>THE PROJECT</b>  | <b>1</b>  |
| <b>HOW WE'RE DOING: A TREND ANALYSIS</b>  | <b>3</b>  |
| <b>WHAT THE TREND DATA TELL US</b>  | <b>7</b>  |
| TO WHAT EXTENT ARE WOMEN AND RACIAL AND ETHNIC MINORITIES UNDERREPRESENTED IN STEM?     | 9         |
| HOW HAVE MINORITY-SERVING INSTITUTIONS CONTRIBUTED TO STEM DEGREE PRODUCTION OVER TIME? | 28        |
| <b>WHAT THE TREND DATA DO NOT TELL US</b>   | <b>36</b> |
| <b>WHAT'S WORKING: A LITERATURE REVIEW</b>  | <b>42</b> |
| <b>WIDELY USED PRACTICES AND COMMON FEATURES OF COMPREHENSIVE PROGRAMS</b>              | <b>42</b> |
| <b>GAPS IN THE EXISTING RESEARCH BASE</b>   | <b>44</b> |
| <b>METHODOLOGICAL LIMITATIONS</b>   | <b>46</b> |
| <b>STAKEHOLDER FEEDBACK</b>   | <b>47</b> |
| <b>GOALS, METRICS, AND ACCOUNTABILITY</b>   | <b>48</b> |
| EXPAND THE DEFINITION OF SUCCESS  | 49        |
| ACCOUNT FOR INSTITUTIONAL DIFFERENCES   | 50        |
| INCREASE ACCOUNTABILITY   | 51        |
| <b>HIGHER EDUCATION'S ROLE</b>  | <b>52</b> |
| ACCOUNT FOR INSTITUTIONAL DIFFERENCES   | 52        |
| REVERSE THE CULTURE OF ATTRITION  | 54        |
| IMPROVE FACULTY DEVELOPMENT   | 54        |
| RESPOND TO WORKFORCE AND INDUSTRY DEMANDS   | 55        |
| ENSURE STEM LITERACY FOR ALL  | 56        |
| STEM ENTREPRENEURSHIP   | 57        |

|  |           |
|--|-----------|
| <b>THE FEDERAL ROLE</b>  | <b>58</b> |
| FUND RESEARCH, EVALUATION, AND DISSEMINATION ON STEM EDUCATION | 59        |
| BUILD CAPACITY   | 59        |
| PROVIDE INCENTIVES FOR CHANGE IN HIGHER EDUCATION              | 60        |
| FUND TARGETED PARTNERSHIP DEVELOPMENT                          | 61        |
| MARKET STEM CAREERS  | 62        |
| CONDUCT NEEDS ASSESSMENTS                                      | 62        |
| EXPAND FEDERAL OUTREACH  | 63        |
| <b>AN OPEN LETTER TO THE NATION</b>                            | <b>64</b> |
| <b>REFERENCES</b>  | <b>67</b> |
| <b>APPENDICES</b>  | <b>68</b> |
| <b>APPENDIX A: METHODOLOGY REPORT</b>                          | <b>68</b> |
| TREND ANALYSIS   | 68        |
| LITERATURE REVIEW  | 70        |
| STAKEHOLDER ROUNDTABLES  | 71        |
| <b>APPENDIX B: IPEDS STEM DISCIPLINES AND SUBDISCIPLINES</b>   | <b>75</b> |
| <b>APPENDIX C: PARTICIPATING INSTITUTIONS</b>                  | <b>80</b> |
| INSTITUTES OF HIGHER EDUCATION                                 | 80        |
| FEDERAL AGENCIES   | 81        |
| PROFESSIONAL ORGANIZATIONS AND ASSOCIATIONS                    | 81        |

FIGURE 1. THE STATE OF STEM FAST FACTS.....7

FIGURE 2. STEM BACHELOR’S DEGREES BY RACE/ETHNICITY ..... 10

FIGURE 3. URM STEM BACHELOR’S DEGREES..... 10

FIGURE 4. STEM BACHELOR’S DEGREES BY SEX..... 11

FIGURE 5. TOTAL STEM BACHELOR’S DEGREES EARNED BY WOMEN, BY RACE/ETHNICITY ..... 11

FIGURE 6. TOTAL URM STEM BACHELOR’S DEGREES EARNED BY WOMEN ..... 11

FIGURE 7. URM STEM BACHELOR’S DEGREES RELATIVE TO POPULATION ESTIMATES ..... 13

FIGURE 8. STEM BACHELOR’S DEGREES RELATIVE TO POPULATION ESTIMATES, 2009 ..... 14

FIGURE 9. BROADENING PARTICIPATION IN STEM PROGRESS INDEX: RACE/ETHNICITY ..... 15

FIGURE 10. STEM BACHELOR’S DEGREES RELATIVE TO POPULATION ESTIMATES BY SEX, 2009 ..... 16

FIGURE 11. PERCENT DISTRIBUTION OF STEM BACHELOR’S DEGREES BY RACE/ETHNICITY..... 17

FIGURE 12. PERCENT DISTRIBUTION OF STEM BACHELOR’S DEGREES BY SEX..... 18

FIGURE 13. PERCENTAGE OF STEM BACHELOR’S DEGREES WITHIN RACE/ETHNICITY ..... 19

FIGURE 14. PERCENTAGE OF FEMALE STEM BACHELOR’S DEGREES EARNED WITHIN EACH RACE/ETHNICITY.20

FIGURE 15. COMPUTER SCIENCE PARTICIPATION RATES, 2009..... 22

FIGURE 16. THE STEM DISCIPLINE PARITY INDEX .....23

FIGURE 17. BROADENING PARTICIPATION IN COMPUTER SCIENCE PROGRESS INDEX .....24

FIGURE 18. THE STEM DISCIPLINE ATTAINMENT GAP BY SEX, 2009 .....25

FIGURE 19. THE STEM DISCIPLINE PERFORMANCE GAP BY SEX, 1989 - 2009 .....26

FIGURE 20. COMPUTER SCIENCE DEGREES BY SEX .....26

FIGURE 21. COMPUTER SCIENCE DEGREES BY RACE/ETHNICITY AND SEX ..... 27

FIGURE 22. TOTAL DEGREE PRODUCTION BY INSTITUTION TYPE.....30

FIGURE 23. TOTAL DEGREE PRODUCTION AT MINORITY-SERVING INSTITUTIONS.....30

FIGURE 24. STEM PRODUCTION BY NON-MINORITY-SERVING INSTITUTIONS BY RACE/ETHNICITY ..... 31

FIGURE 25. URM STEM PRODUCTION BY NON-MINORITY-SERVING INSTITUTIONS BY RACE/ETHNICITY ..... 31

FIGURE 26. STEM DEGREE PRODUCTION AT HBCUS AND PBIS ..... 33

FIGURE 27. STEM DEGREE PRODUCTION AT HSIS ..... 33

FIGURE 28. BACHELOR’S DEGREE PRODUCTION AT HBCUS AND HSIS BY RACE/ETHNICITY .....34

FIGURE 29. STEM DEGREE PRODUCTION AT TCUS .....35

FIGURE 30. FIVE-YEAR PRODUCTION RATES FOR STEM ASPIRANTS ..... 37

FIGURE 31. THE STATE OF STEM FAST FACTS.....38

FIGURE 32. PERSONS WITH DISABILITIES WHO MAJORED IN S&E .....39

FIGURE 33. S&E MAJORS BY DISABILITY STATUS .....39

FIGURE 34. S&E MAJORS BY DISABILITY STATUS AND FIELD..... 40

TABLE 2. PROPOSED INDICATORS ..... 49

## INTRODUCTION

# A National Imperative

Domestic science, technology, engineering, and mathematics (STEM) degree production is not keeping pace with the demand for STEM talent. Women, racial/ethnic minorities, and persons with disabilities are underrepresented in the STEM disciplines. Collectively, these demographic groups represent the largest untapped STEM talent pool in the United States. According to U.S. Census estimates, women represent a larger proportion of the U.S. population than men, and projections indicate that 54 percent of the population will be members of a racial or ethnic minority group by 2050. Because of the shifting demographic landscape, failing to cultivate these pools of potential STEM expertise is a waste of our domestic human resources and, therefore, imposes an opportunity cost on national security interests, the U.S. economy, and our quality of life. The term “Broadening Participation in STEM” refers to a national imperative to exploit these untapped STEM talent pools.

...

**“We have an obligation to the future of our Nation to assure every segment of our population has equal access and opportunity to pursue careers in STEM.”**

**Rep. Johnson (D-TX)<sup>2</sup>**

...

## The Project

Responding to this call, the *Broadening Participation in STEM* project, an effort led by the American Institutes for Research® (AIR®), in consultation with the Institute for Higher Education Policy (IHEP), sought to provide thought leadership on the topic of STEM talent development through:

- **Data Analysis.** Conducting trends analyses and identifying gaps in the STEM data infrastructure to indicate future directions for data collection and analysis
- **Literature Reviews.** Reviewing the scholarship on effective strategies and programs for improving STEM degree attainment among women, underrepresented minorities and persons with disabilities
- **Stakeholder Engagement.** Soliciting the perspectives of a wide range of STEM experts and stakeholders—including representatives from minority-serving institutions (MSIs) and majority-serving institutions, professional associations, federal government agencies, corporations, foundations, and student groups—on the state of undergraduate STEM degree production and recommendations for change

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<sup>2</sup> Proceedings of the Markup by the Subcommittee on Research and Science Education on Committee Print, The National Science Foundation Authorization Act of 2010, H.R. Rep 111-478. (2010). Retrieved from THOMAS: <http://thomas.loc.gov/cgi-bin/cpquery/T?&report=hr478&dbname=111&>

This document summarizes the findings from our inaugural trend analysis, literature review, and stakeholder-convening activities. This final report details the key issues we should consider and the steps we should collectively take if we want to improve the nation's position as a global leader in STEM innovation. We begin by sharing findings from our research activities in the next section, "How We're Doing: A Trend Analysis", and third section, "What's Working: A Literature Review". Each section provides context on the current and historic state of undergraduate STEM education in the United States and outlines what we know and what we need to know to improve practice and policymaking. In the fourth section, "Stakeholder Feedback", we share the concerns and recommendations provided by the stakeholders who participated in our gatherings. This report concludes with a letter to the nation in which we compel all stakeholders to consider broadening participation in STEM a shared burden and responsibility.



## HOW WE'RE DOING: A TREND ANALYSIS

### A National Imperative

To achieve parity in STEM for underrepresented groups, actionable data are needed to inform policy and practice. An essential first step is to examine the imprint of federal and institutional efforts to broaden participation in undergraduate STEM education, as reflected in the historical record. In the wake of these contributions, we need to understand whether and to what extent the academic performance of underrepresented groups has improved in STEM over time. Unfortunately, measuring progress in this arena is not necessarily straightforward.

There is no uniform target or standard method for characterizing or assessing underrepresentation in STEM. Scholarship in this area has considered a number of indicators including, but not limited to, graduation or college (or degree) completion, student retention, student persistence, student attrition, degree attainment (or degrees earned by a student or types of students), STEM aspirations (or interest or degree pursuit as indicated by response to a survey or questionnaire), choice of major and degree production (or degrees awarded or conferred by an institution or type of institution). However, such indicators are often calculated in different ways, are derived from different types of data, result in different findings, and, consequently, are often contested.<sup>3</sup> For instance, the term “completion” has been used to describe the number or percentage of STEM degrees pursued, as suggested by choice of major<sup>4</sup> or degree aspiration<sup>5</sup> relative to the number or percentage of degrees actually earned.

Within these indicators, a range of approaches has been pursued to measure change over time, such as raw numbers, rates (e.g., retention rate of Hispanics in STEM), percent distribution (e.g., proportion of degrees earned by each race/ethnicity group in STEM), parity (e.g., the equitable distribution of men and women in a specific STEM discipline) and performance-gap analyses (e.g., the difference between Black men and Black women in degree-production rates in STEM at Minority-Serving Institutions [MSIs]). Additionally, a host of ways exist to aggregate (e.g., across all race/ethnicities and disciplines) and disaggregate the data (e.g., gender by race/ethnicity differences within each discipline) and an equally large number of reference points, targets, or threshold criteria against which a single indicator

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<sup>3</sup> Postsecondary Education Opportunity. (March 2009). College completion rates: 1947–2007. [http://www.postsecondary.org/last12/201309pg1\\_16.pdf](http://www.postsecondary.org/last12/201309pg1_16.pdf); Ramaley, J. (2012, March 2). Do college-completion rates really measure quality? *The Chronicle of Higher Education*. <http://chronicle.com/article/Do-College-Completion-Rates/131029>.

<sup>4</sup> Chen, X., & Weko, T. (July 2009). *Students who study science, technology, engineering, and mathematics (STEM) in postsecondary education*. Washington, DC: Institute of Education Sciences, National Center for Education Statistics, U.S. Department of Education. <http://nces.ed.gov/pubs2009/2009161.pdf>.

<sup>5</sup> Higher Education Research Institute at UCLA (HERI). (2010 January). *Degrees of success: Bachelor's degree completion rates among initial STEM majors*. <http://www.heri.ucla.edu/nih/downloads/2010%20-%20Hurtado,%20Eagan,%20Chang%20-%20Degrees%20of%20Success.pdf>.

can be compared. STEM education inputs (such as U.S. Census population estimates, postsecondary enrollment rates) and college-readiness measures and STEM education outputs and outcomes (such as historic and projected U.S. labor force demands) are common denominators.

Ultimately, the analytic approach taken to understand the extent to which underrepresented groups are participating in STEM is predicated on research objectives and the availability and accessibility of the data needed to respond to the associated research questions. Using publically available, institution-level longitudinal data, the goal of our trend analysis was (a) to pinpoint specific undergraduate STEM performance gaps between men and women as well as between racial and ethnic minorities and their White and Asian peers; and (b) to identify the types of institutions that have made the most substantial contributions to STEM degree production in the United States toward which federal funding, programs, partnerships and initiatives potentially could be targeted. To these ends, the principal indicators used in our analysis were bachelor's degrees attained (or earned) by student demographic group within and across the STEM disciplines, and bachelor's degrees produced (or conferred or awarded) by type of institution. For each indicator, we explored different ways to represent underrepresentation to paint a fuller picture.

Two overarching research questions and five sub-questions were posed to guide our investigation of the undergraduate STEM education landscape over a 20-year period:

1. To what extent are women and racial and ethnic minorities underrepresented in STEM?
  - **Number of Degrees Earned.** *How have the numbers of STEM bachelor's degrees earned by racial and ethnic minorities and women changed in relation to changes in overall undergraduate enrollment and U.S. population estimates over time?*
  - **Percentage of Degrees Earned.** *How has the share or proportion of STEM bachelor's degrees attained by racial and ethnic minorities and women changed over time across and within the STEM disciplines?*
  - **Performance Gaps.** *Are there bachelor's degree attainment gaps between racial and ethnic groups in specific STEM disciplines? Are there bachelor's degree attainment gaps between men and women in specific STEM disciplines?*
2. How have MSIs contributed to STEM degree production over time?
  - **Number of Degrees Conferred.** *How has the overall number of STEM bachelor's degrees produced by MSIs and non-MSIs changed over time, and does this change vary by institution type?*
  - **Percentage of Degrees Conferred.** *Do MSIs and non-MSIs produce STEM degrees at comparable rates?*

As outlined in more detail in Appendix A, to answer these questions we analyzed extant data collected between 1989 and 2009 by the National Center for Education Statistics' (NCES') Integrated Postsecondary Education Data System (IPEDS) and the U.S. Census Bureau in key programmatic domains that are particularly relevant to the NSF's priorities and mechanisms for broadening

participation.<sup>6</sup> IPEDS is the leading source for data on U.S. colleges, universities, and technical and vocational postsecondary institutions that participate in federal financial aid programs. Domains included undergraduate enrollment and STEM degree completion trends among underrepresented groups at the national level and by institution type, specifically:

- Minority-Serving Institutions (MSIs)
- Historically Black Colleges and Universities (HBCUs)
- Hispanic-Serving Institutions (HSIs)
- Tribal Colleges and Universities (TCUs), Predominantly Black Institutions (PBIs), Non-Minority-Serving Institutions (non-MSIs)

We disaggregated these data by race and ethnicity (Whites, Asian/Pacific Islanders, Blacks, Hispanics, and American Indian/Alaska Natives), sex, and the core STEM disciplines (see Appendix B for a complete list of fields subsumed by the seven core STEM disciplines):

- Agricultural Sciences
- Earth, Atmospheric, and Oceanic Sciences
- Biological Sciences
- Physical Sciences
- Computer Sciences
- Engineering
- Mathematics

This trend analysis is not exhaustive and presents a number of limitations. Primary among these limitations is our exclusion of students with disabilities. We did not include this demographic group primarily for three reasons:

1. **Non-report.** Disability status was not reported in IPEDS prior to 2009, and a large percentage of institutions did not report disability status in the 2009 IPEDS survey. Additionally, postsecondary data on disabilities are frequently excluded in comprehensive institutional records or are confidential
2. **Overreporting and underreporting.** Potentially some degree of overreporting (e.g., to access specialized benefits and services) and/or underreporting (e.g., to avoid stigma) of disability status by students in data gathered by institutions for the *NCES National Postsecondary Student Aid Study (NPSAS)*, *NSF Survey of Earned Doctorates (SED)*, and *NSF Scientists and Engineers Statistical Data System (SESTAT)*.
3. **Varied and noncomparable operational definitions of disability.** According to the Americans with Disabilities Act of 1990, an individual is considered to have a disability if he or she has a physical or mental impairment that substantially limits one or more of his or

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<sup>6</sup> <http://www.nsf.gov/od/broadeningparticipation/bp.jsp>

her major life activities; and/or has a record of such impairment, or is regarded as having such an impairment. However, operational definitions of both physical and mental disability are many, varied, and not necessarily comparable.

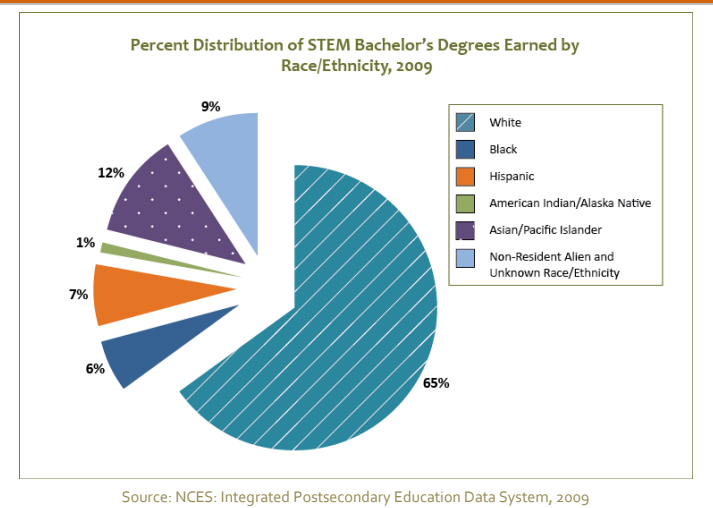
A second limitation was the exclusion of proprietary (i.e., for-profit) and two-year institutions from our analysis of STEM degree production. Third, we did not compare STEM degree attainment or degree production to non-STEM disciplines. Fourth, due to IPEDS data limitations, this analysis considered neither student persistence, retention, nor attrition within or across the STEM disciplines nor college readiness (e.g., the rigor of secondary STEM coursework, math achievement test results). Fifth, we did not investigate the relationship between institutional capacities on STEM degree production (e.g., STEM faculty full-time equivalent, introductory STEM course offerings). Sixth, the trends presented here are purely descriptive. Running statistical tests of significance was considered beyond the scope of the present study. Last, although we share some inferences as we discuss the findings, attributing or uncovering the factors that contribute to the trends discussed in this report was not a focus of this exercise.

This section of the report is divided into two parts. We first discuss what the trend data tell us in terms of STEM degree attainment among underrepresented minorities and women and STEM degree production by MSIs. Second, we discuss what the trend data do not tell us but what would be helpful to know to broaden participation in STEM.

## What the Trend Data Tell Us

Recent job projections published by the Bureau of Labor Statistics indicate that even though STEM occupations presently represent a mere 6 percent of the U.S. labor market, they represent nearly a quarter (24 percent) of the top 25 fastest growing occupations that require a bachelor’s degree at the entry level. Collectively, the six occupations that comprise this 24 percent—biomedical engineers, database administrators, software developers, computer systems analysts, environmental engineers and geoscientists—are projected to increase demand for new workers at a rate of 31 percent by 2020. Biomedical engineers are projected to be the fastest growing among these occupations, with 62 percent projected growth between 2010 and 2020. Comparatively, the projected growth rate averaged over all occupations for the period 2010 to 2020 is just 14 percent<sup>7</sup>.

**FIGURE 1. THE STATE OF STEM FAST FACTS**



Whereas collectively, Blacks (12%), Hispanics (16%), and American Indian/Alaska Natives (1%) are estimated to represent 29 percent of the U.S. population according to U.S. Census data, in 2009, underrepresented minorities comprised less than 14 percent of the STEM bachelor’s degree attainment pool.

Against these projections, we find that higher education is not producing enough STEM graduates to meet these projected labor market demands. In fact, national bachelor’s degree attainment trends in STEM are not promising for any demographic group, including Whites and Asian/Pacific Islanders. As we will illustrate in this section of the report, between 1989 and 2009, Blacks, Hispanics, and women were underrepresented in the domestic pipeline to STEM careers when compared to U.S. Census population estimates, overall undergraduate enrollment, and overall bachelor’s degree attainment rates. For instance, although collectively, Blacks, Hispanics, and American Indian/Alaska Natives are estimated to represent 29 percent of the U.S. population, together these demographic

groups comprised less than 14 percent of the STEM bachelor’s degree attainment pool (Figure 1). Furthermore, the percentage of all bachelor’s degrees earned in a STEM discipline did not realize noteworthy growth over time for all underrepresented minorities (URMs) as well as Whites—falling far short of the gains needed to meet projected labor market demands in 2020. Among Asian/Pacific Islander students, the percentage of bachelor’s degrees earned in STEM declined over time. When disaggregated by STEM discipline, the trend data reveal pronounced and persistent performance gaps between Whites and URMs, between men and women, and between White women and White men.

<sup>7</sup> Bureau of Labor Statistics, U.S. Department of Labor. *Occupational outlook handbook, 2012–13 ed.*, <http://www.bls.gov/ooh> (visited July 23, 2012).

Trend data on STEM degree production at MSIs is more promising. Although non-MSIs produce a greater number of Black and American Indian/Alaska Native STEM graduates, HBCUs produced a larger percentage of STEM degrees among Black students, and TCUs have steadily increased their production of American Indian/Alaska Native STEM graduates, while the percentage of STEM degrees among American Indian/Alaska Natives at non-MSIs remained virtually unchanged. HSIs produced Hispanic STEM graduates at comparable levels to non-MSIs.

We share these trend data on national STEM bachelor's degree attainment among racial and ethnic minorities and women and STEM bachelor's degree production at MSIs in greater detail in this section of the report.



## To what extent are women and racial and ethnic minorities underrepresented in STEM?

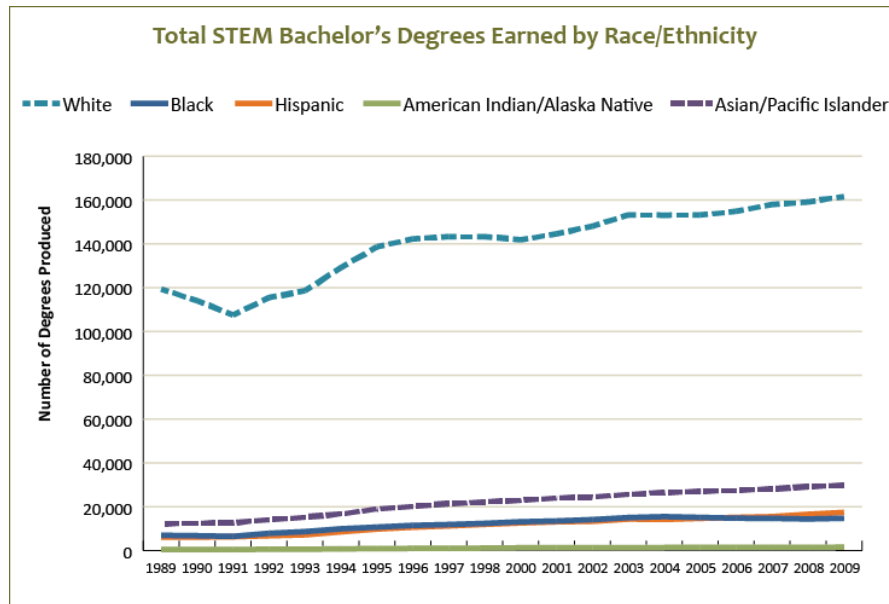
### URMs and women earned an increasingly larger number of STEM bachelor's degrees over time.

To set the stage for our trend analysis, we first reflected on the state of undergraduate STEM education from an overall view by asking how the *raw numbers* of STEM bachelor's degrees have changed. Between 1990 and 2009, the total number of STEM bachelor degrees awarded to students in all racial/ethnic groups increased (Figures 2 and 3). Among racial/ethnic minorities, the total number of STEM bachelor's degrees awarded to Asian/Pacific Islanders has outpaced that of the other minorities and has more than doubled in this time period. Similarly, the numbers of STEM degrees earned by Black students more than doubled between 1989 and 2004, at which point the degree completions reached a plateau. In 2009, Hispanic students earned almost three times more STEM degrees than in 1990. The number of American Indian/Alaskan Native STEM degree recipients continues to be relatively low but is growing at a slightly faster pace than the other groups. The number of STEM bachelor's degrees earned by this group more than tripled (from 485 to 1,518). The trend lines also show that the number of STEM bachelor's degrees attained for all groups except Blacks have increased over time. The number of degrees received by Blacks essentially leveled off around 2005 and has remained fairly constant since that time.

### HOW HAVE THE NUMBERS OF STEM BACHELOR'S DEGREES EARNED BY RACIAL AND ETHNIC MINORITIES AND WOMEN CHANGED IN RELATION TO CHANGES IN OVERALL UNDERGRADUATE ENROLLMENT AND U.S. POPULATION ESTIMATES OVER TIME?

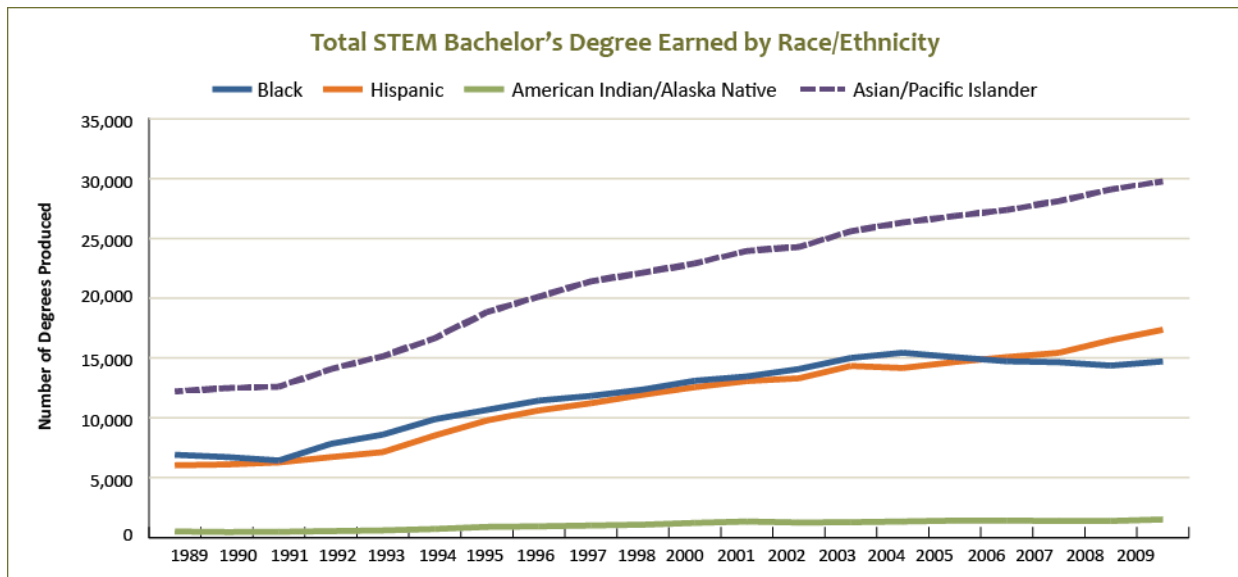
- Underrepresented minorities and women earned an increasingly larger number of STEM bachelor's degrees over time.
- The growth in the number of STEM bachelor's degrees earned by Blacks, Hispanics, and women did not keep pace with population growth, undergraduate enrollment, overall bachelor's degree attainment, and projected STEM labor market growth rates

FIGURE 2. STEM BACHELOR’S DEGREES BY RACE/ETHNICITY



Source: NCES: Integrated Postsecondary Education Data System, 1989–2009

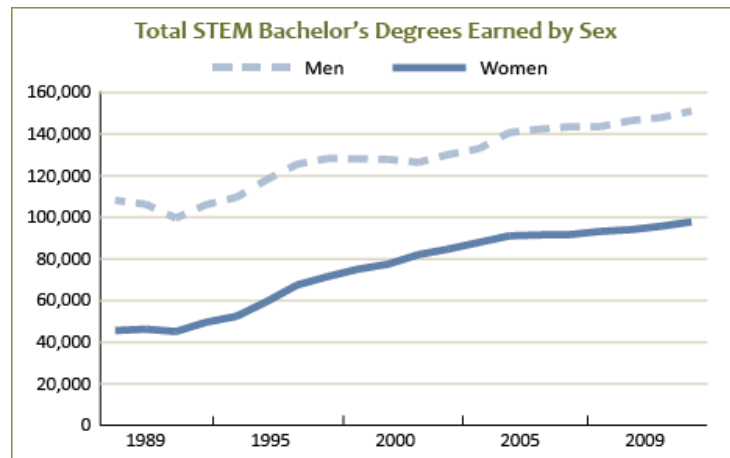
FIGURE 3. URM STEM BACHELOR’S DEGREES



Source: NCES: Integrated Postsecondary Education Data System, 1989–2009

Trend data show that the number of STEM bachelor’s degrees earned by women also increased steadily over time. By 2009, women were earning more than twice as many STEM degrees than in 1989 (Figure 4).

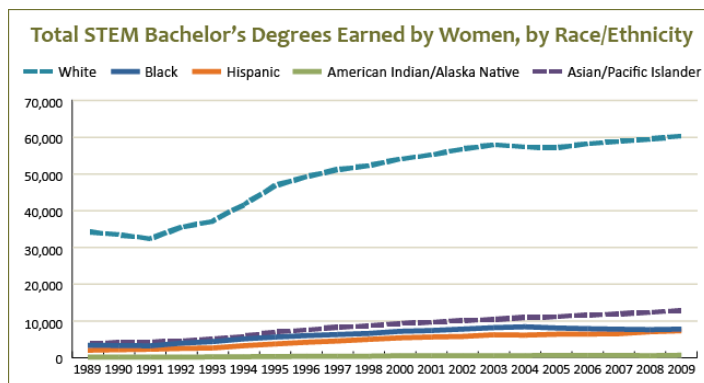
**FIGURE 4. STEM BACHELOR'S DEGREES BY SEX**



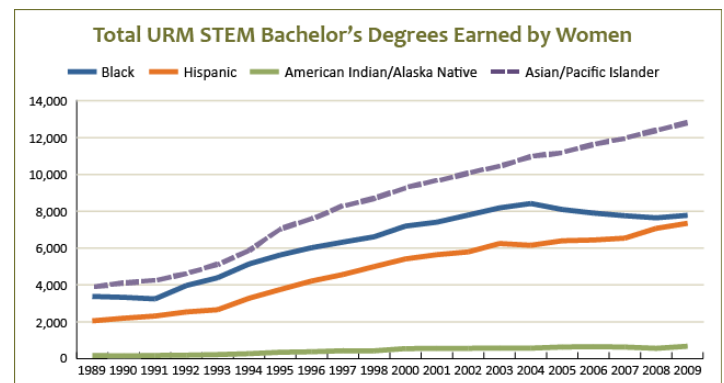
Source: NCES: Integrated Postsecondary Education Data System, 1989-2009

When the numbers of STEM degrees earned by women are disaggregated by race and ethnicity (Figures 5 and 6), the trend data indicate that American Indian/Alaska Native women earned more than four times as many STEM degrees in 2009 than in 1990 (increasing from 147 in 1990 to 674 in 2009), Hispanic and Asian/Pacific Islander women earned approximately three times as many STEM degrees in 2009 as in 1989, and Black women more than doubled the number of STEM degrees earned during the time frame. It should be noted that unlike the other racial/ethnic groups, the number of bachelor's degrees earned by Black women reached a plateau in 2004. Because of their larger representation in the undergraduate population, it is not surprising that White women are earning substantially more STEM degrees than women in the other racial/ethnic groups.

**FIGURE 5. TOTAL STEM BACHELOR'S DEGREES EARNED BY WOMEN, BY RACE/ETHNICITY**



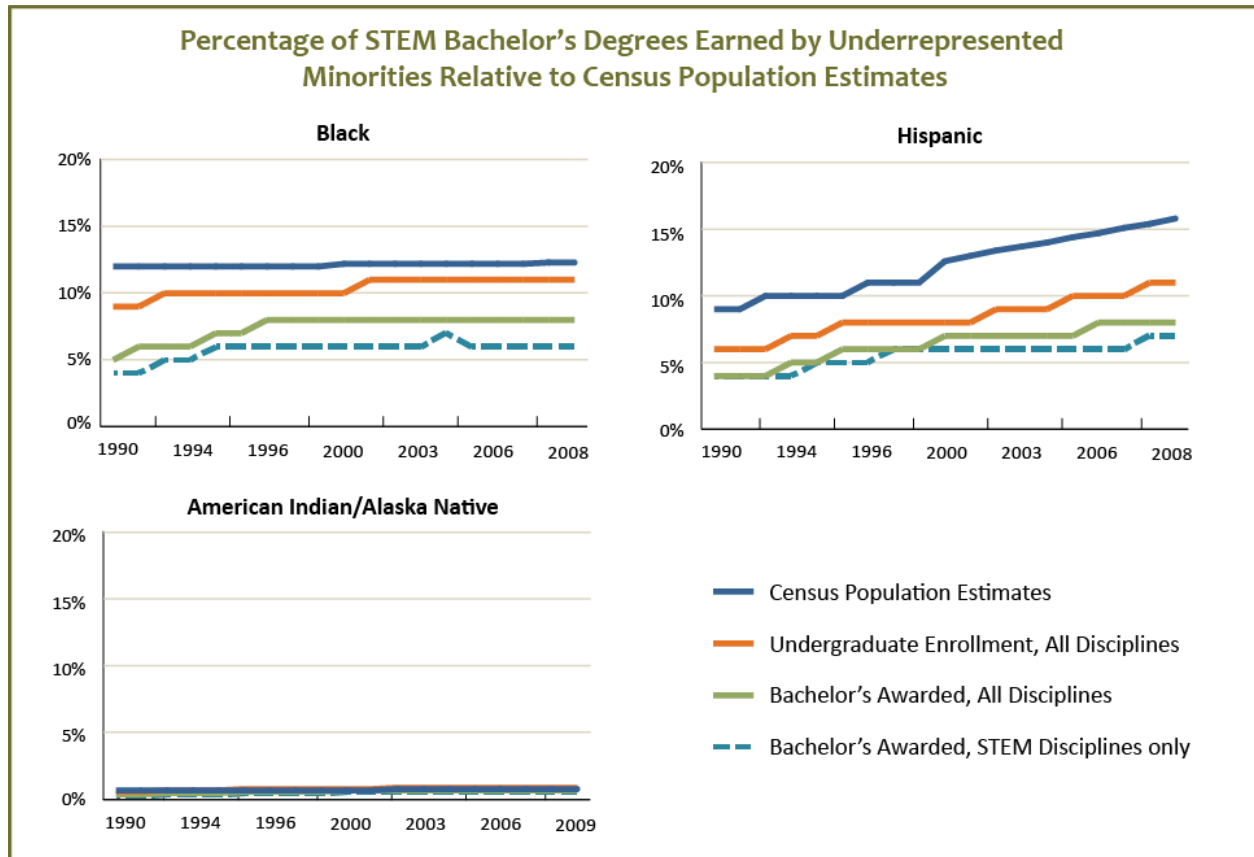
**FIGURE 6. TOTAL URM STEM BACHELOR'S DEGREES EARNED BY WOMEN**



Source: NCES: Integrated Postsecondary Education Data System, 1989-2009

**The growth in the number of STEM bachelor's degrees earned by Blacks, Hispanics, and women did not keep pace with population growth, undergraduate enrollment, overall bachelor's degree attainment, and projected STEM labor market growth rates.** Although the trend data show an increase in the number of degrees earned by URMs and women, these data tell only part of the story. The increase in numbers might simply be a reflection of the increase in enrollment over time and, consequently, it is plausible that, as more URMs and women pursue postsecondary education, a natural increase would occur in the number of students receiving STEM degrees. To explore this plausibility, we compared bachelor's degree attainment rates to undergraduate enrollment rates, overall bachelor's degree completion rates, and U.S. Census population estimates. As shown in Figure 7, the participation of Black and Hispanic students declines as they move throughout the higher education system. The percentage enrolled in undergraduate education was consistently less than each demographic group's representation in the U.S. population, the percentage earning bachelor's degrees was less than the percentage enrolled, and the percentage earning a bachelor's degree in a STEM discipline was even lower.

**FIGURE 7. URM STEM BACHELOR'S DEGREES RELATIVE TO POPULATION ESTIMATES**

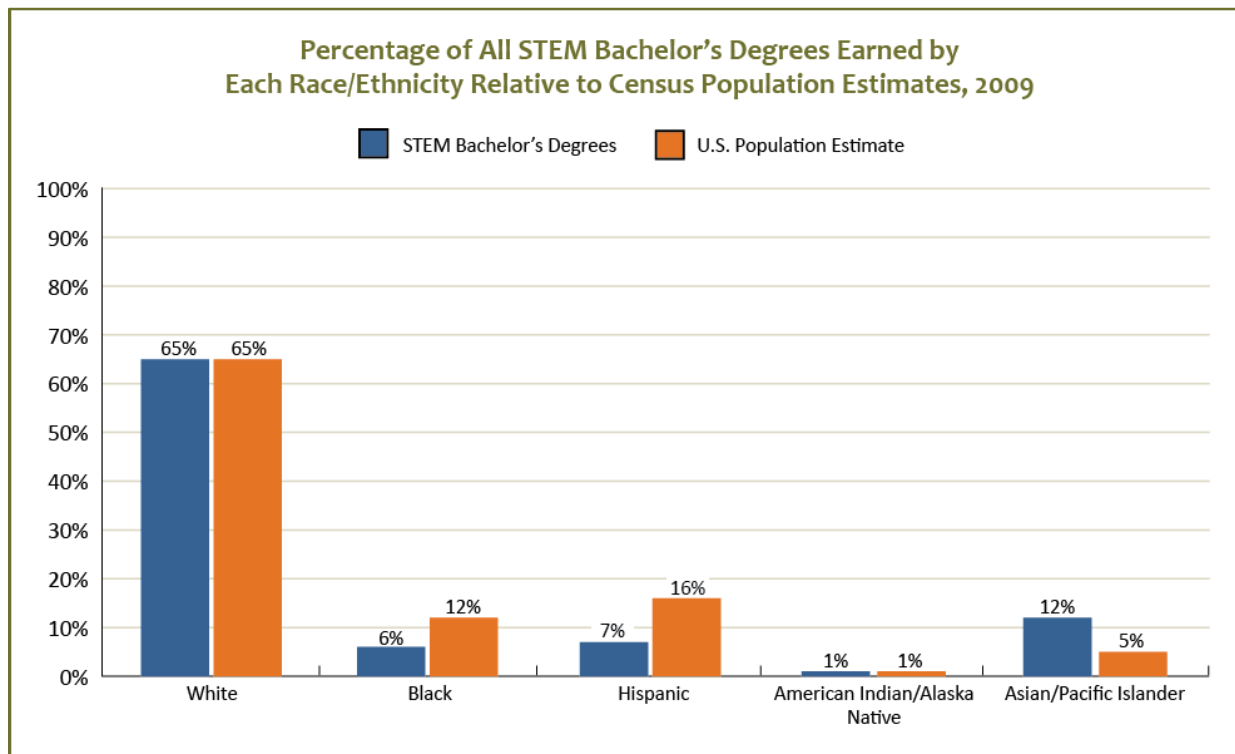


Source: U.S. Census Bureau: Population Estimates, 1990–2009; NCES: Integrated Postsecondary Education Data System, 1990–2009

For example, in 2008, Blacks were approximately 12 percent of the total population, represented about 11 percent of all undergraduate enrollments, received around 9 percent of all bachelor's degrees conferred, but obtained only 6 percent of all STEM degrees conferred. Black bachelor's degree attainment in a STEM discipline grew by less than 3 percentage points over the 20-year period—far from the 31 percent growth needed to fulfill the average projected labor market demand for the fastest growing STEM occupations discussed previously. This trend held true for Hispanics as well, confirming that both racial/ethnic groups are indeed underrepresented in STEM.

Comparatively, as illustrated in Figure 8, in 2009 American Indian/Alaska Natives earned 1 percent of all STEM bachelor's degrees, on par with their U.S. population estimate of 1 percent. Whites earned 65 percent of all STEM bachelor's degrees, on par with their U.S. population estimate of 65 percent. Asian/Pacific Islanders, however, earned 12 percent of STEM degrees—a considerably higher rate than their U.S. population estimate of 5 percent.

**FIGURE 8. STEM BACHELOR'S DEGREES RELATIVE TO POPULATION ESTIMATES, 2009**

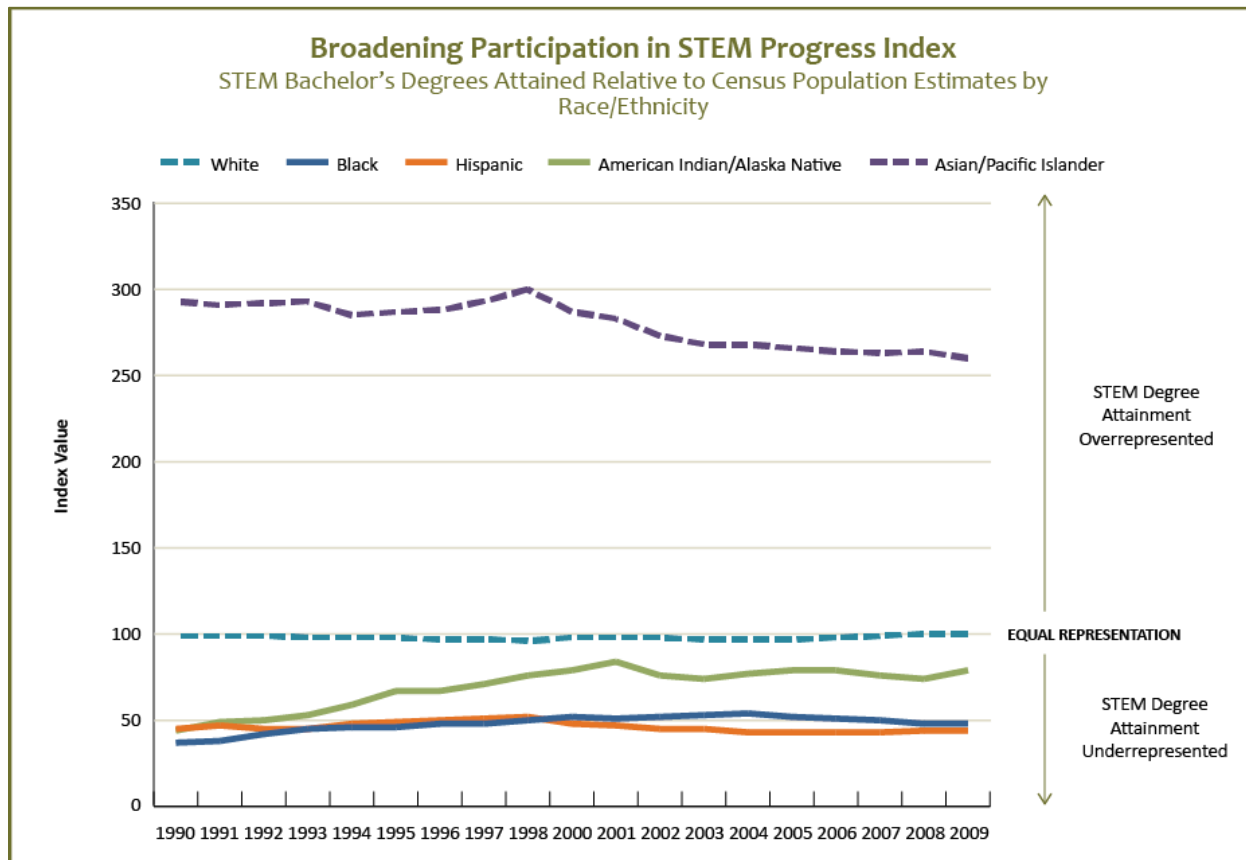


Source: U.S. Census Bureau: Population Estimates, 1990 – 2009; NCES: Integrated Postsecondary Education Data System, 2009

We developed a composite indicator to graphically represent the relationship between STEM degree attainment and U.S. Census population estimates over time. This index, our *Broadening Participation in STEM Progress Index* (Figure 9) compares the percentage of all STEM bachelor's degrees earned by each race/ethnicity group to U.S. Census population estimates for each racial/ethnic group over time. The index demonstrates that between 1990 and 2009, Whites realized equal representation in STEM by consistently earning STEM degrees at rates comparable to their U.S. Census population estimates. During this same time frame, Asian/Pacific Islanders were overrepresented in STEM, while Blacks and Hispanics were underrepresented. *Among the historically underrepresented minority groups, only American Indian/Alaska Natives experienced steady growth.*



**FIGURE 9. BROADENING PARTICIPATION IN STEM PROGRESS INDEX: RACE/ETHNICITY**

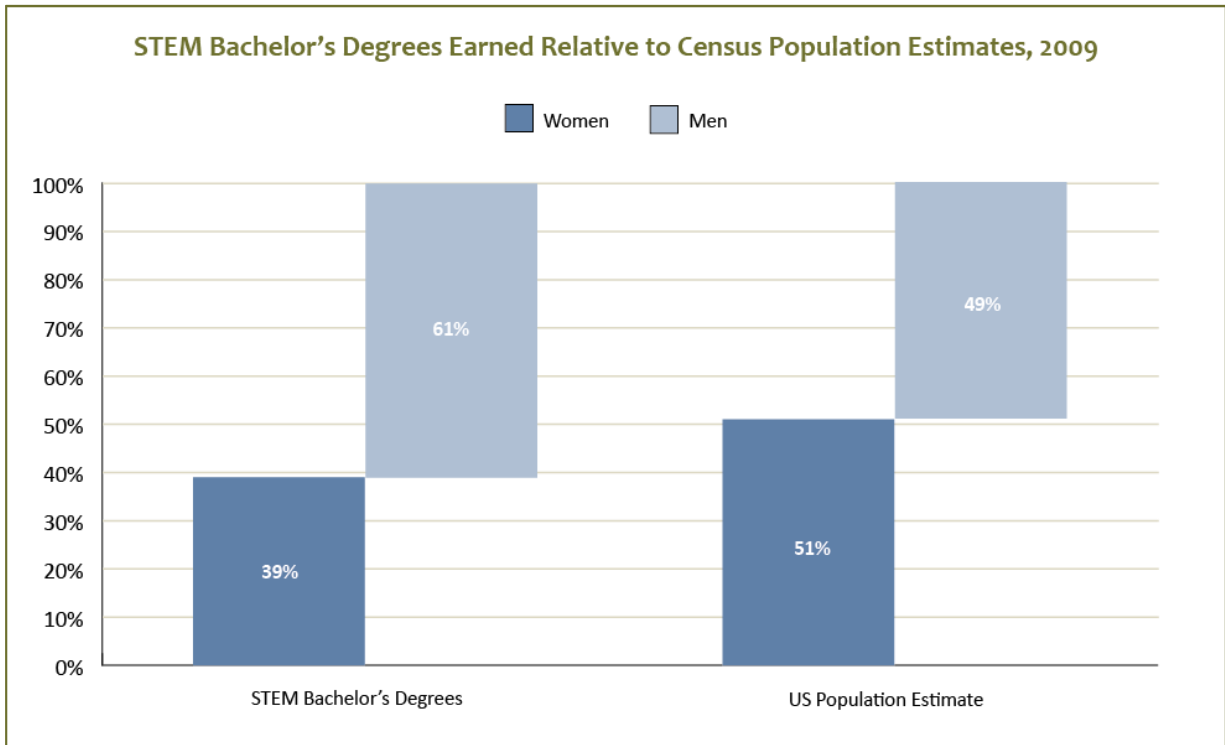


NOTE: Index calculated by percentage of all STEM bachelor’s degrees earned by each race/ethnicity in each year divided by the estimated percentage of each race/ethnicity represented in the U.S. population for each year.

Source: U.S. Census Bureau: Population Estimates, 1990–2009; NCES: Integrated Postsecondary Education Data System, 1990–2009

Women were also underrepresented among STEM bachelor’s degree recipients. As shown in Figure 10, in 2009, women were approximately 51 percent of the U.S. population but only 39 percent of STEM degree recipients, well below the percentage of STEM degrees earned by men (61 percent). This gap between male and female STEM bachelor’s degree attainment was 22 percent.

**FIGURE 10. STEM BACHELOR'S DEGREES RELATIVE TO POPULATION ESTIMATES BY SEX, 2009**



Source: U.S. Census Bureau: Population Estimates, 1990–2009; NCES: Integrated Postsecondary Education Data System, 1990–2009

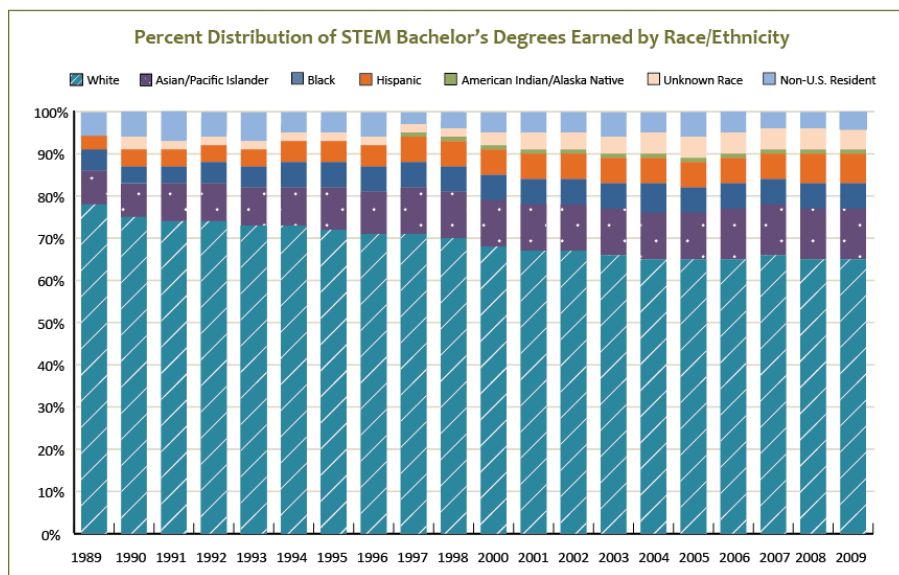
**URMs and women earned an increasingly larger share of STEM bachelor's degrees until leveling off between 2000 and 2009.**

As seen in Figure 11, URM earned a greater share of STEM bachelor's degrees. Specifically, they increased their share by 5 percentage points from about 9 percent in 1989 to about 14 percent in 2009. This growth appears to level off by 2004 for American Indian/Alaska Natives, Blacks, and Hispanics.

**HOW HAS THE SHARE OR PROPORTION OF STEM BACHELOR'S DEGREES ATTAINED BY RACIAL AND ETHNIC MINORITIES AND WOMEN CHANGED OVER TIME ACROSS AND WITHIN THE STEM DISCIPLINES?**

- URM and women earned an increasingly larger share of STEM bachelor's degrees until leveling off between 2000 and 2009.
- The percentage of all bachelor's degrees earned in STEM by URM within each racial/ethnic group has remained essentially unchanged over time for all URM groups and Whites; among Asian students, this percentage has declined over time.

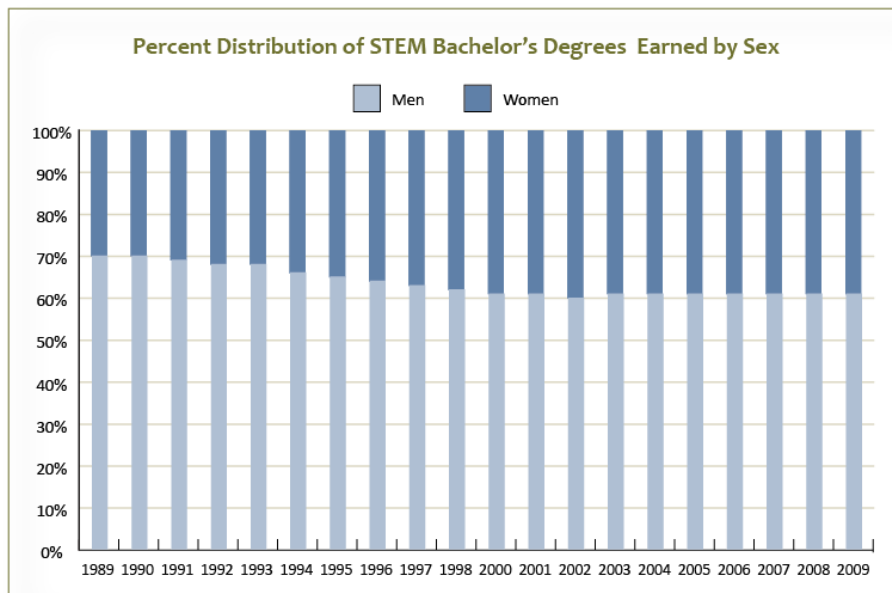
**FIGURE 11. PERCENT DISTRIBUTION OF STEM BACHELOR'S DEGREES BY RACE/ETHNICITY**



Source: NCES: Integrated Postsecondary Education Data System, 1989–2009

The data reveal that this was the case for women as well. Between 1989 and 2009, women earned an increasingly larger share of all STEM bachelor's degrees. Their share increased over time from roughly 30 percent in 1989 to 39 percent in 2009 (Figure 12). However, it is important to note that most of this growth occurred between 1989 and 2000, with little change between 2000 and 2009. The plateaus reached by URM and women in 2001 may be due to declines in high-tech employment and venture funding as well as the U.S. recession experienced during that time period.

**FIGURE 12. PERCENT DISTRIBUTION OF STEM BACHELOR'S DEGREES BY SEX**

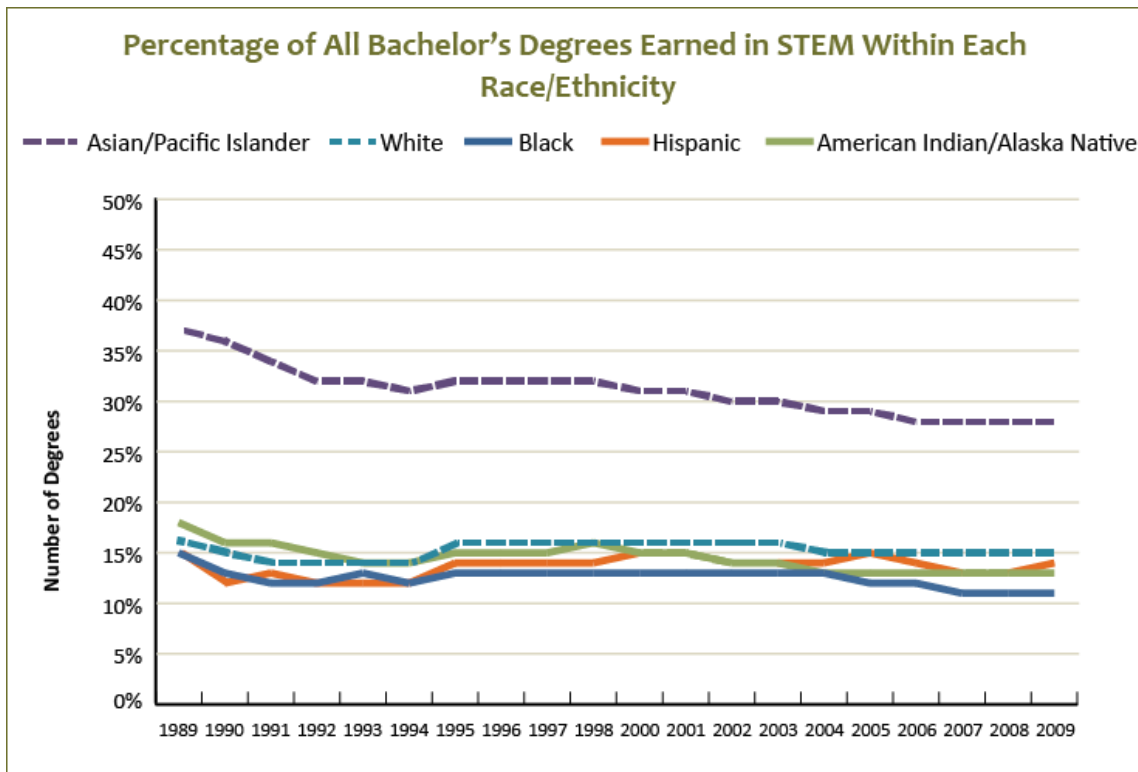


Source: NCES: Integrated Postsecondary Education Data System, 1989–2009

The percentage of all bachelor's degrees earned in STEM by URM*s* within each racial/ethnic group has remained essentially unchanged over time for all URM groups and Whites; among Asian students, this percentage has declined over time. To complement this analysis, we investigated whether there has been an increase in the percentage of bachelor's degrees awarded to underrepresented groups in STEM as a proxy for STEM's popularity among U.S. undergraduates—that is, whether URM*s* and women found earning a STEM degree more attractive over time. The results are not encouraging.<sup>8</sup> As illustrated in Figure 13, the trends show little change in the percentage of bachelor's degrees earned in STEM by URM*s* and Whites over the entire 20-year period.

<sup>8</sup> The findings may be explained by additional factors such as poor preparedness for postsecondary STEM coursework.

**FIGURE 13. PERCENTAGE OF STEM BACHELOR’S DEGREES WITHIN RACE/ETHNICITY**

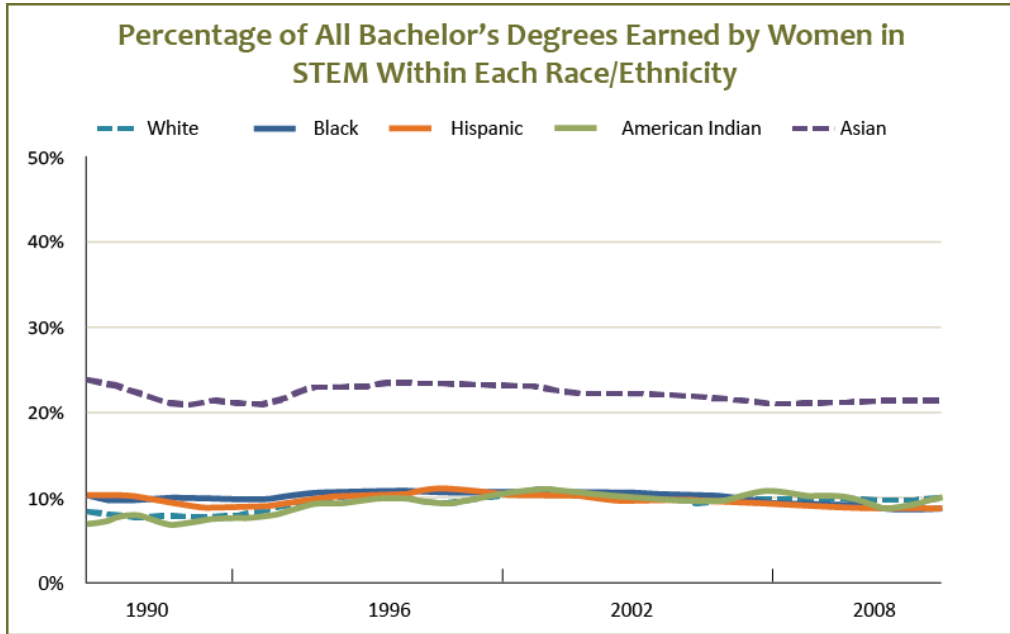


Source: NCES: Integrated Postsecondary Education Data System, 1989–2009

Specifically, of all bachelor’s degrees awarded to Black students in 1989, 13 percent were in STEM disciplines. In 2009, 11 percent of all bachelor’s degrees awarded to Blacks were in STEM. The trend is similar for Hispanic students (16 percent in 1990 and 13 percent in 2009) as well as for American Indian/Alaska Native students, who earned 12 percent of all bachelor’s degrees in STEM in 1989 and 14 percent in 2009. Interestingly, a similar trend also emerged for White students. *Although they earn the largest number of STEM degrees of all racial/ethnic groups, the percentage of bachelor’s degrees earned in STEM among Whites experienced little growth. Furthermore, the percentage of STEM degrees earned by Asian/Pacific Islander students decreased from 36 percent in 1989 to 28 percent in 2009.*

We performed a similar analysis of the growth in the percentage of bachelor’s degrees earned in STEM by women within each racial/ethnic group (Figure 14). Here the data show that the percentage of degrees earned in *STEM disciplines by women also experienced little growth*. Thus, all racial and ethnic groups had little change in the percentage of STEM degrees earned out of the total bachelor’s degrees awarded. With the exception of Asian/Pacific Islander women, the percentage of STEM degrees earned has remained around 10 percent across the time period.

**FIGURE 14. PERCENTAGE OF FEMALE STEM BACHELOR'S DEGREES EARNED WITHIN EACH RACE/ETHNICITY**



Source: NCES: Integrated Postsecondary Education Data System, 1989–2009

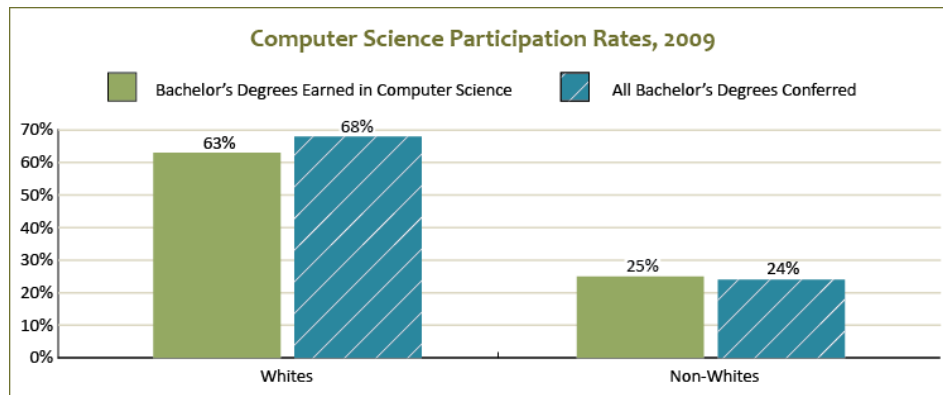
**The gap between Whites and URMs is widest in the agricultural sciences and in the earth, atmospheric, and oceanic sciences.**

Measuring the success of efforts to broaden participation in STEM can be misleading when analyzing the STEM disciplines in the aggregate, as overall trends mask some interesting variations. *When disaggregated by STEM discipline, the trend data reveal pronounced STEM degree attainment gaps between Whites and URMs, between men and women, and between White women and White men.* Because Whites represent approximately 65 percent of the pool of STEM bachelor's degree completions in 2009, we first considered the disparity between White and non-White (i.e., all racial/ethnic minority groups: Blacks, Hispanics, Asian/Pacific Islanders, and American Indian/Alaska Natives) performance in the STEM disciplines by developing a composite index that uses earned bachelor's degrees as a reference point. Proposing a participation goal that students in each demographic group earn STEM bachelor's degrees at the same rate as they attain overall bachelor's degrees, our *STEM Discipline Parity Index* reflects the difference between the 2009 STEM participation rates of non-Whites—Blacks, Hispanics, American Indian/Alaska Natives, and Asian/Pacific Islanders—and Whites. The STEM participation rate is the ratio between the percentage of students within a given demographic group who earned a STEM bachelor's degree and the percentage of overall bachelor's degrees attained by that demographic group, whereby full participation would yield a rate of 100 percent. For example, Whites were slightly *underrepresented* in the pool of computer science graduates in 2009 because they earned 68 percent of all bachelor's degrees conferred but only 63 percent of all computer science degrees yielding a 93 percent participation rate. Non-Whites, on the other hand, were marginally *overrepresented* with a participation rate of 105 percent because they earned 24 percent of all bachelor's degrees but 25 percent of all computer science degrees (Figure 15).

**ARE THERE BACHELOR'S DEGREE ATTAINMENT GAPS BETWEEN RACIAL AND ETHNIC GROUPS IN SPECIFIC STEM DISCIPLINES? ARE THERE BACHELOR'S DEGREE ATTAINMENT GAPS BETWEEN MEN AND WOMEN IN SPECIFIC STEM DISCIPLINES?**

- **The gap between Whites and URMs is widest in the agricultural sciences and the earth, atmospheric, and oceanic sciences.**
- **The gender gap is widest in engineering and the computer sciences.**
- **The biological sciences and agricultural sciences are the only STEM disciplines in which women have reached parity and surpassed men.**
- **A sizeable performance gap exists between White women and White men in the physical sciences; computer science; engineering; and the earth, atmospheric, and oceanic sciences.**

**FIGURE 15. COMPUTER SCIENCE PARTICIPATION RATES, 2009**

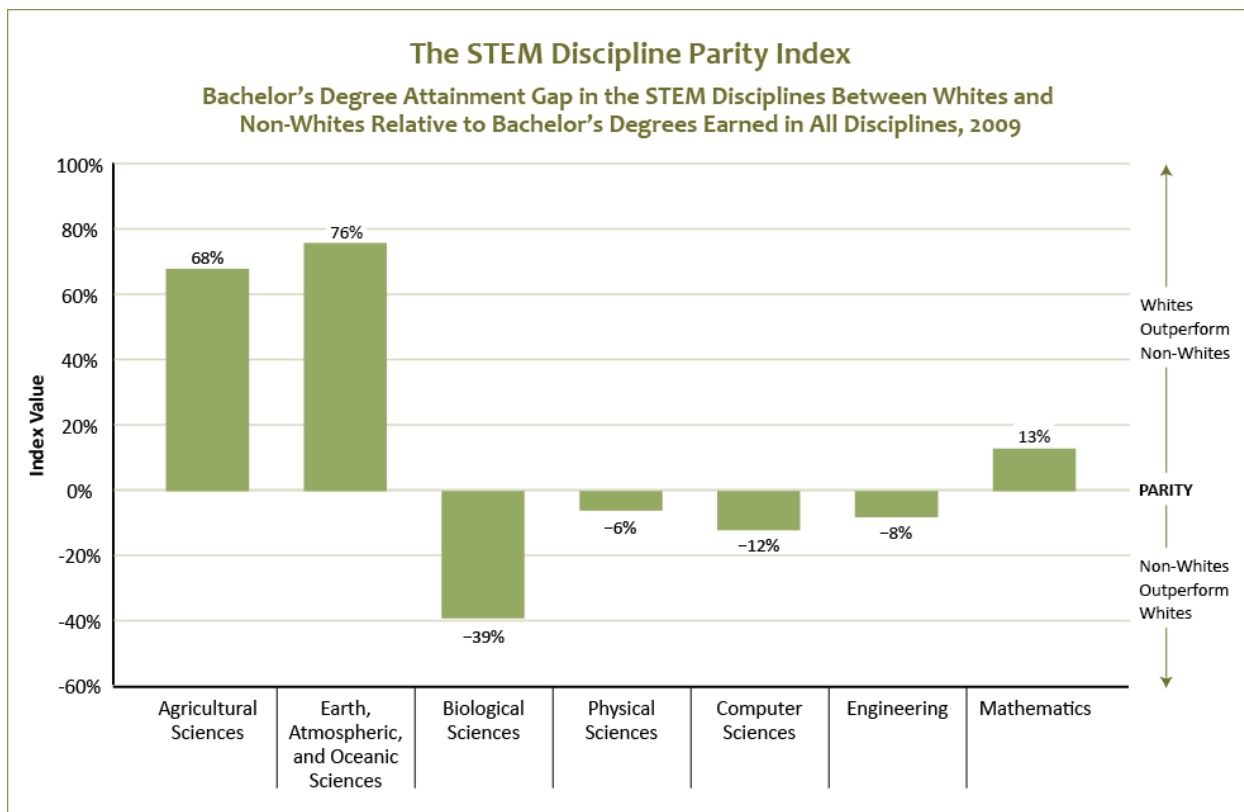


Source: NCES: Integrated Postsecondary Education Data System, 2009

Accordingly, as illustrated in Figure 16, the gap between Whites and non-Whites is greatest as the index approaches 100 percent, parity is reached at 0 percent when both Whites and non-Whites reach full participation, and a negative index value indicates that non-Whites outperform Whites, earning STEM degrees at a higher rate than their representation in the pool of overall bachelor's degree recipients. This index graph indicates that the gap between Whites and non-Whites was widest in the Agricultural Sciences; Earth, Atmospheric, and Oceanic Sciences; and Mathematics disciplines in 2009. Comparatively, non-Whites outperformed Whites in the remaining disciplines earning bachelor's degrees in the biological sciences, computer sciences, physical sciences, and engineering at rates that exceeded their overall bachelor's degree attainment rate of 24 percent.



**FIGURE 16. THE STEM DISCIPLINE PARITY INDEX**

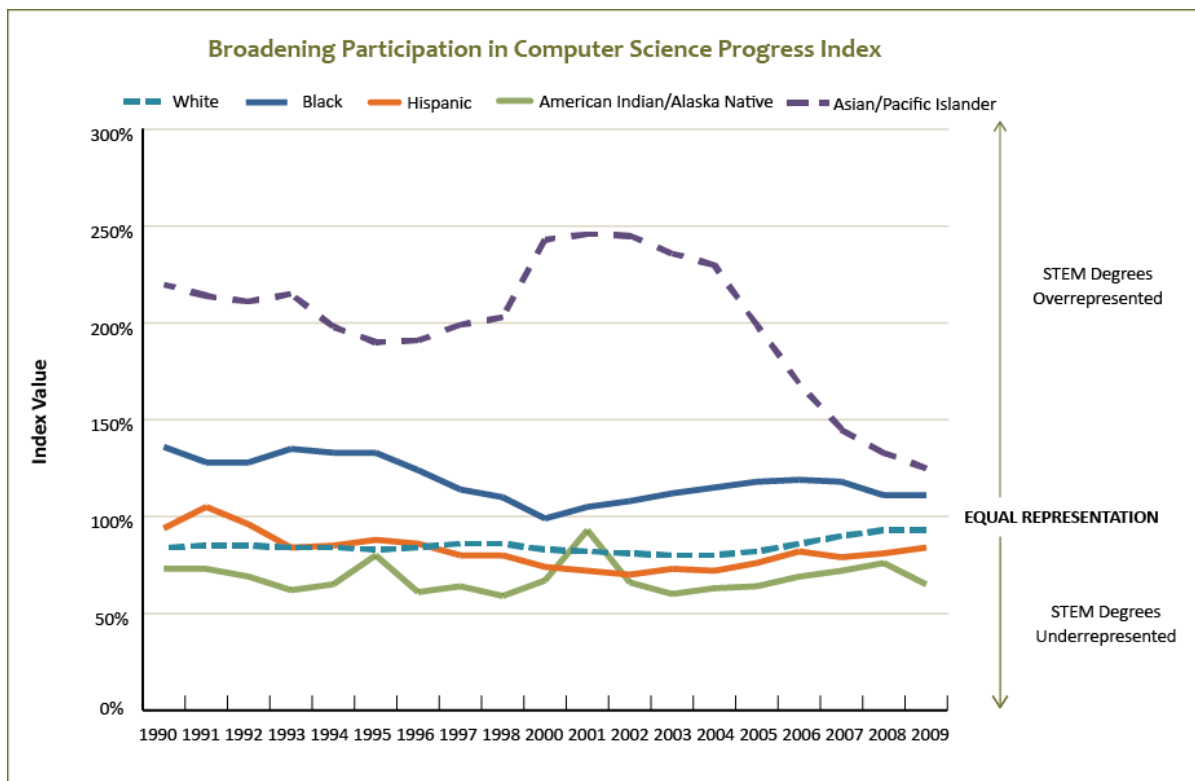


NOTE: “Non-White” = Black, Hispanic, American Indian/Alaska Native, and Asian/Pacific Islander. Parity index calculated by subtracting the STEM participation rates of non-Whites from Whites for each discipline. Participation rate is the percentage of STEM bachelor’s degrees earned by each demographic group (i.e., White and non-White) in each discipline in 2009, divided by the percentage of all bachelor’s degrees conferred earned by each demographic group in 2009.

Source: NCES: Integrated Postsecondary Education Data System, 2009

When disaggregated by race and ethnicity, an index such as the one shown in Figure 17, which we developed and refer to as the *Broadening Participation in Computer Science Progress Index*, can more clearly and accurately highlight the extent to which specific groups are underrepresented or overrepresented in a STEM discipline over time. This index compares the percentage of STEM bachelor’s degrees earned in computer science by each racial/ethnic group to U.S. Census population estimates for each group over time. With 100 percent indicating equal representation in the pool of graduates in 2009, this graphic illustrates that Asian/Pacific Islanders and Blacks are overrepresented in computer science, Asian/Pacific Islanders experienced a sharp decline in the 2000s, and that Whites are approaching equal representation in computer science (an 80-percent index value in 2004 to a 93-percent index value in 2009).

FIGURE 17. BROADENING PARTICIPATION IN COMPUTER SCIENCE PROGRESS INDEX

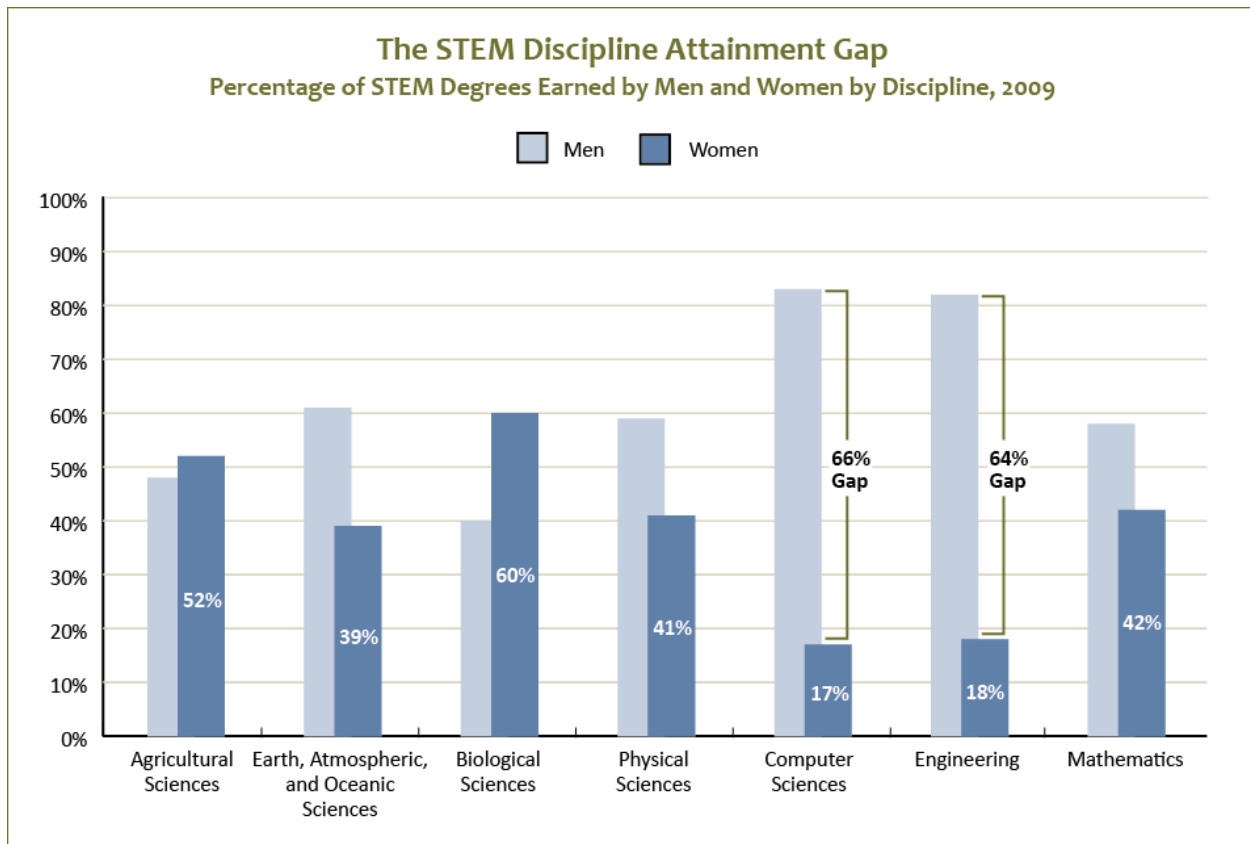


NOTE: Progress index calculated by dividing the percentage of all STEM bachelor’s degrees earned in computer science by each race/ethnicity for each year by the percentage of each race/ethnicity in the U.S. population for each year.

Source: NCES: Integrated Postsecondary Education Data System, 1990 - 2009

**The biological sciences and agricultural sciences are the only STEM disciplines in which women have reached parity and surpassed men; the gender gap is widest in engineering and the computer sciences.** When STEM bachelor’s degree attainment gaps are examined by sex and discipline (Figure 18), the data show that men are earning a larger share of degrees than women in all disciplines except the biological and agricultural sciences. In 1989, men and women were earning bachelor’s degrees in the biological sciences at comparable rates (4 percent). Since that time, the gender gap widened as the degrees earned in the biological sciences by women increased and those earned by men decreased. In the agricultural sciences, men earned degrees at a higher rate than women in 1989, but by 2009, the percentage of degrees earned by women slightly surpassed that of men. Little change occurred in the remaining disciplines. This graph also illustrates that the gender gap is widest in engineering and computer sciences.

**FIGURE 18. THE STEM DISCIPLINE ATTAINMENT GAP BY SEX, 2009**

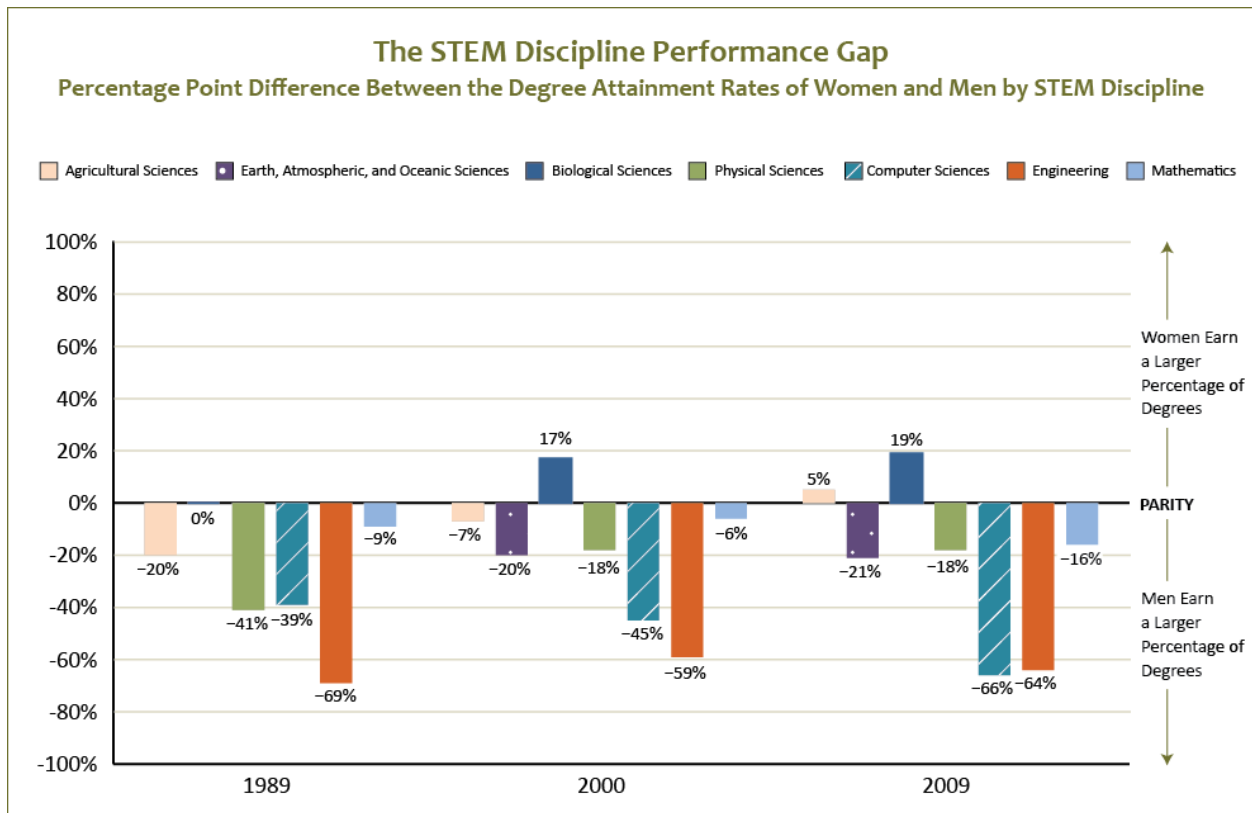


NOTE: Complete gap calculated by subtracting the percentage of all STEM bachelor’s degrees earned by men in each discipline from the percentage of all STEM bachelor’s degrees earned by women in each discipline in 2009.

Source: NCES: Integrated Postsecondary Education Data System, 2009

Moreover, we developed a composite indicator which we refer to as the *STEM Discipline Performance Gap* to explore degree attainment differences over time. The indicator reflects the difference between female and male bachelor’s degree attainment rates in each of the STEM disciplines in 1989, 2000, and 2009. Figure 19 illustrates that the biological sciences and agricultural sciences are the only STEM disciplines in which women reached parity and surpassed men in terms of the number and proportion of degrees earned between 1989 and 2009. The graph also indicates alarmingly that the bachelor’s degree *performance gap between men and women actually increased over time in the computer sciences*. Figure 20 highlights this trend.

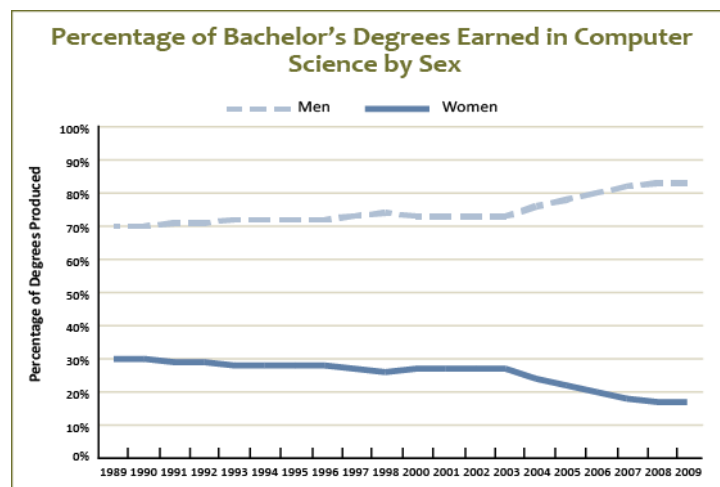
**FIGURE 19. THE STEM DISCIPLINE PERFORMANCE GAP BY SEX, 1989 - 2009**



NOTE: Attainment gap calculated by percentage of all STEM bachelor's degrees earned in each discipline by men in each year subtracted from the percentage of all STEM bachelor's degrees earned in each discipline by women in each year.

Source: NCES: Integrated Postsecondary Education Data System, 1989-2009

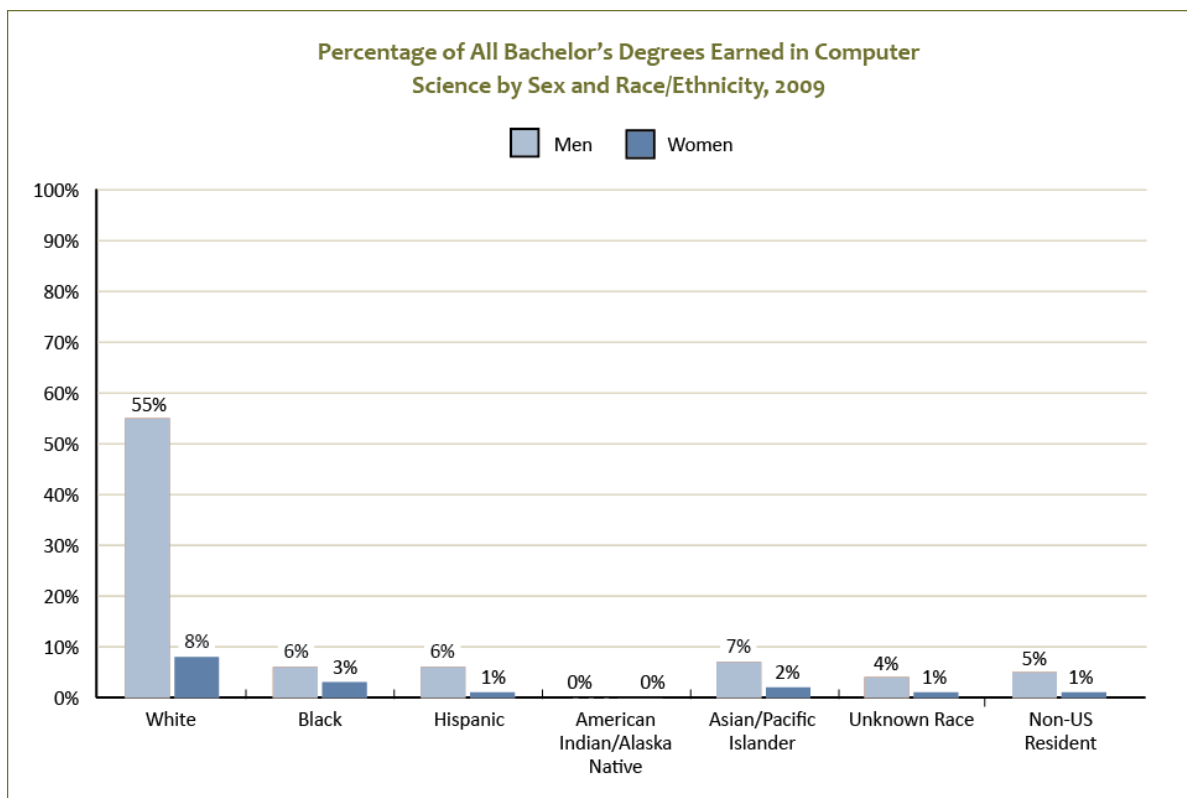
**FIGURE 20. COMPUTER SCIENCE DEGREES BY SEX**



Source: NCES: Integrated Postsecondary Education Data System, 1989-2009

A sizeable performance gap exists between White women and White men in the physical sciences; computer science; engineering; and the earth, atmospheric, and oceanic sciences. This gap is not found among their minority peers. *The gap is widest in the computer sciences* (Figure 21). In 2009, White men earned 55 percent of all bachelor's degrees awarded in the computer sciences while White women earned just 8 percent, representing a 47 percent performance gap. Comparatively, the gap between Black men (6 percent attainment rate) and Black women (3 percent attainment rate) was 3 percent; 5 percent between Hispanic men (6 percent attainment rate) and Hispanic women (1 percent attainment rate); 5 percent between Asian and Pacific Islander men (7 percent) and women (2 percent); and no gap occurred between American Indian/Alaska Native men and women (<1 percent attainment rate).

**FIGURE 21. COMPUTER SCIENCE DEGREES BY RACE/ETHNICITY AND SEX**



## How Have Minority-Serving Institutions Contributed to STEM Degree Production Over Time?

Although the national landscape is not as promising as one might hope, due to labor market projections for 2020, trend data on STEM degree production among underrepresented groups at MSIs are more compelling. MSIs—HBCUs, PBIs, HSIs, and TCUs<sup>9</sup>—have historically played and currently play an important role in the education of minorities in the United States, enrolling and graduating minorities in substantial numbers relative to non-MSIs.<sup>10</sup> For instance, a report focusing on the undergraduate institutions of Black PhD recipients found that the top eight institutions were HBCUs.<sup>11</sup> HBCUs and TCUs, in particular, have the primary mission of serving their respective minority populations. Unlike non-MSIs, which are typically larger institutions and historically have placed a stronger focus on research and development and secured Federal funds accordingly, Federal contributions to MSIs have been allocated to support STEM capacity-building activities—that is, efforts to establish the infrastructure necessary to conduct research in STEM and to train future scientists and engineers.<sup>12</sup> To round out the broadening participation picture, we therefore investigated the comparative role MSIs have played in STEM bachelor’s degree production.

MSIs are federally defined. MSIs identified for this analysis were identified according to U.S. Department of Education (ED) criteria. HBCUs are identified by law as degree-granting institutions established before 1964 with the principal mission of educating Black Americans. HSIs are institutions defined as “Hispanic serving” by the Office for Civil Rights (OCR). They are degree-granting institutions with a full-time-equivalent undergraduate enrollment of 25 percent or more Hispanic students, and at least 50 percent of these Hispanic students have incomes at or below 150 percent of the poverty level as defined by the U.S. Census Bureau.<sup>13</sup> The federal government did not classify institutions as Hispanic serving until

| Institution Type | N     |
|------------------|-------|
| Non-MSI          | 1,913 |
| HBCU             | 88    |
| PBI              | 50    |
| HSI              | 102   |
| TCU              | 9     |

<sup>9</sup> The U.S. Department of Education designates several other types of institutions as minority serving: Alaska Native-Serving Institutions, Asian American and Native American Pacific Islander-Serving Institutions, High Hispanic Enrollment, Minority Institutions, Native American-Serving, Nontribal Institutions, and Native Hawaiian-Serving Institutions. See <http://www2.ed.gov/about/offices/list/ocr/edlite-minorityinst.html>. Our analysis focuses primarily on Black, Hispanic, and Native American students; therefore, we focus on those institutions that serve those populations.

<sup>10</sup> Li, X. (2007, November). *Characteristics of minority-serving institutions and minority undergraduates enrolled in these institutions: postsecondary education. Descriptive analysis report.* (NCES 2008-156). Washington, DC: National Center for Education Statistics, Institute for Education Sciences, U.S. Department of Education. <http://nces.ed.gov/pubs2008/2008156.pdf>.

<sup>11</sup> Burrelli, J., & Rapoport, A. (2008, August). *Role of HCBUs as baccalaureate origin institutions of Black S & E doctoral recipients.* (NSF 08-319). Washington, DC: National Science Foundation. <http://www.nsf.gov/statistics/infbrief/nsf08319/nsf08319.pdf>

<sup>12</sup> Bennof, R. J. (2009, September). *Federal S&E obligations to three types of minority-serving institutions Decline in FY 2007.* <http://www.nsf.gov/statistics/infbrief/nsf09319>.

<sup>13</sup> <http://www.census.gov/hhes/www/poverty/threshold.html>

1992 (Schmidt 2003). TCUs are members of the American Indian Higher Education Consortium (AIHEC) and, for the most part, are controlled by tribes and located on reservations. AIHEC, founded in 1972, initially consisted of six TCUs. Today, AIHEC has grown to represent more than 30 colleges in the United States and one Canadian institution<sup>14</sup>. PBIs maintain at least a 40 percent Black enrollment rate. Table 1 shows the numbers of four-year institutions, for each institution type, that were included in the analysis.

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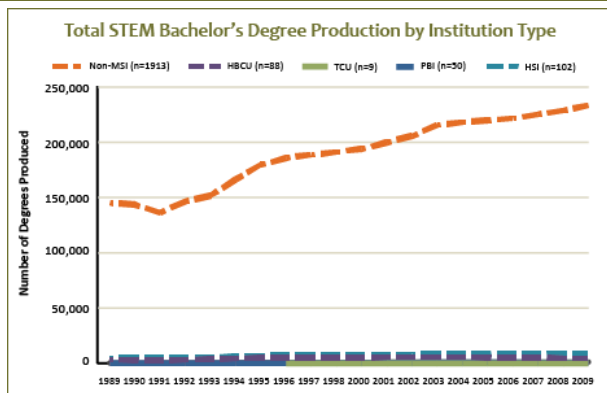
<sup>14</sup> American Indian Higher Education Consortium. <http://www.aihec.org>.

The number of STEM bachelor’s degrees produced among URMs has increased at both MSIs and non-MSIs. Figures 22 and 23 illustrate that the number of STEM bachelor’s degrees produced has increased at both MSIs and non-MSIs. STEM degree production at non-MSIs increased steadily between 1990 and 2004 when it leveled off. The number of degrees conferred by these institutions increased for all racial/ethnic groups (Figures 24 and 25). Figures 22 and 23 also indicate that non-MSIs have awarded more STEM bachelor’s degrees than MSIs. This is not surprising, as non-MSIs enroll more minority students than MSIs although URMs collectively represented only 7 percent of all bachelor’s degrees earned at non-MSIs in 1989 and 13 percent in 2009.

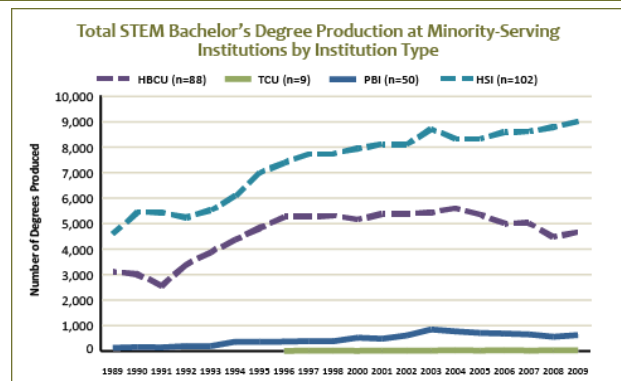
**HOW HAS THE OVERALL NUMBER OF STEM BACHELOR’S DEGREES PRODUCED BY MSIs AND NON-MSIs CHANGED OVER TIME, AND DOES THIS CHANGE VARY BY INSTITUTION TYPE?**

- The number of STEM bachelor’s degrees produced among URMs has increased at both MSIs and non-MSIs.
- HBCUs and TCUs produced a larger percentage of STEM degrees among Black and American Indian/Alaska Native students than non-MSIs, respectively.

**FIGURE 22. TOTAL DEGREE PRODUCTION BY INSTITUTION TYPE**



**FIGURE 23. TOTAL DEGREE PRODUCTION AT MINORITY-SERVING INSTITUTIONS**

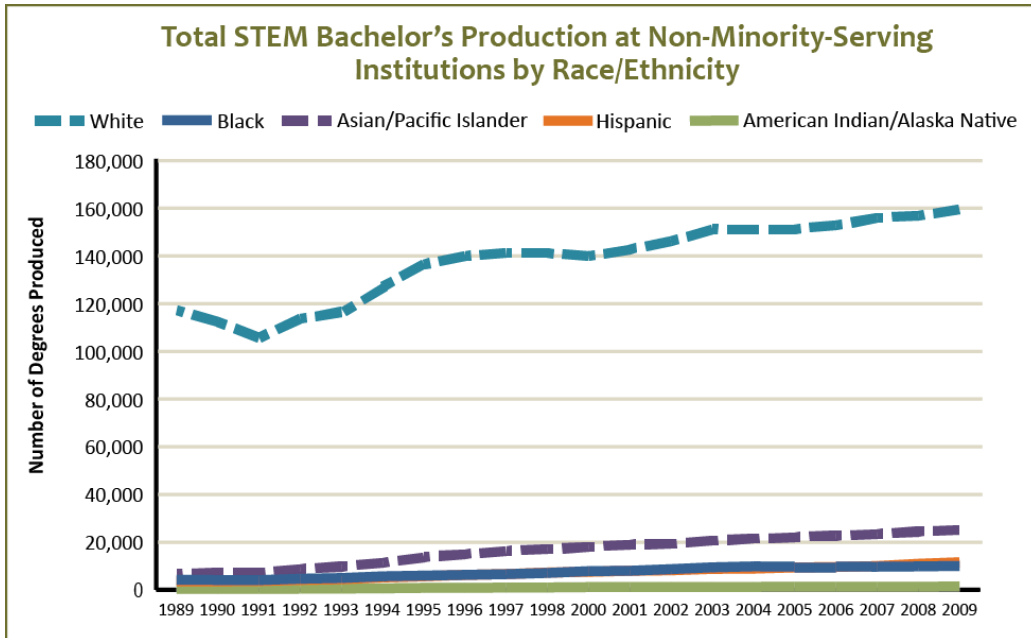


Source: NCES: Integrated Postsecondary Education Data System, 1989–2009

For HSIs and HBCUs, most of the growth in STEM bachelor’s degree production occurred between 1989 and 1996. The number of degree recipients reached a plateau between 1996 and 2004 and began to decline slightly after that. Although relatively small, the number of STEM degrees produced by PBIs has increased over time. This number peaked in 2003 and then dropped. However, by 2009, the number of degrees completed was more than five times what it was in 1989. TCUs did not begin to confer STEM bachelor’s degrees until 1996.

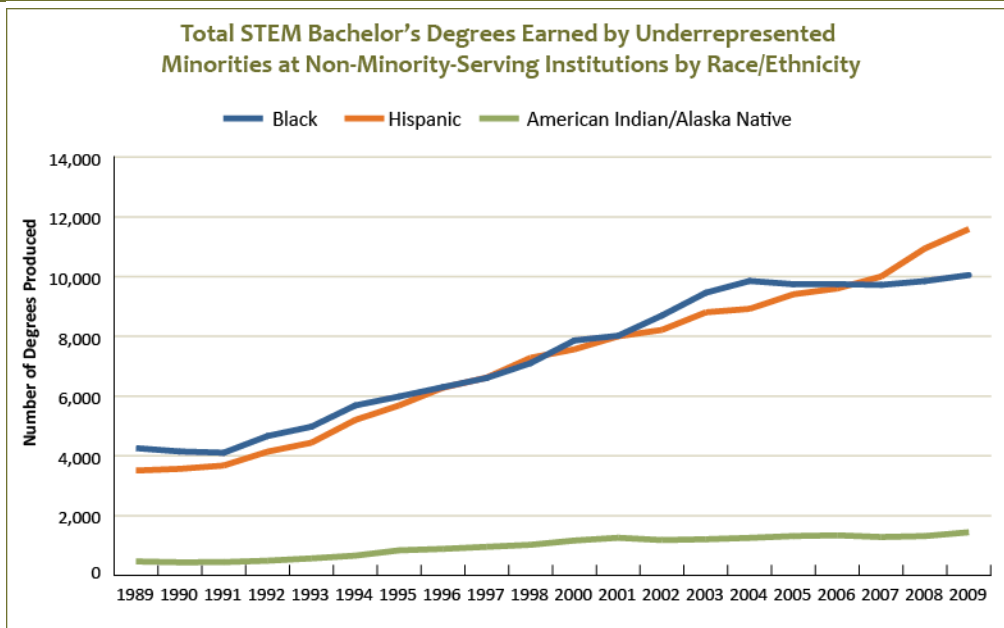


**FIGURE 24. STEM PRODUCTION BY NON-MINORITY-SERVING INSTITUTIONS BY RACE/ETHNICITY**



Source: NCES: Integrated Postsecondary Education Data System, 1989–2009

**FIGURE 25. URM STEM PRODUCTION BY NON-MINORITY-SERVING INSTITUTIONS BY RACE/ETHNICITY**



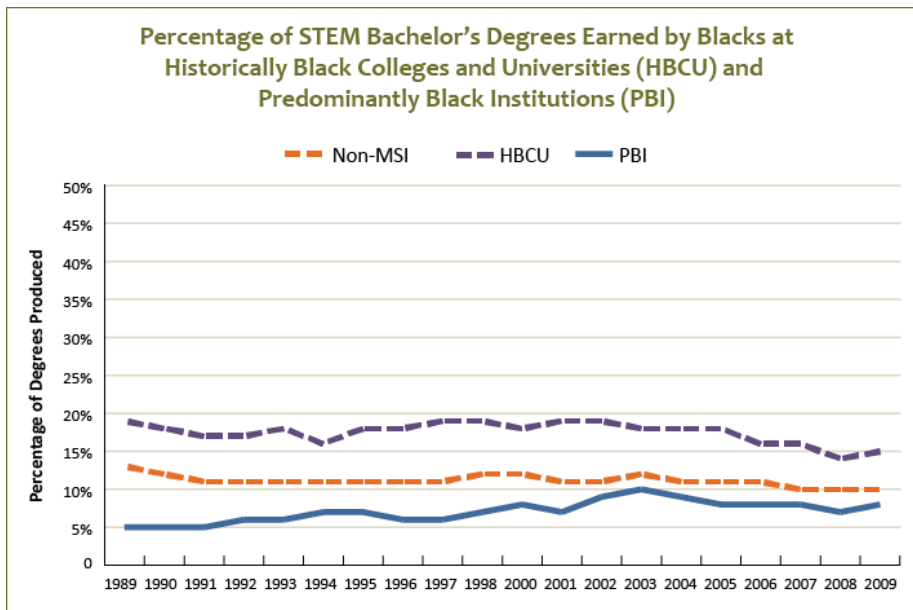
Source: NCES: Integrated Postsecondary Education Data System, 1989–2009

**HBCUs produce a larger percentage of STEM bachelor's degrees among Blacks than non-MSIs produce; PBIs produce STEM bachelor's degrees among Blacks at lower rates than non-MSIs produce.** Blacks received 80 to 88 percent of all bachelor's degrees conferred at HBCUs. It therefore comes as little surprise that although non-MSIs produced a greater number of Black STEM graduates, HBCUs produced a larger percentage of STEM bachelor's degrees (Figure 26). Although the trend at HBCUs has remained relatively unchanged over time, the data show that Black students at these institutions receive a higher percentage of degrees in STEM than their peers at both non-MSIs and PBIs. Figure 26 shows that from 1989 to 2009 between 15 percent and 18 percent of all degrees awarded to Blacks at HBCUs were in a STEM discipline. Comparatively, the percentage of STEM degrees earned by Blacks ranged from 10 percent to 12 percent at non-MSI's and just 5 to 8 percent at PBIs where Blacks represented 42 to 63 percent of all bachelor's degree completions between 1989 and 2009.

#### **DO MINORITY-SERVING INSTITUTIONS AND NON-MINORITY SERVING INSTITUTIONS PRODUCE STEM DEGREES AT SIMILAR RATES?**

- **HBCUs produce a larger percentage of STEM bachelor's degrees among Blacks than non-MSIs produce.**
- **PBIs produce STEM bachelor's degrees among Blacks at lower rates than non-MSIs produce.**
- **HSIs produce STEM bachelor's degrees among Hispanics at levels comparable to non-MSIs.**
- **STEM degree production among American Indian/Alaska Natives has increased steadily at TCUs, while the percentage of STEM degrees produced in this group by non-MSIs has leveled off.**

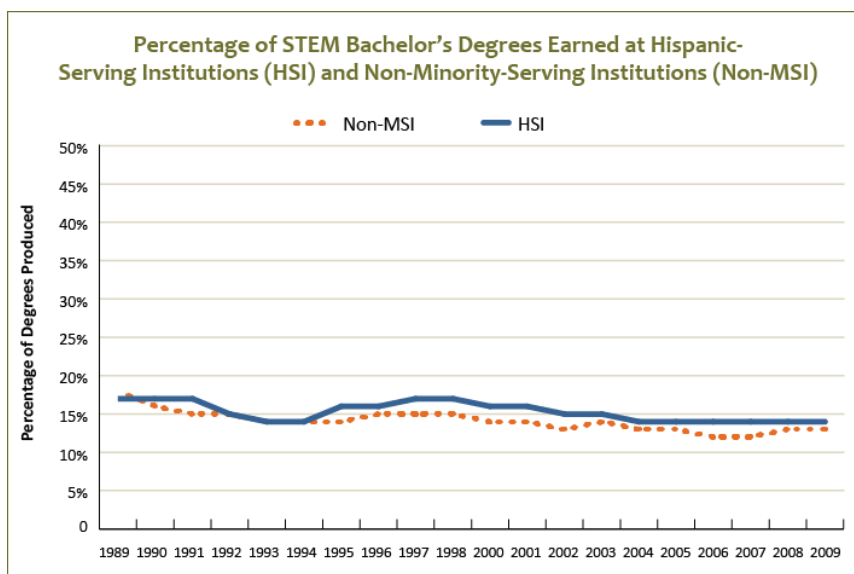
**FIGURE 26. STEM DEGREE PRODUCTION AT HBCUs AND PBIs**



Source: NCES: Integrated Postsecondary Education Data System, 1989–2009

**HSIs produce STEM bachelor's degrees among Hispanics at levels comparable to non-MSIs.** This trend did not change considerably over time (Figure 27).

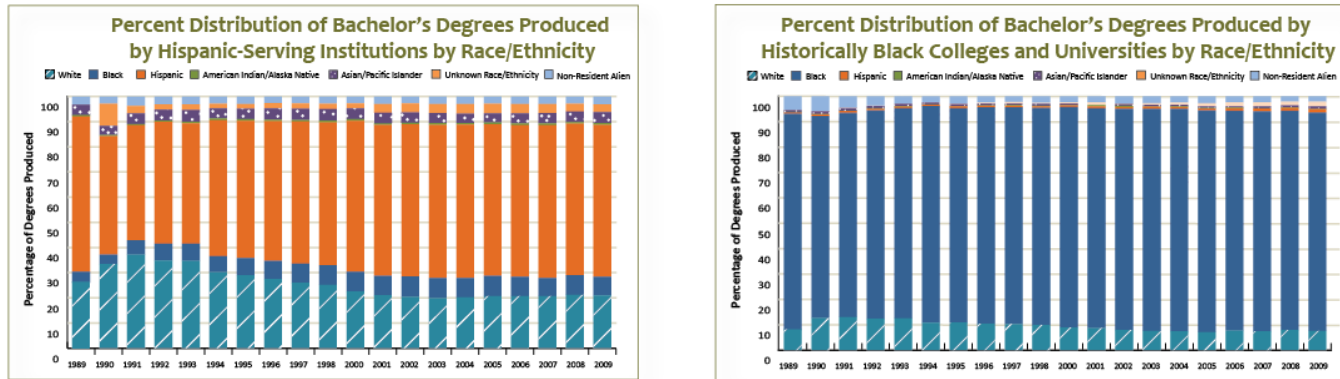
**FIGURE 27. STEM DEGREE PRODUCTION AT HSIs**



Source: NCES: Integrated Postsecondary Education Data System, 1989–2009

It should be noted that unlike the percentages of Blacks who received bachelor’s degrees from HBCUs (80 to 88 percent of all bachelor’s degrees conferred by HBCUs), Hispanics represented a smaller percentage of HSI bachelor’s degree recipients (approximately 47 to 62 percent of all bachelor’s degrees conferred between 1989 and 2009) (Figure 28).

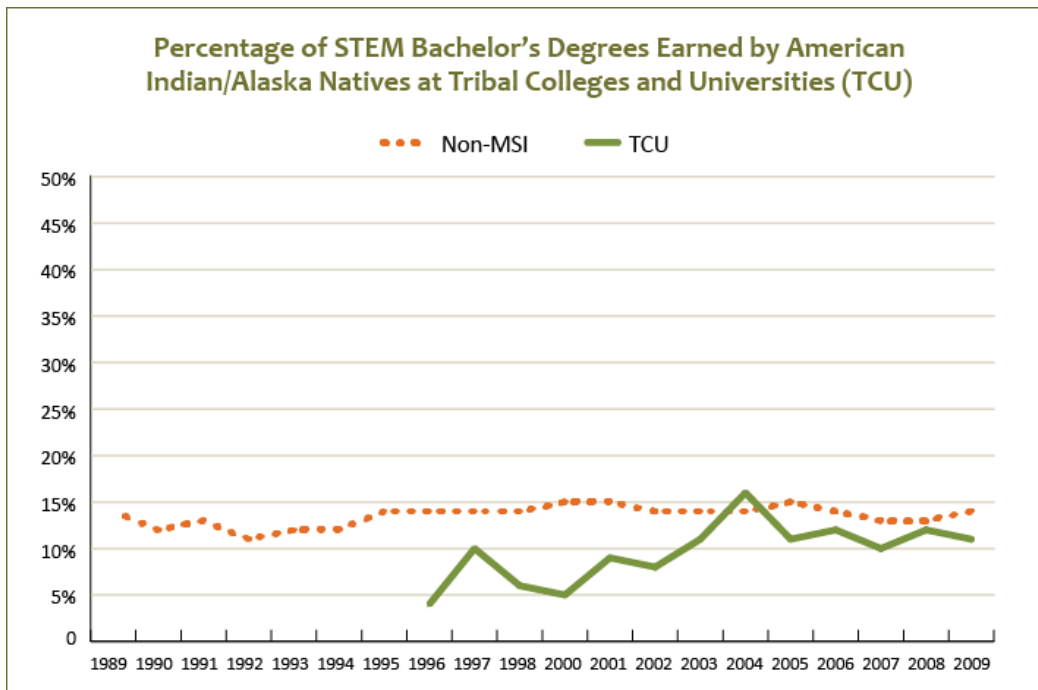
**FIGURE 28. BACHELOR’S DEGREE PRODUCTION AT HBCUs AND HSIs BY RACE/ETHNICITY**



Source: NCES: Integrated Postsecondary Education Data System, 1989 - 2009

**STEM degree production among American Indian/Alaska Natives has increased steadily at TCUs, while the percentage of STEM degrees produced by non-MSIs has leveled off.** Although non-MSIs produce a larger percentage of STEM degrees among American Indian/Alaska Native students, this percentage has remained virtually unchanged over time at around 13 percent. Comparatively, STEM degree production has increased steadily at TCUs (Figure 29). American Indian/Alaska Natives represented 55 percent of all bachelor’s degree completions at TCUs in 1989 and 92 percent of all completions by 2009. The percentage of STEM bachelor’s degrees produced by TCUs increased from no degrees awarded between 1989 and 1993 to roughly 11 percent of degrees conferred in 2009. Thus, the gap between non-MSIs and TCUs in the percentage of students receiving STEM bachelor’s degrees has narrowed considerably over this time period.

**FIGURE 29. STEM DEGREE PRODUCTION AT TCUs**



Source: NCES: Integrated Postsecondary Education Data System, 1989–2009

## What the Trend Data Do Not Tell Us

Although the trend data provide a broad overview of the state of STEM education in the United States, the data raise a number of questions about the success of efforts to broaden participation in STEM. For instance, significant federal, philanthropic, and corporate investments have been made in an attempt to broaden the participation of URMs, women, and persons with disabilities in STEM. However, the extent to which these efforts actually have contributed to any observed increases in the participation of underrepresented groups in STEM is unknown. Perhaps more importantly, although many of the observed trends show very little progress over time, it is unclear what these trends would have been without these investments.

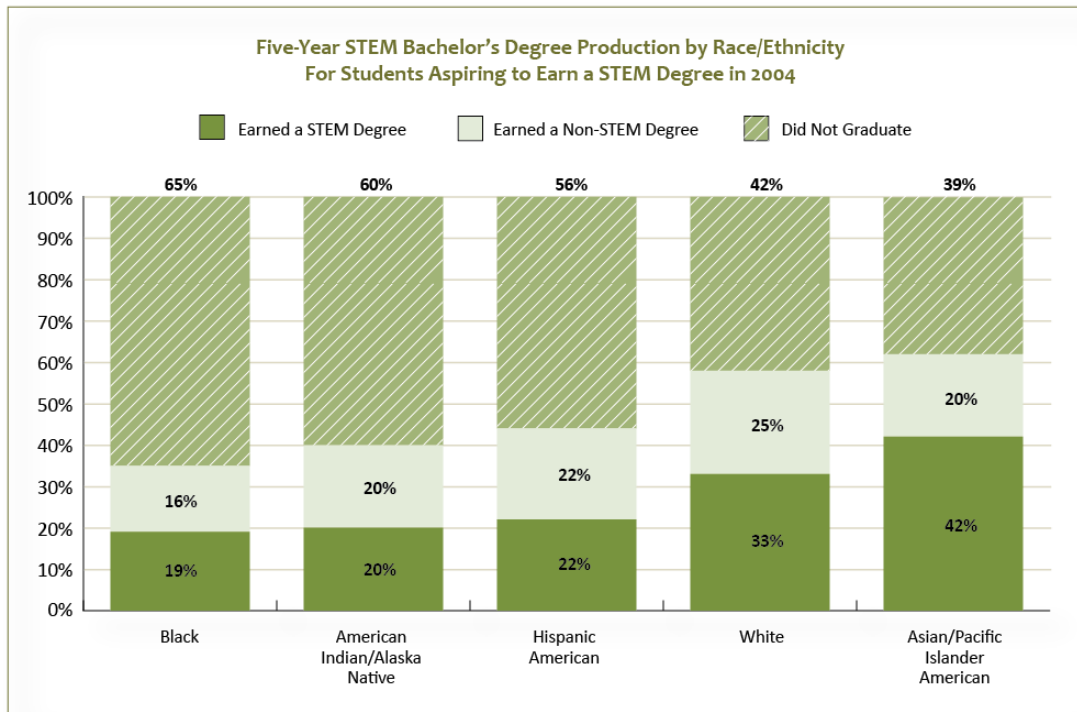
We close this section by asking what factors contributed to the observed trends. This is a key question that a trend analysis cannot answer, but we offer some candidates to consider for future research:

- **Access, Opportunity, Persistence, Retention, and Completion.** What factors intervene between interest and completion at the undergraduate level? The road to STEM degree completion begins with access and opportunity. It is a well-known fact that students do not all have the same opportunities and educational preparation when they begin their undergraduate studies. This preparation likely plays a big role in the decisions that students make regarding their degree and career pursuits. For better understanding of the trends, data are needed on key characteristics of the students who are enrolling in college, particularly their level of academic preparation. For example, if the increase in enrollment is driven primarily by students who are less academically prepared and have had limited access to educational opportunities that could help bolster their chances of succeeding in STEM (e.g., foundational math and science courses), it is unlikely that significant increases will occur in the number of students who choose STEM disciplines over other disciplines. The lack of degree production in STEM among underrepresented racial/ethnic minorities goes beyond a lack of interest in the field. A 2010 Higher Education Research Institute (HERI) report found that less than 25 percent of URMs who upon college entrance aspired to earn a STEM degree in 2004 successfully earned a degree in STEM by 2009 (Figure 30)<sup>15</sup>. Specifically, of the students who aspired to attain a STEM degree in 2004, less than one fourth of Hispanic (22 percent), American Indian and Alaska Native (20 percent), and Black students (19 percent) actually earned the degree within five years. Alarming, the majority of these students did not earn a bachelor's degree at all by the end of five years.

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<sup>15</sup> Eagan, K., Hurtado, S., & Chang, M. (2010). What matters for STEM degree completion: Expanding and diversifying college graduation. Los Angeles: Higher Education Research Institute, <http://heri.ucla.edu/nih/downloads/AACU%202010%20-%20Eagan,%20Hurtado,%20Chang%20-%20What%20Matters%20in%20STEM.pdf> (viewed May 14, 2012)

**FIGURE 30. FIVE-YEAR PRODUCTION RATES FOR STEM ASPIRANTS**



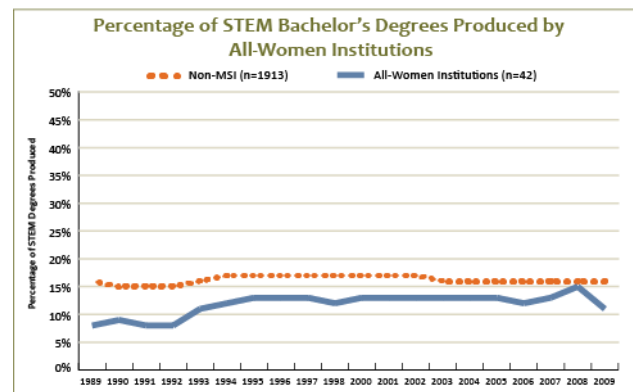
Source: Higher Education Research Institute, <http://heri.ucla.edu/nih/downloads/AACU%202010%20-%20Eagan,%20Hurtado,%20Chang%20-%20What%20Matters%20in%20STEM.pdf>

The HERI data strongly suggest that issues related to both student academic preparation as well as institutional-level factors may be contributing to the loss of students in STEM. Understanding the mechanisms that affect student retention in STEM may shed light on some of the observed trends described above; therefore, further study is merited.

- The Discipline Gap.** What institutional, individual, and instructional factors drive observed completion gaps? Why are some disciplines more attractive to women than others? Why are some disciplines more attractive to specific racial/ethnic groups than others? The trend data looked at degree completions across all eligible institutions, and an examination of degree completion by institution and degree programs was beyond the scope of this study. However, some institutions are doing a better job at broadening participation than others. Understanding the factors that contribute to or hinder success would help to identify programs and strategies that could be replicated across institutions.

- Institutional Differences.** Why are some MSIs more successful than others in producing STEM bachelor's degrees among URMs? A notable feature of American higher education is the wide variation in its institutions. Some U.S. colleges and universities are internationally recognized, and their mission includes not only educating the best and brightest but also conducting research. These institutions offer both undergraduate and graduate degrees and attract students from all over the world. Other colleges are more regional in focus and may not be well known outside of a limited radius. Other colleges and universities, like the MSIs examined in this section of the report, have as their mission to serve specific populations. MSIs, however, are a diverse group of institutions as well; they include universities that grant doctorates and conduct state-of-the-art research and others that admit any student with a high school diploma or GED. It is thus risky to take the aggregate findings that we report and generalize to all HBCUs, HSIs or TCUs. Indeed, we see considerable variation in STEM bachelor's degree production within these groups of institutions, and some colleges and universities have greatly increased both the numbers and percentages of STEM bachelor's degrees. However, we do not have the data to explain why some MSIs are more successful than others in improving STEM bachelor's degree completions. Additionally, we need to know much more about the role of two-year institutions, single-sex institutions, and other MSIs such as Native Hawaiian-Serving Institutions and Alaskan Native-Serving Institutions in STEM degree production. We know, for example, that the STEM degree production gap between all-women institutions and non-MSIs has virtually closed over time (Figure 31). Future trend analyses should address such research gaps for true understanding of how to broaden the participation of underrepresented students in STEM.
- Students with Disabilities.** A modest analysis of enrollment and science and engineering (S&E) degree pursuit used data from the 2008 National Postsecondary Student Aid Study (NPSAS). Unlike the IPEDs data used for our trend analysis, NPSAS reflects data on students' major field of study, as opposed to degree upon graduation, and students' choice of major in the following S&E fields: computer science, engineering, life sciences, mathematics, physical sciences, and the social and behavioral sciences. Data suggest that students with disabilities are faring better in STEM than are URMs and women. As shown in figure 32, persons with disabilities major in S&E (11%) at rates comparable to their undergraduate enrollment rates (11%) and census population estimates (12%). Additionally, persons with disabilities major in S&E (22%) at rates

FIGURE 31. THE STATE OF STEM FAST FACTS



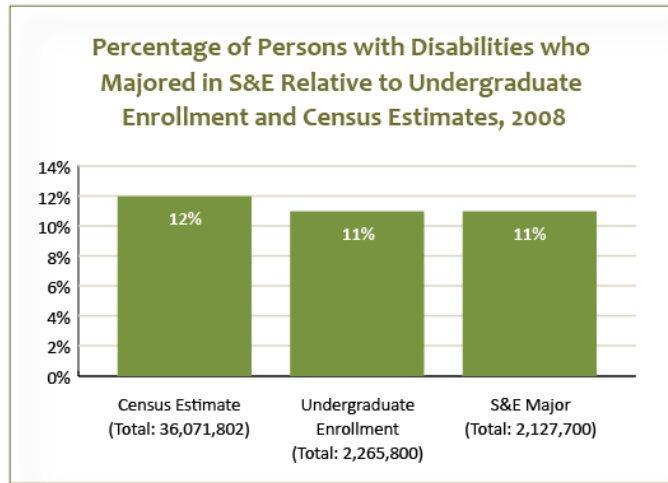
Source: NCES: Integrated Postsecondary Education Data System, 1989–2009

The STEM degree production gap between all-women institutions and non-Minority-Serving institutions has virtually closed over time.



comparable to students with no disability (23%) across all (Figure 33) and within each major field of study (Figure 34).

**FIGURE 32. PERSONS WITH DISABILITIES WHO MAJORED IN S&E**



**FIGURE 33. S&E MAJORS BY DISABILITY STATUS**

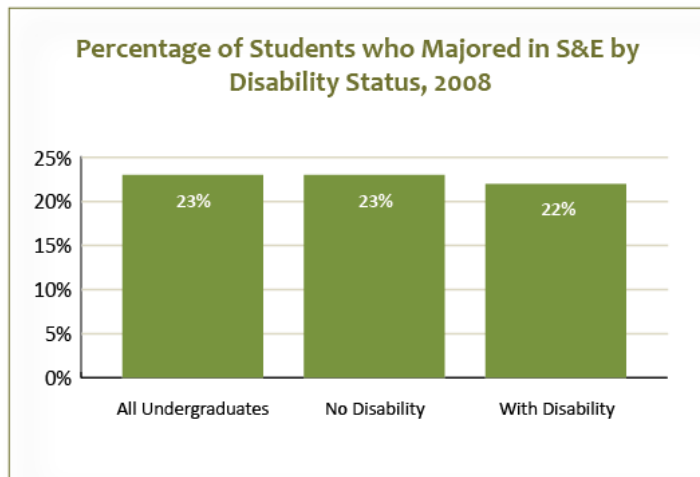
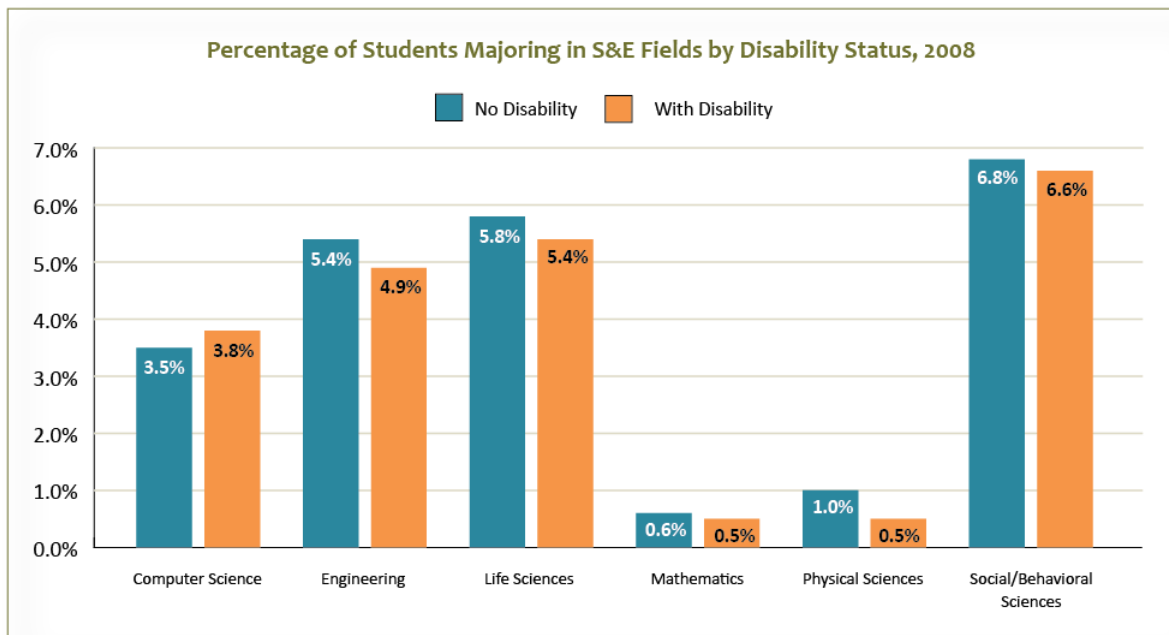


FIGURE 34. S&amp;E MAJORS BY DISABILITY STATUS AND FIELD



Source: National Postsecondary Student Aid Study (NPSAS), 2008

With these data as context, a number of questions come to mind that it is essential to answer to better understand the current state and needs of students with disabilities in STEM in an actionable way. These questions include, but are not limited to:

- **Completion.** Do persons with disabilities complete degrees at rates comparable to others with the same choice of major or does significant attrition occur?
- **Underreporting.** Do these data account for students with “invisible” disabilities (e.g., an auditory impairment or cognitive dysfunction for which the individual does not use an assistive device that is obvious to an onlooker)?
- **Type of Disability.** Do STEM degree completion disparities occur within the population of students with disabilities?

**OUR TRENDS ANALYSIS IS A STARTING POINT NOT AN END POINT.** It should be noted that we are sensitive to potential unintended policy implications (e.g., discontinuation of a federal subsidy program, program consolidation, or funding cuts) associated with the misinterpretation of data such as the trends we present in this report. These data are an effort to broaden perspectives on not only the state of STEM education in the United States but, more importantly, to broker a national discussion regarding how best to assess progress in this arena. This report merely paints a descriptive picture, offering no statistical tests of significance and exercising no value judgments or policy

recommendations about the most appropriate next steps for the nation. To paint a broader picture, we turn then to the scholarship on undergraduate programs and practices that specifically target underrepresented groups to increase their participation in STEM. The next section of the report examines the existing research that has been conducted on some of these mechanisms to identify potential strategies that promote the success of all students in STEM.

## WHAT'S WORKING: A LITERATURE REVIEW

### Identifying Promising Practices

As part of the effort to assess broadening participation initiatives, AIR conducted a comprehensive but nonexhaustive literature review, examining the effect of programs and interventions designed to broaden the participation of ethnic minorities, women, and persons with disabilities in STEM fields. Fifty-six studies were selected for review based on the following criteria:

- The study was published between 1995 and 2010;
- The participants included ethnic minorities, women, and persons with disabilities;
- A program, intervention, or strategy was evaluated;
- The study included outcomes related to broadening participation (e.g., undergraduate and graduate enrollment, achievement, retention, degree attainment, and career choice or aspirations); and
- The study was empirical.

### Widely Used Practices and Common Features of Comprehensive Programs

Our review of the literature found that the existing research on the effectiveness of programs and interventions designed to broaden participation in STEM is somewhat limited<sup>16</sup>. With this in mind, we identified several widely used practices that were found to be positively associated with outcomes that broaden participation in STEM. These were: undergraduate research, academic support, social integration and student support, and institutional capacity building.<sup>17</sup>

**Undergraduate Research.** A lack of interest in STEM careers and a lack of motivation represent additional factors that often contribute to students' abandonment of STEM disciplines (NAS, 2010). There is a clear need to engage students and make learning relevant. Several interventions tried to address this issue by providing undergraduate research opportunities. Research opportunities available during the summer and/or the academic year provided students with practical, hands-on learning experiences that allowed them to connect classroom learning with real-world experiences. Research experiences also gave students the opportunity to work directly with faculty. Faculty members served as role models and as an additional source of student support. In some programs, research opportunities, particularly those offered

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<sup>16</sup> We established a criterion of "rigor" which refers to the extent to which the research design allows one to make causal conclusions about the program or intervention.

<sup>17</sup> Although the practices have been grouped into four main categories, there is significant overlap in the goals and activities associated with each practice.

during the summer, provided financial support for students. This support appeared to be an added benefit that allowed students to gain experience and develop strengths in a field of interest without having to sacrifice the opportunity because they had to work to meet financial obligations.

**Undergraduate Academic Support.** Research indicates that underrepresented students often enter college lacking adequate STEM exposure and preparation to succeed in undergraduate STEM coursework (NAS, 2010). These students tend to perform poorly in introductory STEM courses, and their poor performance is often cited as a reason that many abandon their STEM goals. To address this lack of preparation and exposure, the majority of interventions and programs reviewed included academic support for students. At the undergraduate level, academic support was often provided in the form of tutoring, supplemental instruction in STEM courses, facilitated study groups, academic enrichment, or specific courses designed to help students gain academic skills in a particular field. At some institutions, successful completion of a program was directly related to students' ability to progress into a specific major (Armstrong & Thompson, 2003), providing students with a "second chance" to build up their knowledge and skills and remain in the STEM pipeline. Programs were generally implemented during the freshman and sophomore years and ranged in length from about one semester to two years. However, a small number of programs offered support throughout students' undergraduate years (Alexander, Foertsch, & Daffinrud, 1998; Clewell, Cosentino de Cohen, & Tsui, 2010; Villarejo & Barlow, 2007). Academic support was generally provided in conjunction with the other practices described in this report and was implemented at both the precollege and the undergraduate levels.

**Precollege Programs.** Academic support prior to college often occurs in summer bridge or academic enrichment programs. Such programs provide an opportunity to assist incoming freshmen with the transition to college. Summer bridge programs ranged in duration from about two to eight weeks and generally took place at or were associated with an undergraduate institution. These programs include a focus on academic areas in which students may need additional support to bolster their knowledge and academic skills, particularly in courses that serve as a gateway into STEM disciplines (e.g., math and science). Similarly, academic enrichment programs exposed students to the rigor of college-level coursework to build an academic foundation that would potentially promote persistence in STEM. Academic enrichment programs were implemented during the summer (Hanidu, Rachedine, Oladipupo, Jothimurugesan, & Adeyiga, 1996) and/or during the high school year (Campbell et al., 1998; Lam, Srivatsan, Doverspike, Vesalo, & Mawasha, 2005).

**Social Integration/Community Building.** Research suggests that a feeling of isolation and a lack of social connections within their learning environments is one reason for lower STEM retention rates among underrepresented groups (Poirier, Tanenbaum, Storey, Kirshstein, & Rodriguez, 2009; NAS, 2010). As a result, many of the programs reviewed sought to address this issue by increasing students' social support, building academically oriented social networks, and creating a sense of community. Strategies to achieve this goal included collaborative learning activities, peer support networks, peer mentoring and peer tutoring (often provided by upperclass minority students in relevant STEM disciplines), unique living arrangements, faculty mentoring, family involvement, community service, and ongoing social activities. In some

cases, social integration and community building began before students started college, via summer bridge and transition programs. In addition to the academic component mentioned earlier, summer bridge programs generally included a social component. Specifically, this component aimed to help students become acclimated to the university setting by providing opportunities for social interactions with peers and university staff before the start of their freshman year. Additional program activities included a general orientation to college, seminars on academic survival skills (e.g., time management and study skills), and career awareness sessions.

**Capacity Building.** Broadening participation in STEM is a multifaceted issue that requires a multipronged approach. Institutional factors that contribute to student persistence and retention in STEM cannot be ignored. Although most of the studies reviewed focused on interventions that targeted student-centered issues (e.g., a lack of academic preparation and social integration), some examined institutional capacity<sup>18</sup> (Clewell, Cosentino de Cohen, & Tsui, 2010; Clewell et al., 2005; Rodriguez, Kirshstein, & Hale, 2005). These studies found that capacity building targeted four key areas that were associated with positive broadening participation outcomes: faculty development, curricular reform, collaborations and partnerships, and physical infrastructure. The following are examples of activities implemented in each target area.

**Faculty Development.** New faculty were recruited; additional measures were provision of research support, professional development on mentoring and pedagogy or instructional strategies (e.g., new instructional approaches and integrating technology into instruction), and diversity sensitivity training.

**Curricular Reform.** Gatekeeper or other existing courses were revised along with, development of new courses and majors, adoption of new instructional approaches, the integration of research into the curriculum, and the introduction of distance-learning courses.

**Collaborations and Partnerships.** Collaborations and partnerships occurred with universities or high schools, state or local agencies, and organizations or NSF-funded programs.

**Physical Infrastructure.** Classrooms and laboratories were improved, along with purchase or upgrade of equipment.

## Gaps in the Existing Research Base

The evaluation research on programs designed to broaden participation in STEM shows numerous current and previous initiatives implemented to address this issue. As described above, findings from these programs suggest several practices that appear promising; however, the current body of evidence is incomplete, and numerous gaps still exist in the current knowledge base. The gaps are primarily the result of:

- **Methodological limitations.** The methodological approaches employed by many studies that examine the impact of various interventions on broadening participation outcomes are lacking.

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<sup>18</sup> Programs that focused on institutional capacity were generally large, well-funded, comprehensive programs.

- **Incomplete data.** Many existing programs have not been evaluated, and among programs that have been evaluated, a number of variables have not been explored.

The following section describes some of these gaps and also can serve as a roadmap to guide future evaluations.

**Institutional Outcomes.** Only a handful of studies examined institutional capacity building and the impact of interventions on institutional outcomes. Factors such as institution-wide buy-in or capacity building are key to program sustainability. This area warrants further investigation.

**An Examination of Individual Program Interventions.** Most initiatives consisted of multiple interventions, and evaluations of these interventions often lacked an assessment of how each impacted outcomes. An examination of individual program interventions has important implications for how programs should be designed to gain a greater return on investment.

**Representation of Specific STEM Disciplines.** Most of the literature focused on biology or life sciences, engineering, and computer and information sciences. Fewer studies examined interventions targeting students in physical sciences and mathematics, and no studies were found that examined interventions targeting students in agricultural sciences. It is possible that the lack of research reflects the amount of emphasis placed on broadening participation in these less-studied disciplines. However, more information is needed on minority participation in these STEM fields.

**Representation of Specific Underrepresented Student Populations.** In most of the studies reviewed, Black and Hispanic students were the predominant minority groups represented. American Indian/Alaska Native students and persons with disabilities were underrepresented in the literature, so we do not have a clear sense of whether commonly used practices are equally suitable for these groups.

**Focus on Minority Men.** Our review of the literature produced evaluations of interventions that focused on women, but none focused specifically on minority men. Programs that targeted women generally tried to address the issues that make women shy away from STEM fields dominated by men. It is likely that other issues, specific to minority men, have contributed to their low numbers in STEM, and these issues need further exploration. Some studies did report results by gender, but this was not common. For some minority groups, women are outperforming men in terms of STEM degree production in particular fields, so research examining what types of programs work best for minority men is needed.

**Longitudinal Studies Examining the Impact on Degree Attainment, Graduate Enrollment, and the STEM Workforce.** Although the underlying goal of most of the programs was to increase the participation of underrepresented groups in STEM, few studies followed students through the pipeline to show long-term outcomes through graduation and beyond. The empirical literature on programs that aim to broaden participation in STEM is skewed toward retention/persistence and achievement, particularly achievement in introductory or gateway courses that serve as prerequisites for STEM majors. Although it is generally assumed that achievement in these courses leads to persistence, the current body of literature is fragmented and does not involve longitudinal designs that follow students to connect findings from the early stages of the pipeline (i.e., precollege, freshmen, and sophomore years) with findings

during the later stages of the pipeline (i.e., degree attainment, graduate enrollment, and participation in the STEM workforce).

**Program Implementation.** Although the studies described the program components, most lacked detailed information about the implementation of these components and the extent to which they were implemented with fidelity. This information would be valuable for expanding or scaling up successful programs across different institutions.

## Methodological Limitations

A number of methodological challenges made it difficult to make conclusive statements about what works and for whom. These challenges include:

- **Lack of subgroup analyses.** The majority of the literature reviewed focused on minorities as a group. Very few studies conducted subgroup analyses by ethnic group, making it difficult to determine whether certain interventions were more or less successful for specific ethnic groups. Focusing on findings for minorities as a group also masked within-group differences. A similar issue emerged with findings on women. Data on women were generally included in data for URMs; thus it is unclear whether there were interaction effects based on gender and ethnicity.
- **Lack of control or comparison groups.** Many of the studies reviewed did not include a control or comparison group. Without data for a similar group that did not participate in a given program or intervention, it is difficult to determine whether the reported results could be attributed to the intervention.
- **No control for preprogram differences or demographic variables.** Some studies that did include a control group failed to control for demographic characteristics (i.e., socioeconomic status [SES]), pre-program differences or available pre-program measures that are linked to study outcomes. This means that **intervention and control groups were not always comparable**, again increasing the possibility that findings could be attributed to factors outside of the intervention.
- **Small sample sizes.** Many studies reported fairly small sample sizes. This limited the generalizability of findings. Having a small sample also played a significant role in the lack of subgroup analyses, as any attempt to break down the already small sample by URM status would compromise the reliability and validity of findings.
- **No pre-test measures of outcome variables.** Having pre-test (baseline) measures of key outcome variables would provide valuable information about the amount of change between the start and end of a particular intervention. Thus, without baseline data, when two groups are compared and the group receiving the intervention scores higher or lower than the comparison group, there is no way to know whether these differences existed prior to the intervention. This makes it nearly impossible to determine the true impact of the program.



## STAKEHOLDER FEEDBACK

### Realizing the Potential of Domestic STEM Talent Pools

Our trend analyses indicated that Blacks, Hispanics, and women are indeed underrepresented in the domestic pipeline to STEM. The percentage of bachelor's degrees earned in a STEM discipline has not realized considerable growth over time for any demographic group including Whites. When disaggregated by STEM discipline, the trend data indicate pronounced completion gaps between Whites and racial and ethnic minorities, between men and women, and between White women and White men. Taken together, these trends confirm concerns about the capacity of the present U.S. workforce development infrastructure to prepare any and all students for a career in STEM. However, the story is not entirely bleak. Although non-MSIs produce a greater number of Black and American Indian/Alaska Native

STEM graduates, HBCUs produce a larger percentage of STEM degrees among Black students, and TCUs have steadily increased their production of American Indian/Alaska Native STEM graduates, while the percentage of STEM degrees among American Indian/Alaska Natives at non-MSIs has remained virtually unchanged. HSIs produced Hispanic STEM graduates at comparable rates as non-MSIs.

Our literature review found that many programs and interventions have been designed and implemented to increase the number of URMs and women who successfully progress through the STEM pipeline. Promising practices employed by these programs include undergraduate research opportunities, pre-college summer bridge and academic enrichment programs, academic supports such as tutoring, student community-building efforts such as peer support networks, institutional capacity building such as facility development, the improvement of the physical infrastructure for STEM instruction and research, curricular reform, and cross-campus collaborations and partnerships. Our review concluded that, although hampered by methodological limitations, the studies we identified indicate that participation in these programs is positively associated with broadening participation outcomes, such as achievement, retention, degree completion, graduate enrollment, and pursuit of a STEM career.

With this backdrop in mind, a number of pressing policy concerns and challenges exist that current data and research cannot or have yet to adequately address, such as discerning what steps need to be taken at the undergraduate level to better align STEM degree production with U.S. labor market needs and identifying measures, other than degree completion, that can be used to monitor, evaluate, and identify effective broadening participation in STEM interventions. Our stakeholder roundtable events were designed as discussion sessions to solicit feedback and suggestions in response to such outstanding questions.

In March and April 2011, we convened nearly 100 members of the higher education community and its stakeholders, including representatives from two-year and four-year institutions, minority-serving institutions and majority-serving institutions, corporations, nonprofit organizations, philanthropic foundations, STEM professional associations, and STEM student organizations from across the country to provide insight and direction on strategies and recommendations for change to increase the participation, retention, and completion rates of underrepresented groups in STEM at the

undergraduate level. In May 2011, the project convened a third gathering, a roundtable of representatives from the federal policy community (see Appendix A for a description of our sampling and participant recruitment process and Appendix C for a complete list of the participating institutions, organizations, and federal agencies).

These meetings marked the first time that a broad cross-section of individuals with a vested interest in improving undergraduate STEM education outcomes for all students came together to provide the nation, STEM educators and researchers, and the larger STEM federal policy making community, with their recommendations for improvement. To set the stage for our roundtable discussions, the stakeholders who participated in the gatherings were presented preliminary trend analysis and literature review findings to confirm, refute, and enlighten their prevailing perceptions and beliefs about the state of STEM degree completion among underrepresented groups and degree production by U.S. colleges and universities. Attendees then participated in a series of roundtable discussions, facilitated by AIR and IHEP STEM and higher education experts, to share perspectives and recommendations on three topics.

1. **Goals, Metrics, and Accountability.** What indicators should be used to measure success in broadening participation and completion in STEM degree programs at colleges and universities?
2. **Higher Education's Role.** What role should higher education play to broaden participation in STEM?
3. **The Federal Role.** What role should federal funders play to support higher education's capacity to broaden participation in STEM?

A summary of the core concerns and suggestions raised by the stakeholders are shared here, organized by these topic areas. Perspectives offered by the participants of the March and April convening of higher education representatives and stakeholders are reported under the first topic area, Goals, Metrics, and Accountability, as well as the second, Higher Education's Role. The perspectives offered by the participants of the federal policy community roundtable are reported under the third and final topic, The Federal Role.

## Goals, Metrics, and Accountability

Although the trend data strongly suggest that significantly more work needs to be done to broaden participation in STEM, they raise some important questions about how to define and measure success. Specifically, are the metrics used to measure success sufficient and, if not, what metrics should be used? Is there appropriate accountability for achieving these goals, particularly from institutions receiving funding? We posed these questions to stakeholders, and the following presents a summary of their concerns and suggestions for addressing these concerns. In general, these concerns and suggestions fell under three key categories: (1) expanding the definition of success, (2) accounting for institutional differences, and (3) increasing accountability.

## Expand the Definition of Success

**The current definition of success is too narrow.** Currently, graduation rates are the primary measure of success for undergraduate STEM initiatives. Researchers and funders generally look to see whether the numbers or percentages of students in each underrepresented group are increasing within the STEM disciplines. Although stakeholders generally agreed that it is one indicator of success, this measure alone is not sufficient to account for the breadth of achievements that have come about as the result of a wide range of broadening participation initiatives. By focusing on graduation rates, the assumption is that success is defined by the completion of a four-year degree in the STEM disciplines. And when these numbers do not increase, it is assumed that the initiative is failing. However, all agreed that defining and demonstrating success cannot be viewed in such a narrow manner and that a number of different measures could serve as indicators of success.

*The Role of Two-Year Institutions and Tribal Institutions.* Two-year and Tribal institutions are often left out when examining the success of broadening participation initiatives. This lack of attention has occurred in part because of the lack of consistent data on the degrees and certificates conferred by these institutions. However there appears to be an underlying belief that bachelor degrees are essential; therefore, the importance of degrees and certificates from community colleges in STEM is often overlooked. Stakeholders noted that obtaining a degree or certificate from a community college or Tribal

**TABLE 2. PROPOSED INDICATORS**

**STEM persistence/retention/attrition rates.** The percentage of students who start college with the goal of majoring in a STEM field and actually persist and achieve their goal

**Course completion rates.** The percentage of students who actually complete certain STEM courses, particularly those viewed as “weed out” courses

**Skill development.** The percentage of students who demonstrate proficiency in a particular STEM field (e.g., the number of computer science majors who are functional in a programming language [e.g., C++] or who receive a particular certification)

**Dispositional and attitude measures.** Changes in students’ perception of STEM coursework and careers

**Graduate school enrollment.** The percentage of underrepresented students who pursue graduate education in a STEM field

**STEM employment.** The percentage of underrepresented students who graduate with a degree in STEM and go on to work in a STEM field

**Two-year degree or Certificate attainment.** The percentage of students who receive a two-year degree or Certificate in a STEM field

**Transfer rates.** The percentage of students who transfer to a four-year institution to pursue a STEM degree

**STEM employment.** The percentage of students who graduate with a four- or two-year degree or certificate in STEM and go on to work in a STEM or STEM-related field

**STEM faculty measures.** The number of adjuncts teaching core STEM courses pre/post funding; the number of tenured STEM faculty per department

**Value of Degree.** The percentage of students who are accepted into graduate school or gain employment in their field of study after graduation compared to the percentages at similar institutions

**Resources.** The availability of resources (e.g., state-of-the-art equipment) and opportunities (e.g., paid internship experiences)

**Inclusion of socioeconomic and first-generation college student status as subgroups.** Examining key indicators across each of these subgroups would provide a more comprehensive picture of broadening participation success.

Institution is just as important, as these degrees also lead to viable careers in STEM. These institutions also prepare students for transfer to bachelor's degree-granting institutions and for work in their communities (as is reportedly the case for many students who attend Tribal Colleges); yet with the focus on degree attainment, these efforts are often ignored. To acknowledge the true contributions of two-year and Tribal Institutions and to assess the success of their efforts to broaden participation, stakeholders suggested that considerations of quality and value as well as expansion of the definition of underrepresentation are essential to a framework of success.

*Quality and Value.* Stakeholders expressed concern that the focus on degree completion may overshadow the *quality* of students' educational experience and the overall *value* of the degree, leading, at times, to degrees that were "watered down and no longer of value". Therefore, attempts to demonstrate the success of broadening participation efforts need to account for the type of education underrepresented students receive to ensure equality of access to resources, opportunities, and quality instruction. The value of the degree earned was also viewed as key in defining and measuring success. Simply having a degree in STEM is not sufficient. Whether students are able to get jobs in a specific field of study, with a particular degree, and from a particular institution, as well as the extent to which these jobs serve as solid stepping stones to career development should be taken as quality indicators. Many stakeholders felt that transparency around quality and the benefits of obtaining a STEM degree needs to be a part of public understanding; especially for low-income and underrepresented students who may not always be privy to this type of information. As one stakeholder commented, "We need to show people the value of a degree, and help them evaluate the value of different educational experiences, especially when the costs are extremely different." While acknowledging the inherent difficulty in defining and measuring quality and value, stakeholders noted that including these characteristics in the definition of success has important implications for accountability—implications which may not be readily accepted by many institutions of higher education.

*Expanding the Definition of Underrepresentation.* Efforts to broaden participation in STEM currently target underrepresented racial/ethnic minorities, women, and persons with disabilities. However, stakeholders suggested that the URM definition should be expanded to include students' SES, first-generation college-going status, and the non-traditional student. This broader definition of underrepresentation could expand the pool of students who are targeted by current broadening participation efforts and potentially could promote changes in the strategies used to attract certain students to STEM while still addressing some of the issues faced by many students from the original underrepresented groups.

#### Stakeholder Feedback

- Move beyond STEM degree completion as an indicator of success (e.g., persistence/retention/attrition rates, course-completion rates, skill development, dispositional and attitudinal measures).
- Include indicators that account for the contribution of two-year institutions.
- Evaluate STEM degree program quality, including instructional quality and the value of an earned degree.

### Account for Institutional Differences

**Institutions of higher education are not created equal.** Identifying the appropriate indicators is only the first step in examining the success of ongoing broadening participation efforts. One of the most significant takeaways from the stakeholders was that institutional differences are largely ignored. Institutions have different student populations, resources, and their overall capacity for broadening

participation varies. Therefore, it is not enough just to identify a set of metrics by which all institutions should be measured. Instead, any assessment of success must account for institutional differences.

#### Stakeholder Feedback

- Establish *institutional baselines* to account for the unique context and starting point of each institution (e.g., student demographic characteristics, student academic preparedness, mobility and transfer rates, the proportion of nontraditional students, teaching capacity, research infrastructure, faculty development needs, and history of funding) and use these institutional baseline data to create an *institutional profile* against which funders can set expectations and evaluate programs.
- Group institutions with similar baselines, and establish for each grouping benchmarks against which funders can measure progress and make fair comparisons between institutions.

### Increase Accountability

**Institutions are not held accountable for broadening participation in STEM.** The final step in reframing how we define and measure success involves accountability. A significant investment has been made over the past 20 years to increase the participation of underrepresented groups in STEM. In general, most stakeholders agreed that, to continue making progress, higher and more consistent accountability practices are needed for institutions that receive funding. Most importantly, accountability should start from the beginning of the funding process and should be incorporated into the expectations of the funder and integrated into the fabric of the proposed work.

Stakeholders' suggestions fell primarily into three phases: (1) proposal, (2) award or implementation, and (3) evaluation.

## Stakeholder Feedback

### *Phase 1: Proposal Phase*

- Include clear accountability criteria in Requests for Proposal.
- Require institutions to develop and include clear accountability plans in their proposals.
- Hold institutions accountable for program activities by requiring grantees to explain their rationale for specific activities and how they plan to implement specific program components.

### *Phase 2: Award or Implementation Phase*

- Hold institutions accountable for program outcomes. These outcomes should go beyond degree attainment to include indicators such as student learning outcomes, skill outcomes (e.g., What are graduates able to do?), teaching outcomes and both quantitative and qualitative measures. Outcomes should be specific, measurable, clearly documented, realistic, and account for the unique contextual and cultural factors of individual institutions.
- Require grantees to demonstrate, through appropriate documentation, the active participation of a certain percentage of students from underrepresented groups. This percentage would be based on the total population of underrepresented students at each institution.
- Hold institutions and grantees accountable for program activities and follow-up to ensure that they are implementing program activities as planned.

### *Phase 3: Evaluation Phase*

- Reward institutions that meet or exceed accountability standards, and withdraw funding from those that are not making progress.
- Evaluate outcomes by department or discipline instead of simply looking at the institution as a whole.

## Higher Education's Role

The higher education community is in a unique position to develop strategies for confronting its own challenges related to broadening participation in STEM. Institutions of higher education vary widely in terms of their missions, goals, resources, and student populations. With this variety in mind, we requested stakeholder input on the role that higher education itself can play in broadening participation in STEM. Six categories of concerns and suggestions are summarized below. They include: (1) accounting for institutional differences, (2) reversing a culture of attrition, (3) improving faculty development, (4) responding to workforce and industry demands, (5) ensuring STEM literacy for all, and (6) supporting STEM entrepreneurship.

### **Account for Institutional Differences**

**Institutions play different but equally valuable roles in producing STEM talent.** A fundamental concern of stakeholders was that institutional differences in higher education are not properly accounted for in efforts to broaden participation in STEM. The stakeholders agreed that different institutions play very different, but equally important, roles in broadening participation and ultimately producing new members of the STEM workforce, and these roles should be acknowledged.



Stakeholders emphasized that different institutional types serve students with different needs and intentions. In offering solutions for recognizing institutional differences, stakeholders felt that each institution should aspire to serve the unique needs of its own students and should be encouraged and assisted in the pursuit thereof. Stakeholders' suggestions focused primarily on capacity building at both two-year and four-year schools.

*Two-Year Institutions.* Many of the stakeholders represented two-year community colleges and TCUs. For these institutions, the most immediate concern is the expansion of capacity: the ability to serve more students, provide more opportunities, provide more resources, and encourage better outcomes. In these institutions, a new classroom, a new microscope, a new instructor might appear rather modest, especially when compared with the needs of large research universities, but small changes can have a large impact in helping these schools achieve their mission. Funding that expands capacity at these institutions can make an immediate and long-term difference.

It is also essential to consider the needs of students who attend two-year colleges and TCUs—specifically, where they are coming from and where they are going. Although the numbers vary across schools, two-year institutions by and large serve and welcome many students who need remediation to pursue a STEM education. The successful execution of remedial programs for students in community colleges ultimately serves to expand the pool of students who can and will go on to pursue careers in STEM.

Likewise, students at two-year schools often have a “nontraditional” goal with regard to leaving two-year schools—often valuing immediate employment, attaining a vocational certificate, or transferring to a four-year institution. Unfortunately, current metrics prioritizing degree completion might reflect poorly on two-year schools that successfully produce transfers. School and student-tracking data and metrics should be structured to reward two-year schools that have high transfer rates to four-year schools, and the role of two-year schools as stepping stones into four-year higher education should be encouraged and fostered.

*Four-Year Schools.* In four-year undergraduate institutions, institutional missions in STEM may conform with more “traditional” notions of higher education—preparing students for STEM graduate education and/or the STEM professoriate, and contributing to scientific discovery and innovation. Capacity

#### Stakeholder Feedback

- Expand the capacity of two-year institutions to:
  - Remediate academically underprepared students for STEM coursework
  - Successfully transfer students to four-year STEM degree programs

building is a pressing concern at many four-year schools, and they need to be supported in their efforts to offer STEM education as broadly as possible. Specifically, undergraduate STEM offerings in a variety of fields, combined with broad research opportunities and high instructional quality, will serve to attract students to STEM, keep them engaged in STEM, and give them a sound practical background when they pursue further STEM education and/or a STEM career.

## Reverse the Culture of Attrition

**A pervasive culture of attrition exists in the STEM disciplines.** The stakeholders repeatedly voiced concern that student attrition in STEM disciplines is extraordinarily high. Many reasons were offered: institutional pressure to graduate students within a fixed amount of time (two years or four to six years, respectively); four-year institutions prioritize research over teaching, rendering only the most high-achieving, that is, the least burdensome students, attractive to faculty and thus creating an inhospitable environment for many students; the academic underpreparation of many minority students, specifically; and the lack of adequate financial support for student need. While course rigor should not be compromised, the stakeholders proposed a number of solutions to address high rates of student attrition.

*Community building.* Community building that creates environments of support within the colleges was among the most popular recommendations. The manifestation of these communities could be through peer-support networks, mentoring programs, tutoring programs, and social functions. Well-developed communities can provide both academic and emotional support to STEM students, leading to a more personalized relationship between students and faculty, thereby producing an environment for greater persistence in STEM.

*Eliminating "gatekeeper" cultures.* Introductory STEM courses are often treated as "gatekeepers" to a STEM education, inordinately "weeding out" many students. It was the opinion of many stakeholders, however, that "gatekeeper" courses unnecessarily deter many students from even attempting to major in STEM, and are "weeding out" students who may actually possess the ability to succeed in STEM. Stakeholders cautioned that the gatekeeping nature of introductory courses, in particular, should be toned down to allow greater early-college access to STEM.

*Instructional quality and research opportunities.* Stakeholders emphasized that STEM attrition can be combated with high-quality instruction that keeps students engaged in STEM courses and gives them an opportunity to succeed. Furthermore, research opportunities can help maintain student engagement by offering students concrete outcomes and by helping to buttress their classroom education, thus improving students' ability to succeed in coursework.

### Stakeholder Feedback

- Ameliorate the competitive, gate-keeper culture of STEM, especially in introductory courses.
- Develop relational pedagogy to improve student outcomes.
- Engage students in STEM research throughout their undergraduate experience.
- Strengthen student support services.
- Improve within-institution community building.

## Improve Faculty Development

**The quality of undergraduate STEM instruction needs to be improved.** Stakeholders raised the concern that faculty need to be better prepared to address the learning needs of struggling and diverse student populations. To this end, the stakeholders proposed a number of faculty development goals.



*Cultural competency.* Stakeholders strongly emphasized that, to serve “nontraditional” students more effectively, many faculty needed to improve their cultural competence, with regard to both engagement with students and STEM instruction. Representatives from TCUs described the ways they were able to accommodate their nontraditional students and the positive impact they were able to effect. Many spoke specifically about how they tailor their STEM instruction, and even research, to make it relevant to the community their school serves.

#### Stakeholder Feedback

- Provide faculty development in the areas of:
  - Mentoring
  - Cultural competence
  - Fostering student engagement
  - Community engagement
  - Formative assessment to support instruction
- Establish new and strengthen existing STEM summer institutes and summer bridge programs

*Community outreach.* Some stakeholders took these strategies a step beyond, organizing community outreach to popularize STEM studies among the surrounding population and demonstrate the value of STEM research. In these instances, successful community outreach could have the effect of turning community support toward STEM studies—studies that can be long and arduous, and their value may not be immediately clear to the family and neighbors of the student pursuing the degree.

*Mentoring.* In addition to seeking support in developing community outreach programs and a culturally relevant curriculum, stakeholders also advocated peer-mentoring programs for both students and instructors as well as developing ways to evaluate the effectiveness of training programs and the quality of their own instruction.

*Remediation and engagement.* The focus groups also dedicated significant attention on strategies to address students’ underpreparedness at the undergraduate level. Representatives of two-year schools were particularly informative in this regard, describing successful implementation of remediation strategies for incoming students. Many two-year instructors also described successful outcomes that resulted from an emphasis on personal engagement with students who entered school in need of remediation.

*Partnerships.* Stakeholders described successful implementation of K–16 partnerships, summer institutes, summer bridge programs, and community outreach research programs, all of which they credited with improving the level of preparedness of incoming undergraduates.

## Respond to Workforce and Industry Demands

**STEM degree production and workforce needs are not aligned.** Stakeholders identified the need to align STEM degree production with workforce and industry demands. To increase enrollment in STEM programs and to improve outcomes for students who pursue STEM careers, many stakeholders emphasized the importance of effectively communicating to students real STEM workforce needs. The general consensus was that this does not happen currently in any concerted way. One stakeholder warned, “We need to worry not just about graduation, but graduation to do what?” Stakeholders suggested a few strategies for improving STEM education’s focus on STEM industry demands.

*Workforce alignment.* Stakeholders suggested that increased STEM enrollments and completions could result by encouraging students to study STEM disciplines in which greater employment opportunities are available upon graduation. Additionally, successful professional placements would serve not only to give students a positive return on their educational investment but also generate positive publicity and examples for opportunities in STEM fields.

#### Stakeholder Feedback

- Align STEM degree production with workforce development needs.
- Educate students about their STEM employment and career prospects.

*Honest advice.* However, stakeholders cautioned against giving students irrational or dishonest advice about their prospects in STEM. Many spoke of being forbidden by their administration from actively discouraging a student from a given field, a policy which they felt forces them to give students disingenuous feedback. Rather than rely on “gatekeeper” courses to filter out early college STEM pursuers, some stakeholders preferred having the ability to have frank discussions with students about how to succeed in STEM, or about what sort of STEM career students could and could not expect with their level of performance.

Overall, stakeholders advocated strengthening counseling approaches and programs that give STEM students honest and practical advice about courses of study in school and career planning related to real workforce needs.

## Ensure STEM Literacy for ALL

**Undergraduate STEM education does not promote STEM literacy for all.** Although the stakeholder focus groups primarily considered broadening participation issues as they applied to STEM majors, the concept of broadening participation in STEM meant, to many stakeholders, encouraging a “STEM for All” approach in higher education. At present, too many college graduates are leaving school without even a basic grasp of STEM fundamentals. Stakeholders agreed that the nation’s citizenry should have basic scientific literacy. One participant clearly stated it, saying, “The notion that the pipeline leads to a STEM career is limiting and fails to understand the bigger idea of ‘science for all.’ We need our citizenry to have basic scientific literacy.” Another participant argued that, “We need to consider that a large percentage of individuals in our workforce will benefit from STEM skills, even if they will never be STEM professionals. If they had better math skills, better skills working with data, they would benefit from that. Those skills are very marketable.” In other words, higher education leadership needs to prioritize the scientific and technological education of all students, not just those seeking STEM degrees and careers. This would also allow those who are not formally trained in STEM to access STEM careers at the margins, since greater scientific literacy supports a greater market for STEM professionals. One stakeholder concluded,

*There’s legitimacy to the workforce pathway, but it can’t be to the exclusion of those who do not aspire to a STEM career. We can’t leave behind everyone else who could contribute to STEM issues. We need to encourage [STEM] students to take courses in business and political science. They need to know those things. And the people in those fields need to know about science. This*

*communication connection is missing as we train people in STEM. They can't explain to people what it is they're doing and what it means to [others].*

Specific recommendations offered by the stakeholders on this topic included the following:

**STEM literacy.** It was the opinion of many stakeholders that, as STEM educators and administrators, they have a responsibility to promote general STEM literacy for all students, regardless of field of study, to support greater STEM understanding in American civic life. Greater public levels of STEM literacy would benefit non-STEM professionals in their professional life as well as lead to a broad base of support in society for STEM, ultimately encouraging more beginning college students to pursue a STEM education. They felt that offering more introductory STEM courses for non-STEM majors could help to further this mission.

| Stakeholder Feedback  |
|---|
| <ul style="list-style-type: none"> <li>Make introductory STEM courses accessible to non-STEM majors (e.g., offer introductory courses for non-STEM majors on STEM literacy development).</li> <li>Improve STEM literacy in the public policy and business arenas by requiring STEM literacy coursework for STEM majors.</li> <li>Promote cross-fertilization of faculty and course development across STEM and non-STEM disciplines.</li> </ul> |

**STEM communications.** Beyond merely requiring introductory STEM courses for college students, many stakeholders felt the most effective way to promote the “STEM for All” approach would be through proactive and public communication strategies aimed at informing all students why strong STEM fundamentals will benefit them in their eventual non-STEM careers.

**Cross-fertilization of faculty.** Reciprocally, the stakeholders felt that STEM majors should take courses in college to gain a basic literacy in topics like business and political science, thereby benefiting their own professional careers. The cross-fertilization between STEM and other academic disciplines will promote a greater awareness of STEM, and eventually greater support for pursuing STEM and greater STEM literacy.

## STEM Entrepreneurship

**Undergraduate STEM education neglects STEM entrepreneurship.** Stakeholders expressed great concern that, regardless of quality of instruction, STEM majors were leaving school without the necessary skills to succeed in entrepreneurial roles. Thus, they suggested that STEM education should also offer instruction in entrepreneurship for students. Such a strategy not only would generate positive financial outcomes for STEM majors but could lead to the creation of more jobs for future STEM graduates.

| Stakeholder Feedback   |
|--|
| <ul style="list-style-type: none"> <li>Train STEM students to be creative and innovative thinkers.</li> <li>Explicitly teach students how to create their own jobs instead of simply preparing them for employment.</li> </ul> |

**Encouraging creativity.** Because an education in entrepreneurship would focus on creativity and innovation, STEM entrepreneurs could be expected to develop new models and practices in their fields,

contributing to the overall progress of STEM. Furthermore, the scientific breakthroughs and burgeoning business that could be expected as a result of widespread STEM entrepreneurship could expand the job market for STEM graduates.

...

**“It’s about innovation and creativity across the curriculum. Our role as leaders in technology is really related to the capacity to create and innovate. That’s what we need to encourage. That’s what we need to expect.”**

...

*Encouraging entrepreneurship.* As entrepreneurs, STEM graduates could potentially create their own jobs, rather than be only subject to the tides of the STEM labor market. And of course, healthier professional prospects for STEM graduates could be expected to encourage increased enrollment and interest in undergraduate STEM studies.

## The Federal Role

To promote the belief that our nation cannot solve the science and technology problem—the need for more domestic STEM expertise—unless we look to all U.S. students as a potential source of STEM talent, the federal policy roundtable began with a discussion of the most pressing policy challenges facing efforts to broaden participation in STEM. These stakeholders agreed that K–12 preparation, early exposure to STEM, and the affordability of higher education are principal concerns. They agreed that if students do not receive adequate preparation in science and mathematics at the elementary and secondary school levels, there is little chance for success in STEM coursework at the postsecondary level. They feared that the high-stakes accountability climate which prioritizes language arts and mathematics threatens early exposure to science, technology, and engineering learning opportunities. The affordability of a college degree was also viewed as a barrier to pursuing STEM careers. Even though most STEM bachelor’s degrees yield a relatively higher return on investment in terms of compensation in the workplace, the stakeholders raised the concern that underrepresented minority students and their families may be more cost sensitive than their majority counterparts—especially if students need to enroll in remedial coursework, adding additional semesters to a student’s graduation plan and, consequently, requiring a greater financial investment over time.

With this context in mind, questions were raised about the steps federal agencies could take to influence STEM degree completion among underrepresented groups who face these challenges. Specifically, we asked the roundtable participants to share their thoughts about what role their respective agencies have or should have in efforts to broaden participation in STEM, what accountability measures should be in place for institutions receiving federal funding, how and to what degree we should hold institutions accountable institutions for impacting STEM degree completion among underrepresented groups, what steps federal agencies could take to ensure that STEM degree production is aligned with future labor market needs, and how their respective agencies are uniquely positioned to broaden participation in STEM and to complement the efforts of other agencies. Their concerns and suggestions fell under eight broad categories. These are summarized below: (1) funding research, evaluation, and dissemination on STEM education; (2) building capacity; (3) engaging two-year institutions; (4) incentivizing change in higher education; (5) funding targeted partnership development; (6) marketing STEM careers; (7) conducting needs assessment; and (8) expanding federal outreach.

## Fund Research, Evaluation, and Dissemination on STEM Education

**What works in STEM education is not widely known.** These stakeholders emphasized that the federal government must do more to help policymakers and practitioners learn and understand what constitutes “effective practices.” One commented, “We still act like we don’t know how to improve people’s STEM skills.” And yet, for all that we do know, this same individual stated, we rarely talk about the most effective practices and how to implement them: “We are approaching this from so many angles, but rarely do we just talk about what’s effective, and how we can share and replicate effective practices.” These sentiments contrasted with what several other attendees said earlier about not having enough direct evidence. Some, but not all, of those practices that contribute to undergraduate success in STEM may be known. Further, there seems to be a breakdown in communicating to the broader educational community about what practices to prioritize.

While some efforts to broaden participation in STEM at the federal level have demonstrated progress, evidence of this progress is often isolated given sporadic program evaluations. Many outreach professionals often rely on small-scale evaluation or anecdotal evidence over time to inform their thinking and direction. In an era of evidence-based practice, this process is obviously unacceptable. As one participant put it,

*We don’t know if we need directed programs, or what the most effective ones would be. If there was a lever we could turn that would tell us which practices are the most effective, that would be helpful. We give a lot of money broadly to schools, and we get feedback on success, but we don’t know necessarily which aspects of each program were responsible for the success. If we did, we could encourage the next round of grant recipients to do the same.*

There was broad consensus on this point. Another stakeholder pointed out a need to invest in promising programs and practices as well as to allocate funds for the assessment of those practices.

## Build Capacity

**Federal funding is concentrated in well-resourced, four-year institutions.** Stakeholders repeatedly raised the concern that federal funding should be an instrument not only to support STEM program sustainability and innovation at well-established universities but also to improve the STEM teaching and research infrastructure at under-resourced two- and four-year institutions. This funding is essential to improve access and opportunity to a high-quality STEM education for all students. Funding should be provided to help struggling STEM departments recruit and retain talented faculty; to support technical assistance in such areas as STEM instructional program design, student retention, and cross-campus collaboration; enable cross-dissemination and cross-institution partnership development opportunities between two and four-year schools; and provide targeted funding opportunities that respond to the goals of two-year institutions, such as remediation and developmental education, transfers to four-year institutions, certificate programs, preparation for employment, support for nontraditional students, community outreach, and community building.

### Stakeholder Feedback

- Fund more research and evaluation to collect evidence on promising practices to inform funding decisions.
- Fund dissemination efforts to better inform policymakers, faculty, and program developers of promising practices in undergraduate STEM education.

### Stakeholder Feedback

- Provide grants to build the capacity of under-resourced and teaching institutions.
- Award grants to support faculty recruitment and development for struggling STEM departments.
- Offer and/or fund technical assistance.
- Capitalize on the unique strengths of two- and four-year institutions by enabling cross-dissemination and cross-institution partnership development opportunities.
- Provide funding opportunities that respond to the specific goals of two-year institutions.

## Provide Incentives for Change in Higher Education

**Institution-wide buy-in is needed to broaden participation in STEM.** Stakeholders stressed that the goal of diversifying STEM education at the undergraduate level can be realized only when championed by high-level administrators at institutions of higher education. They believed that federal agencies are uniquely poised to encourage this change through strategic funding mechanisms. For instance, senior leadership could be held accountable by requiring them to detail their commitment to efforts to broaden participation for all awards made to their institution. Leaders could be required to sign a memorandum of understanding that continued funding would be predicated on their institution's ability to provide evidence of progress towards improving the retention, learning, research opportunities, and degree production for underrepresented groups.

Another area in which federal funding could incentivize change is teacher effectiveness. The stakeholders suggested that insufficient data is available on instructional effectiveness at the undergraduate level. More disturbing is the perception that institutions often refuse to discuss pedagogy. As one stakeholder noted, "Institutions just say it's their business. The last [presidential] administration got clobbered for trying to wade into this conversation. I think we need to acknowledge that we don't really have these answers." Roundtable participants volunteered a number of unanswered questions:

- Are we developing diverse STEM talent or are we sorting, sifting, and selecting?
- What are we actually training students to know and do, and how does this compare to what we actually need students to know and do to be successful in a STEM career upon graduation?
- Is there some way that we could provide incentives or think about what would be the measures of effective teaching in college, especially at the introductory level, where we lose a huge number of talented students?
- To what extent are the least experienced instructors teaching first-year coursework, and to what extent does teacher inexperience present a real barrier to student persistence in STEM?

- What does effective teaching look like in undergraduate STEM, and which institutions, faculty, and departments are exemplars in this arena?

The stakeholders agreed that questions such as these are a rich area for future research.

#### Stakeholder Feedback

- Hold senior leadership accountable by requiring administrators to certify their understanding that continued funding is predicated on their institution's ability to provide evidence of progress toward improving the retention, learning, research opportunities, and degree production for underrepresented groups.
- Provide incentives that encourage the use of measures of teacher effectiveness at the undergraduate level, especially in introductory courses.

## Fund Targeted Partnership Development

**More targeted partnerships are needed to broaden participation in STEM.** Many stakeholders agreed that another goal of the federal government is to promote and build partnerships. In particular, federal agencies can provide the resources to establish connections across institution types and levels (e.g., a local research consortium of a research institution with a community college and a teaching college), between similar types of schools (e.g., small HBCUs, HSIs, TCUs), across departments within a single institution, and with industry and small business to provide research and internship opportunities for students.

#### Stakeholder Feedback

- Provide funding to support targeted partnership development:
  - *Across institution types and levels*
  - *Between similar types of schools*
  - *Across departments within a single institution, and*
  - *With industry and small business to provide research and internship opportunities for students*



## Market STEM Careers

**Students do not appear to be attracted to STEM careers.** Stakeholders voiced their concern that students do not find careers in STEM attractive. To address this issue, a number of roundtable participants recommend that federal agencies do a better job of marketing the benefits and appeal of a career in STEM to students at the K–12 and postsecondary levels.

### Stakeholder Feedback

- Improve the marketing of STEM careers to students

## Conduct Needs Assessments

**Funding decisions are made with incomplete information.** The stakeholders argued that federal agencies do not have the right data and information on evidence-based practices with which to make funding decisions. They believe that good data mean federal agencies can thoughtfully direct funds to those institutions that are most effective and to those students that can benefit the most. One suggestion affirmed by multiple stakeholders was the establishment of a comprehensive national reporting system to track students’ progress through the pipeline to STEM from cradle to career—a system that includes:

- The contributions of two-year and for-profit institutions to STEM talent development;
- Expands the collection of data on student interest, engagement, persistence, retention, and success in STEM education; and
- Addresses the data challenges associated with tracking STEM coursework and completion among students with disabilities, at tribal colleges and two-year institutions, and among the growing population of nontraditional students.

...

**“If we are spending time and money preparing people for jobs that aren’t there, then we’re being deceitful.”**

...

### Stakeholder Feedback

- Establish a comprehensive national reporting system to track student progress through the pipeline to STEM, from cradle to career, that includes two-year and for-profit institutions.
- Conduct routine needs assessments to prevent duplicative programming, encourage coordination and collaboration, and fill funding gaps across federal funding agencies by determining:
  - *The roles, goals, and funding programs offered by the various funding agencies,*
  - *STEM labor market and policy needs,*
  - *Incentives to encourage students to pursue training in the disciplines for which the need is greatest as well as disincentives for saturated disciplines,*
  - *Outreach activities of the various agencies, and*
  - *Federal policies and federally funded mechanisms that support or present barriers to career advancement in each of the STEM disciplines.*



Citing concerns that agency activities operate too often in silos, the stakeholders also suggested that federal agencies should undergo routine assessment of their efforts to broaden participation in STEM so that needs assessment outcomes inform funding priorities, and that more cross-agency coordination and collaboration should occur. For example, some agencies have learned from economists and labor projection experts that certain STEM fields are saturated with advanced degrees. As an example of how agencies are responding to this concern, the National Institutes of Health (NIH) director is examining how we train future biomedical researchers, with an eye to whether or not institutions are training too many people and thus damaging the desirability of a biomedical research career path. A related concern is the slow pace at which researchers are able to move through their careers, thus hampering their advancement, creating a bottleneck of junior biomedical professionals, and potentially dissuading others to follow their path. One stakeholder pointed out that two indicators of this problem are the average age of a researcher when he or she first wins an RO1 grant (the average age was given as 42) and the low probability of ever receiving a grant. One stakeholder claimed that only one in four applicants is awarded an NIH grant. Additionally, very rigid ideas exist about the pathways one can take into a STEM career. One participant recommended that we need to consider careers such as nursing as technical trades, as “legitimate portals to STEM,” and that we create more entry points into the STEM fields considering such models as the “stackable credentials” advocated by the Department of Labor.

### Expand Federal Outreach

...  
 “Some students will never see organizations like NASA, ... so it’s very important that we send [NASA] to them.”  
 ...

**STEM expertise within federal agencies has not been fully exploited.** Federal employees could do a good deal more in helping students become interested in pursuing and staying in STEM fields. As one participant pointed out, “... the federal government employs so many STEM professionals. Labs need to have these people out talking to students....We need role models. Students need to see the cool things that STEM professionals do.” This comment led to a discussion about the importance of internship programs at federal laboratories, yet, it was noted that many agencies have cut such programs, even though they recognize the importance of “real-world” experiences to promote interest and persistence in STEM careers. In addition to bringing students into federal labs, there was

agreement on the importance of partnerships with K–12 and higher education that allow for scientists to visit schools and institutions. Yet, this is not meant to be what someone called, “drive by” development. Such partnerships must be predicated on multiple conversations and attempts on both sides to understand the educational and professional contexts, benefits, and challenges of pursuing such work. As one participant pointed out, “Some students will never see organizations like the National Aeronautic and Space Administration [NASA] or the Navy, so it’s very important that we send [federal agencies/workers] to them.”

| Stakeholder Feedback |  |
|----------------------|--|
| ■                    | Engage more federal employees in K–16 outreach activities as role models, mentors, and guest teachers. |
| ■                    | Increase internship and research collaboration opportunities within federal research laboratories.     |

## AN OPEN LETTER TO THE NATION

### Broadening Perceptions to Broaden Participation

Dear Citizens of the United States of America:

Our nation's position as a global leader in innovation and progress in the science, technology, engineering, and mathematics (STEM) fields is in peril. Domestic STEM degree production is not keeping pace with the growing demand for STEM talent. In our elementary and secondary schools, we are failing to motivate, engage, and adequately prepare students to pursue STEM degrees at the postsecondary level. In our colleges and universities, access is increasingly cost-prohibitive. Among those who are able to pursue higher education, we are failing to recruit, retain, and graduate

enough students with STEM degrees. We are underutilizing the potential contributions of two-year colleges. Simply put, we are neither cultivating nor growing the STEM expertise the nation needs. Women and racial and ethnic minorities are underrepresented in the STEM disciplines. Collectively, these demographic groups represent the largest untapped pool of potential STEM talent in the United States. According to U.S. Census estimates, women represent a larger proportion of the U.S. population than men, and projections indicate that 54 percent of the population will be a member of a racial or ethnic minority group by 2050. Given the shifting demographic landscape, failing to tap these human resource pools is a waste of domestic assets and, therefore, imposes an opportunity cost on national security interests, the U.S. economy, and our quality of life.

The term, "broadening participation in STEM" refers to a national imperative to develop these untapped STEM talent pools. Accordingly, the *Broadening Participation in STEM* project, led by the American Institutes for Research (AIR) was designed to identify the challenges and opportunities for enhancing STEM degree attainment across the nation particularly among historically underrepresented groups. In conducting a trend analysis of national STEM bachelor's degree attainment between 1989 and 2009, our findings are unmistakable and unambiguous: *National STEM bachelor's degree completion trends are not promising for any U.S. demographic group including Whites and Asian/Pacific Islanders.*

- **Blacks, Hispanics and women are underrepresented in the domestic pipeline to STEM.** Although the number and share of bachelor's degrees earned in STEM by underrepresented minorities and women has increased over time, this growth did not keep pace with population growth, undergraduate enrollment, overall bachelor's degree attainment, and projected STEM labor market growth rates.
- **The percentage of bachelor's degrees earned in a STEM discipline has not realized considerable growth over time for any demographic group, including Whites.** Among Asian/Pacific Islanders, the percentage of bachelor's degrees earned in a STEM discipline has actually *declined* over time.
- **When disaggregated by STEM discipline, the trend data indicate pronounced performance gaps between Whites and racial and ethnic minorities, between men and women, and between White women and White men.** For example, the biological sciences and the agricultural sciences are the *only* STEM disciplines in which women have *reached parity and*

*surpassed men* in terms of the number and proportion of bachelor's degrees earned; a sizable *gender gap persists* in engineering and the computer sciences; and unlike their minority peers, there is a *substantial attainment gap* between White women and White men in the physical sciences, computer sciences, engineering, and the earth, atmospheric and oceanic sciences.

Concerning the role of Minority-Serving Institutions (MSIs), our findings were similarly unambiguous. Historically Black Colleges and Universities (HBCUs) and Tribal Colleges and Universities (TCUs) have an historical mission to target Black and American Indian students, respectively, in higher education. Hispanic-Serving Institutions (HSIs) are more recent in the higher education landscape with federal designation, and many have revised their missions with specific language that targets Hispanic students.

- **Although non-MSIs produce a greater number of Black and American Indian/Alaska Native STEM graduates, HBCUs produce a larger percentage of STEM degrees among Black students, and TCUs have steadily increased their production of American Indian/Alaska Native STEM graduates although the percentage of STEM degrees among American Indian/Alaska Natives at non-MSIs has remained virtually unchanged.**
- **HSIs produce Hispanic STEM graduates at levels comparable to non-MSIs.**

We solicited the perspectives of a wide range of national STEM education experts and stakeholders—including representatives from MSIs and non-MSIs, professional associations, federal agencies, corporations, foundations, and student groups—on the state of undergraduate STEM degree production and recommendations for change. We convened roundtable discussions in Washington, D.C., on three occasions in the spring of 2011 to gather this feedback. The representatives and thought leaders who participated in our listening sessions provided judicious observations and counsel on ways to improve our STEM education and workforce development infrastructure. Of these, a number stand out:

- The current definition of success in broadening participation in STEM is too narrow; we need to move beyond simple degree completion rates to a wider range of measures.
- The role of two-year institutions, TCUs and other MSIs must be enhanced and should not be diminished; different types of institutions play different but equally valuable roles in producing STEM talent.
- There is an alarming and pervasive culture of attrition in the STEM disciplines.
- Federal funding is too concentrated in well-resourced, four-year and research institutions at the expense of other types of institutions in serious need of capacity-building. These institutions, two-year institutions, and MSIs, educate a critical mass of underrepresented minorities.
- STEM degree production and workforce needs are not aligned.
- Higher education is not promoting STEM literacy for all.
- STEM education is largely preparing students to be employees while neglecting their development as entrepreneurs.
- Federal agencies need to coordinate their efforts and rely on better data with which to make funding decisions.

**Broadening participation is a critical national priority and a shared responsibility.** Principal among the suggestions offered by the stakeholders are the need to:

- Establish a comprehensive national reporting system to track student progress through the pipeline to STEM, from cradle to career, that includes two-year and for-profit institutions;
- Align STEM degree production with national talent-development needs;
- Ensure the highest quality P–16 STEM education workforce including teachers, faculty, and the educators and researchers who train and support them; and
- Engage the nation in STEM literacy, awareness, and action.

**How do we forge a new path so that the state of STEM education in 2032 is different from that in 2012?**

Our trend analyses covered a 20-year span and compel a new outlook for how we go about the business of developing STEM talent in the United States. The recommendations shared by the stakeholders who participated in our gatherings point to deep changes needed in our approaches to promoting STEM success for all. Their perspectives can help us reignite a vision for our nation as a global leader in STEM innovation—a nation that embraces diversity in STEM as an asset rather than an obstacle. Key policy considerations to move forward as a nation include:

- **A Vision for 2032.** What will the national STEM landscape look like when traditionally underrepresented groups are well-represented in the pipeline to a STEM career?
- **STEM Teaching and Learning.** What innovations in the undergraduate experience in STEM will need to be in place to realize a different set of trends over the next 20 years?
- **STEM Workforce.** What steps can we take today to ensure that STEM degree completions are aligned with labor market needs in the next 20 years?

**When great demographic shifts have occurred in our country, these shifts are often accompanied by dramatic surges in innovation. Our nation is at this point now.** Now is the time to capitalize on the substantial and emerging STEM talent unique to a country as large and diverse as the United States. All Americans must share the burden and responsibility of broadening participation in STEM in the interest of our nation's continued prosperity and security.

Sincerely,

Carlos Rodriguez, Principal Investigator (AIR)

Lauren Banks Amos, Project Director (AIR)

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## APPENDICES

### Appendix A: Methodology Report

#### Trend Analysis

The American Institutes for Research® (AIR®) research team analyzed extant data in key programmatic domains that are particularly relevant to the National Science Foundation's (NSF's) priorities and mechanism for broadening participation (<http://www.nsf.gov/od/broadeningparticipation/bp.jsp>) and disaggregated these data by race/ethnicity, sex, disability status, and science, technology, engineering, and mathematics (STEM) discipline. These domains included institutional-level enrollment and degree-attainment trends among underrepresented groups at (a) the national level; and (b) Minority-Serving Institutions (MSIs). This document provides an overview of the methodology for this analysis.

#### *Data: Integrated Postsecondary Education Data System (IPEDS) Public-Use Data, 1990–2009*

The primary data source for these analyses is the U.S. Department of Education's (ED's) Integrated Postsecondary Education Data System (IPEDS; [www.nces.ed.gov/ipeds/datacenter](http://www.nces.ed.gov/ipeds/datacenter)) public-use data. IPEDS is a system of interrelated surveys conducted annually by the ED's National Center for Education Statistics to gather information on enrollments, program completion, graduation rates, and other factors. Data are gathered from every college, university, and technical and vocational institution that participates in federal student financial aid programs (<http://nces.ed.gov/ipeds/about>). The data for the current analyses come from IPEDS surveys conducted from 1990 through 2009. Enrollment and degree attainment data for all institutions surveyed during this time frame were gathered along with data on institutional characteristics, student demographics, and fields of study.

#### *Sample of Institutions: Non-Proprietary, Degree-Granting Institutions*

We restricted our sample to nonproprietary, degree-granting (bachelor's) institutions in the United States and Puerto Rico. Because the trend analysis covers a 20-year time span, some institutions changed status across the years. Data are included only for the institutions during the years that they were degree-granting and nonproprietary.

#### *Minority-Serving Institution Status designation*

The MSI designation is determined by the ED's criteria for Historically Black Colleges and Universities (HBCUs), Tribal Colleges and Universities (TCUs), Hispanic Serving Institutions (HSIs; 25 percent Hispanic enrollment), and Predominantly Black Institutions (PBIs; 40 percent Black enrollment and at least 1,000 undergraduate students).<sup>19</sup> Because classifications such as HSI or PBI are dependent on the racial/ethnic composition of the institution, an institution's status as an HSI or PBI can change from year to year. For the trend analysis on MSIs, we wanted to include only institutions that were considered "stable" as an MSI. We defined stable MSIs as those institutions that met the enrollment qualifications

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<sup>19</sup> PBIs and HSIs were identified using the IPEDS enrollment data.

for HSI/PBI at least 50 percent of the time. The final sample of MSIs was generated from the list of IPEDS institutions, using the ED criteria. By 2009, the sample of MSIs granting bachelor's degrees comprised 83 HBCUs<sup>20</sup>, 7 TCUs<sup>21</sup>, 108 HSIs<sup>22</sup>, and 39 PBIs.<sup>23</sup>

### *Measures: Enrollment and Degree Attainment*

We present trends for undergraduate enrollment, and bachelor's degree attainment. Attainment data are disaggregated by STEM discipline, race/ethnicity (Black, Hispanic, American Indian/Alaska Native, White, Asian/Pacific Islander), gender, and MSI status.

### *The STEM Disciplines*

We identified seven STEM disciplines, based on the NSF classification of Science and Engineering fields from the 2010 Science and Engineering Indicators report. These are:

1. Agricultural Sciences
2. Earth, Atmospheric, and Oceanic Sciences
3. Biological Sciences
4. Physical Sciences
5. Computer Sciences
6. Engineering
7. Mathematics

In IPEDS, degree programs are categorized by the Classification of Instructional Programs (CIP).<sup>24</sup> From 1995 to the present, degree programs were identified using a six-digit CIP code. We used both the 1990 and 2000 CIP code crosswalks to categorize each CIP code into one of the seven STEM disciplines or as non-STEM. Prior to 1995, IPEDS categorized degree programs by using two-digit CIP codes. The two-digit codes are not precise enough to identify accurately all of the STEM disciplines (e.g., earth, atmospheric, and ocean sciences did not have a two-digit code but was part of physical sciences), and some two-digit codes included disciplines that were both STEM and non-STEM. We chose to mark two-digit CIP code series that comprised mostly six-digit CIP codes as STEM disciplines. This means that some disciplines that are considered as STEM in 1990–1994 are considered as non-STEM in the 1995–2009 data.

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<sup>20</sup> A full list of HBCUs is available on the ED Website, <http://www2.ed.gov/about/inits/list/whhbcu/edlite-list.html>.

<sup>21</sup> A full list of Tribal Colleges and Universities is available on the ED Website: <http://www2.ed.gov/about/inits/list/whtc/edlite-tcllist.html>.

<sup>22</sup> ED has not published an official list of HSIs but a definition is available on their Website: (<http://www2.ed.gov/programs/idueshsi/definition.html>). Additional information on HSIs can be found at the following Websites; Hispanic Association of Colleges and Universities ([http://www.hacu.net/hacu/HSI\\_Definition\\_EN.asp?SnID=2](http://www.hacu.net/hacu/HSI_Definition_EN.asp?SnID=2)); *Excelencia* in Education: Emerging HSIs (<http://www.edexcelencia.org/research/hsi/hsi-lists>).

<sup>23</sup> ED has not published an official list of PBIs. Our definition of PBIs is the first two criteria under section C on the following Website: <http://www2.ed.gov/programs/pbi/eligibility.html>.

<sup>24</sup> The CIP is the accepted federal government statistical standard on classifying instructional programs (<http://nces.ed.gov/pubs2002/2002165.pdf>).



### *Analytic Model*

Degree attainment trends, from 1989 to 2009, are presented for the total number of STEM bachelor's degrees earned, for the percentage of STEM bachelor's degrees conferred across race/ethnicities, and for the percentage of STEM bachelor's degrees earned within a race/ethnicity. The *percentage of STEM degrees earned across race/ethnicities* refers to the percent of STEM graduates who belong to each racial/ethnic group (e.g., Black STEM graduates/STEM graduates for all racial/ethnic groups). The *percentage of STEM degrees earned within a race/ethnicity* refers to the proportion of graduates from a given race/ethnicity who graduate in STEM (e.g., Black STEM graduates/Black total graduates).

### **Literature Review**

The literature review consisted of three phases: (1) search, (2) screen, and (3) summarize. For phase 1, the search strategy involved a search of online data bases such as ERIC, EBSCO, and JSTOR as well as STEM-related Websites and journals. The following key search terms were combined to identify potential resources:

#### *Key Search Terms*

- STEM
- Specific STEM fields (science, technology, engineering, math, computer science, chemistry, biology, physics, etc.)
- Specific underrepresented groups (underrepresented ethnic groups, women, persons with disabilities)
- Evaluation-related terms (evaluation, intervention, effect/effectiveness, impact)
- Outcome-related terms (access, enrollment, participation, retention, persistence, achievement, aspiration, completion/attainment, career, workforce)

In addition, we also searched for specific STEM programs (e.g., TCUP, LSAMP, HBCU-UP, Meyerhoff, etc.). The initial search resulted in more than 220 references. During the next phase, the references were screened to identify those that met the following criteria for inclusion in the literature review:

- The study is empirical and presents a research question, data analysis, and findings based on the research question(s). Empirical studies include quantitative, qualitative, or mixed-methods studies employing a randomized, quasi-experimental, or nonexperimental design.
- The study reports on an intervention, initiative, strategy, or policy that aims to increase the participation of underrepresented groups (i.e., Blacks, Hispanics, American Indian/Alaska Natives, women, and persons with disabilities) in STEM fields OR addresses factors related to broadening participation in STEM.
- The study reports outcomes on one or more underrepresented groups (e.g., if the sample consists of both underrepresented minorities (URMs) and non-URMs, outcomes must be disaggregated to report specific URM outcomes).
- The study reports outcomes related to at least one of the following: enrollment, retention, persistence, attrition, achievement, degree attainment/completion, degree production,



graduate enrollment, career/workforce development, graduate aspiration, career/workforce development, or noncognitive development (e.g., interventions that increase students' math self-concept).

- The study reports outcomes related to *undergraduate* (two-year and four-year institutions) experiences in STEM. (e.g., a study based on a high school intervention must report outcomes at the undergraduate level, or a study investigating an undergraduate intervention can report on post-undergraduate outcomes such as graduate school enrollment).
- The study was published between 1995 and 2010.

After applying these criteria, the list of appropriate references was reduced to approximately 60 studies and reports. In the final phase, these reports were summarized by using a template that captured the following information

- Research question
- Description of the intervention, initiative, strategy
- Assessment of rigor (high, moderate, or low on the basis of the research design)
- Key findings
- Recommendations
- A brief summary of the study

This information was then used to generate a broad review of the literature regarding (a) the overall effectiveness of broadening participation efforts, (b) identification of factors or strategies that could potentially increase the return on investment, and (c) identification of research gaps that warrant exploration.

## Stakeholder Roundtables

An iterative process was used to select higher education institutions for participation in the stakeholder roundtables. The ultimate goal was to have a diverse sample of stakeholders from both two- and four-year degree-granting institutions that represented the institution types listed below.

The following criteria were used in compiling a list to use for the potential sample. Institutions selected represent a balanced cross-section of:

1. Two- and four-year public and four-year private not-for-profit colleges/universities with MSI designation:
  - a. Historically Black Colleges and Universities (HBCUs)
  - b. Tribal Colleges and Universities (TCUs)
  - c. Hispanic Serving Institutions (HSIs)
  - d. Predominantly Black Institutions (PBIs)
2. Two- and four-year public and four-year private not-for-profit predominantly White institutions
3. Institutions housing current broadening participation programs:
  - a. Historically Black Colleges and Universities Undergraduate Program (HBCU-UP)
  - b. Tribal Colleges and Universities Program (TCUP)
  - c. LSAMP Louis Stokes Alliances for Minority Participation (LSAMP)

We also envisioned having a final attendee list representing approximately:

- 1/3 predominantly White institutions (PWIs) and 2/3 MSIs
- 40 percent community colleges (CCs)
- 30 percent HSIs
- 25 percent HBCUs and PBIs (knowing the PBI number would be much smaller)
- 15 percent TCUs

The following sets of data/information were used to identify and select participants.

- Integrated Postsecondary Education Data System (IPEDS) 2008/09.
- HBCU-UP, TCUP, and LSAMP grantees (provided by NSF).
- National Center for Education Statistics definition of HSIs: *Institutions with Hispanic students constituting at least 25 percent of the undergraduate enrollment, while students of all other individual minority groups each constitute less than 25 percent of the total undergraduate enrollment but that are not HBCU or TCU.*
- National Center for Education Statistics definition of PBIs: *Institutions with Black students constituting at least 25 percent of the total undergraduate enrollment while students of all other individual minority groups each constitute less than 25 percent of the total undergraduate enrollment but that are not designated as HBCUs or Tribal Colleges and Universities (TCUs).*
- National Center for Education Statistics definition of Tribal Colleges and Universities (TCU): *TCUs or institutions that have American Indians/Alaska Natives constituting at least 25 percent of their undergraduate enrollment while students of all other individual minority groups each constitute less than 25 percent of the total undergraduate enrollment, but that are not HBCU.*

**STEP 1:** An approximate, representative 10 percent sample was drawn (using IPEDS) from a population of public and private non-profit two- and four-year institutions ( $n = 2,655$ ). The sample ( $n = 252$ ) was derived by using four key institutional-level characteristics: (1) degree of urbanicity; (2) size (full-time equivalent [FTE] undergraduates); (3) census region; and (4) presence of a medical school. In other words, the sample ( $n = 252$ ) is representative of the larger population on these four dimensions. Each of these dimensions describes aspects of institutions that may influence undergraduate access and completion in STEM. Selected institutions were limited to the following:

- Institutions that grant STEM associates and bachelor's degrees (i.e., institutions that only grant certificates or did not grant STEM degrees were excluded).
- Institutions with 10% or greater degree production in STEM (e.g., percent of graduates who earned a STEM degree).

**STEP 2:** To ensure sufficient numbers of associate's degree-granting institutions and HSIs, a 50 percent sample was drawn from the remaining institutions ( $N = 2,314$ ). The same criteria mentioned above were used in the selection of these postsecondary institutions, as well. The CCs and HSIs were taken from this run and added to the run from Step 1.

**STEP 3:** Once the IPEDs lists were compiled, we did a number of checks to make sure our sample was representative of the proportion of institutions (e.g., MSIs, CCs, etc.) we ultimately wanted in attendance. When the list did not conform to that proportion, we utilized NCES MSI data (i.e., separately run lists of institutions in each MSI sector) to randomly select additional institutions to add to our master sample.

**STEP 4:** To invite the proper number of institutions to yield an approximately 30 percent meeting acceptance rate, we reduced the total number of institutions on the master list, using a random number generator in Microsoft Excel. Another check of institutional representation was assessed after this process. A “primary” and a “secondary” list were developed. When we didn’t get the 30 percent response from the primary list, we sent out invitations to the secondary list.

**STEP 5:** Invitations were sent to an institution’s chief academic officer (e.g., provost) and requested that person attend or a person designated from their campus who could speak to our topic. For those institutions with NSF funds (i.e., HBCU-UP, TCUP, LSAMP), we suggested (although it was not required) they consider choosing the Principal Investigator or a program staff member of said program.

**STEP 6:** The project team monitored RSVPs several times per week between our initial mailing and the first event to ensure we were getting the institutional representation we desired. In several cases, we made follow-up phone calls to urge attendance.

### *Federal Policy Community*

Individuals were selected through purposeful sampling and were contacted for participation via e-mail and paper invitations. A number of invitees were identified via federal agency Websites. When Website content included program descriptions in the areas of diversity, inclusion, equal opportunity, educational outreach, and the like, identified contact persons were recorded and added to a list of potential invitees. It should be noted that much room for improvement exists in regard to the visibility of these efforts on agency Websites. There was great variation in the level of visibility of diversity and inclusion efforts as outright priorities. Of course, not all agencies have a strong portfolio of diversity programming or robust internal offices for equal opportunity.

Aside from identifying individuals on agency Websites, much success occurred with the use of a snowball sampling technique, that is, through reaching out to known agency contacts with oversight responsibilities for educational outreach, diversity programming, etc. The BP project team brainstormed potential invitees and secured contact information; they too were sent an e-mail and paper invitation (note that NSF also provided several names and agencies to contact). When individuals were not able to attend or were not responsive, additional outreach took place through e-mail and telephone contact. In either case, individuals were asked to provide potential other invitees based on information provided regarding the purpose of the meeting.

|   |  |
|---|--|
| <p><b>Federal Agencies/Employers:</b></p> <ol style="list-style-type: none"> <li>1. National Science Board</li> <li>2. National Academy of Sciences</li> <li>3. National Academy of Engineering</li> <li>4. National Institutes of Health</li> <li>5. Department of Energy</li> <li>6. Department of Defense</li> <li>7. Department of Education</li> <li>8. National Aeronautics and Space Administration (NASA)</li> <li>9. Environmental Protection Agency</li> <li>10. National Institute of Standards and Technology</li> <li>11. National Oceanic and Atmospheric Administration</li> <li>12. Department of Commerce</li> <li>13. Department of Transportation</li> <li>14. Department of Labor</li> <li>15. Homeland Security</li> <li>16. National Security Agency</li> <li>17. Central Intelligence Agency</li> <li>18. Federal Bureau of Investigation</li> <li>19. Bureau of Alcohol, Tobacco, Firearms, and Explosives</li> </ol> | <p><b>Federal Laboratories:</b></p> <ol style="list-style-type: none"> <li>1. Jet Propulsion Laboratories (JPL)</li> <li>2. Sandia National Laboratories</li> <li>3. Los Alamos National Laboratory</li> <li>4. Jefferson Lab (JLab)</li> <li>5. Oak Ridge National Laboratory (ONRL)</li> <li>6. Argonne National Laboratory</li> <li>7. Brookhaven National Laboratory</li> <li>8. Fermilab</li> </ol> <p><b>White House:</b></p> <ol style="list-style-type: none"> <li>1. Office of Science and Technology Policy</li> <li>2. Office of Management and Budget</li> </ol> <p><b>Congressional Committees:</b></p> <ol style="list-style-type: none"> <li>1. Senate Committee on Health, Education, Labor, and Pensions</li> <li>2. House Committee on Education and Labor</li> </ol> <p><b>Associations/Nonprofits:</b></p> <ol style="list-style-type: none"> <li>1. American Association for the Advancement of Science</li> <li>2. Quality Education for Minorities Network</li> </ol> |
|---|--|

**Student Community**

The list below represents national STEM student organizations, many of which engage in active advocacy work and will be able to assist in identifying undergraduate and graduate student leadership:

1. SACNAS: Advancing Hispanics/Chicanos & Native Americans in Science
2. American Indian Science and Engineering Society
3. National Society of Black Scientists and Engineers
4. National Society of Black Physicists
5. Society of Women Engineers
6. Mathematics, Engineering, Science Achievement

## Appendix B: IPEDS STEM Disciplines and Subdisciplines

### Agricultural Sciences

- Agricultural and Extension Education Services
- Agricultural and Horticultural Plant Breeding
- Agricultural Animal Breeding
- Agricultural Animal Breeding and Genetics
- Agricultural Animal Health
- Agricultural Animal Nutrition
- Agricultural Communication/Journalism
- Agricultural Extension
- Agricultural Public Services, Other
- Agriculture, Agriculture Operations, and Related Sciences, Other
- Agriculture/Agricultural Sciences Other
- Agronomy and Crop Science
- Animal Health
- Animal Nutrition
- Animal Physiology
- Animal Sciences, General
- Animal Sciences, Other
- Dairy Science
- Environmental Science/Studies
- Fishing and Fisheries Sciences and Management
- Food Science
- Food Science and Technology
- Food Sciences and Technology, Other
- Food Technology and Processing
- Forest Harvesting and Production Technician
- Forest Management/Forest Resources Management
- Forest Production and Processing, Other
- Forest Products Technology/Technician
- Forest Resources Production and Management
- Forest Sciences and Biology
- Forest Technology/Technician
- Forestry, General
- Forestry, Other
- Horticultural Science
- International Agriculture
- Land Use Planning and Management/Development
- Livestock Management
- Natural Resources Law Enforcement and Protective Services
- Natural Resource Economics
- Natural Resources and Conservation, Other
- Natural Resources Conservation and Research, Other
- Natural Resources Management and Policy
- Natural Resources Management and Policy, Other
- Natural Resources/Conservation, General
- Plant Breeding and Genetics
- Plant Protection (Pest Management)
- Plant Protection and Integrated Pest Management
- Plant Sciences, General
- Plant Sciences, Other
- Poultry Science
- Range Science and Management
- Soil Chemistry and Physics
- Soil Science and Agronomy, General
- Soil Sciences
- Soil Sciences, Other
- Taxidermy/Taxidermist
- Urban Forestry
- Water, Wetlands, and Marine Resources Management
- Wildlife and Wildlands Science and Management
- Wood Science and Wood Products/Pulp and Paper Technology

## Biological Sciences

- Anatomy
- Animal Behavior and Ethology
- Animal Genetics
- Aquatic Biology/Limnology
- Biochemistry
- Biochemistry, Biophysics and Molecular Biology, Other
- Biochemistry/Biophysics and Molecular Biology
- Bioinformatics
- Biological and Biomedical Sciences, Other
- Biological Immunology
- Biology/Biological Sciences, General
- Biomathematics and Bioinformatics, Other
- Biomedical Sciences, General
- Biometrics
- Biometry/Biometrics
- Biophysics
- Biopsychology
- Biostatistics
- Biotechnology
- Biotechnology Research
- Botany/Plant Biology
- Botany/Plant Biology, Other
- Cardiovascular Science
- Cell Biology and Anatomy
- Cell Physiology
- Cell/Cellular and Molecular Biology
- Cell/Cellular Biology and Anatomical Sciences, Other
- Cell/Cellular Biology and Histology
- Conservation Biology
- Developmental Biology and Embryology
- Ecology
- Ecology, Evolution, Systematics, and Population Biology, Other
- Endocrinology
- Entomology
- Environmental Biology
- Environmental Toxicology
- Epidemiology
- Evolutionary Biology
- Exercise Physiology
- Foodservice Systems Administration/Management
- Genetics, General
- Genetics, Other
- Genetics, Plant and Animal
- Human/Medical Genetics
- Immunology
- Marine Biology and Biological Oceanography
- Marine/Aquatic Biology
- Medical Microbiology and Bacteriology
- Microbiological Sciences and Immunology, Other
- Microbiology, General
- Microbiology/Bacteriology
- Miscellaneous Biological Specializations, Other
- Molecular Biochemistry
- Molecular Biology
- Molecular Biophysics
- Molecular Genetics
- Molecular Pharmacology
- Molecular Physiology
- Molecular Toxicology
- Neuroanatomy
- Neurobiology and Neurophysiology
- Neuropharmacology
- Neuroscience
- Nutrition Sciences
- Oncology and Cancer Biology
- Parasitology
- Pathology, Human and Animal
- Pathology/Experimental Pathology
- Pharmacology
- Pharmacology and Toxicology
- Pharmacology, Human and Animal
- Physiology, General
- Physiology, Human and Animal

- Physiology, Pathology, and Related Sciences, Other
- Plant Genetics
- Plant Molecular Biology
- Plant Pathology/Phytopathology
- Plant Physiology
- Population Biology
- Radiation Biology/Radiobiology
- Radiation Biology/Radiobiology
- Reproductive Biology
- Structural Biology
- Systematic Biology/Biological Systematics
- Toxicology
- Virology
- Vision Science/Physiological Optics
- Wildlife Biology
- Zoology/Animal Biology
- Zoology/Animal Biology, Other

### Computer Sciences

- Artificial Intelligence and Robotics
- Computer and Information Sciences and Support Services, Other
- Computer and Information Sciences, Other
- Computer and Information Sciences, General
- Computer and Information Systems Security
- Computer Graphics
- Computer Programming, Other
- Computer Programming, Specific Applications
- Computer Programming, Vendor/Product Certification
- Computer Programming/Programmer, General
- Computer Science
- Computer Software and Media Applications, Other
- Computer Systems Analysis/Analyst

- Computer Systems Networking and Telecommunications
- Computer/Information Technology Services Administration and Management, Other
- Data Modeling/Warehousing and Database Administration
- Data Processing and Data Processing Technology/Technician
- Information Science/Studies
- Information Technology
- System Administration/Administrator
- System, Networking, and LAN/WAN Management/Manager
- Web Page, Digital/Multimedia and Information Resources Design
- Web/Multimedia Management and Webmaster

### Earth, Atmospheric, and Oceanic Sciences

- Atmospheric Chemistry/Climatology
- Atmospheric Physics and Dynamics
- Atmospheric Sciences and Meteorology, General
- Atmospheric Sciences and Meteorology, Other
- Earth and Planetary Sciences
- Geochemistry
- Geological and Earth Sciences/Geosciences, Other
- Geology/Earth Science, General
- Geophysics and Seismology
- Hydrology and Water Resources Science
- Meteorology
- Oceanography
- Oceanography, Chemical and Physical
- Paleontology

## Engineering

- Aerospace, Aeronautical and Astronautical Engineering
- Agricultural/Biological Engineering and Bioengineering
- Architectural Engineering
- Biomedical/Medical Engineering
- Cartography
- Ceramic Sciences and Engineering
- Chemical Engineering
- Civil Engineering
- Civil Engineering, Other
- Computer Engineering, General
- Computer Engineering, Other
- Computer Hardware Engineering
- Computer Software Engineering
- Construction Engineering
- Electrical, Electronics and Communications Engineering
- Engineering Design
- Engineering Mechanics
- Engineering Physics
- Engineering Science
- Engineering, General
- Engineering, Other
- Environmental/Environmental Health Engineering
- Forest Engineering
- Geological Engineering
- Geological/Geophysical Engineering
- Geophysical Engineering
- Geotechnical Engineering
- Industrial Engineering
- Industrial/Manufacturing Engineering
- Manufacturing Engineering
- Materials Engineering
- Materials Science
- Mechanical Engineering
- Metallurgical Engineering
- Mining and Mineral Engineering
- Naval Architecture and Marine Engineering

- Nuclear Engineering
- Ocean Engineering
- Operations Research
- Petroleum Engineering
- Polymer/Plastics Engineering
- Structural Engineering
- Surveying Engineering
- Systems Engineering
- Textile Sciences and Engineering
- Transportation and Highway Engineering
- Water Resources Engineering

## Mathematical Sciences

- Actuarial Science
- Analysis and Functional Analysis
- Applied Mathematics
- Applied Mathematics, Other
- Business Statistics
- Computational Mathematics
- Mathematical Statistics and Probability
- Mathematics
- Mathematics and Statistics, Other
- Mathematics, General
- Mathematics, Other
- Operations Research
- Statistics, General
- Statistics, Other

## Physical Sciences

- Acoustics
- Analytical Chemistry
- Astronomy
- Astronomy and Astrophysics, Other
- Astrophysics
- Atomic/Molecular Physics
- Chemical Physics
- Chemistry, General
- Chemistry, Other
- Elementary Particle Physics
- Inorganic Chemistry



- Medicinal and Pharmaceutical Chemistry (MS, PhD)
- Medicinal/Pharmaceutical Chemistry
- Metallurgy
- Miscellaneous Physical Sciences, Other
- Nuclear Physics
- Optics/Optical Sciences
- Organic Chemistry
- Physical and Theoretical Chemistry
- Physical Sciences
- Physical Sciences, Other
- Physics, General
- Physics, Other
- Planetary Astronomy and Science
- Plasma and High-Temperature Physics
- Polymer Chemistry
- Solid State and Low-Temperature Physics
- Theoretical and Mathematical Physics

## Appendix C: Participating Institutions

A representative from each of the following institutions, agencies, and organizations participated in one of the Broadening Participation in STEM stakeholder feedback events.

### Institutes of Higher Education

|   |   |
|---|---|
| Adelphi University                              | Malcolm X College                           |
| Alcorn State University                         | Massachusetts Institute of Technology       |
| Allen University                                | McNeese State University                    |
| Bloomfield College                              | Mesalands Community College                 |
| Brookdale Community College                     | Miami Dade College                          |
| Cabrillo College                                | Morgan State University                     |
| California State University Chico               | New Mexico Junior College                   |
| California State University, Bakersfield        | New Mexico State University                 |
| California State University, Fresno / Lyles     | New York City College of Technology         |
| College of Engineering                          | North Carolina Central University           |
| California State University, Los Angeles        | Northern Arizona University                 |
| Canada College                                  | Occidental College                          |
| Cankdeska Cikana Community College              | Oglala Lakota College Math and Science      |
| Carnegie Mellon University                      | Department                                  |
| Cheyney University of Pennsylvania              | Palo Alto College                           |
| Chief Dull Knife College                        | Pima Community College                      |
| City College of New York of the City University | Queensborough Community College             |
| of New York                                     | Quincy College                              |
| Clafin University                               | Saint Augustine's College                   |
| College of Menominee Nation                     | Saint Mary's University                     |
| College of the Sequoias                         | San Joaquin Delta College                   |
| Community College of Denver                     | Santa Fe Community College                  |
| Coppin State University                         | Savannah State University                   |
| Delaware State University                       | Simmons College                             |
| Fairmont State University                       | Sitting Bull College                        |
| Fort Belknap College                            | South Dakota School of Mines and Technology |
| Georgia Institute of Technology                 | South Dakota State University               |
| Golden West College                             | Talladega College                           |
| Grambling State University                      | Tennessee State University                  |
| Harvard University Medical School               | Texas Southern University                   |
| J.F. Drake State Technical College              | United Tribes Technical College             |
| Johns Hopkins University                        | University of California–Berkeley           |
| Kansas City Kansas Community College            | University of California–Los Angeles        |
| Kapiolani Community College                     | University of California–Santa Cruz         |
| La Salle University                             | University of Colorado–Boulder              |
| Lane College                                    | University of Hawaii at Hilo                |
| Lincoln University in Missouri                  | University of South Alabama                 |
| Linn-Benton Community College                   | University of St. Thomas                    |
| Louisiana State University                      | University of Texas at Austin               |
|   | University of Texas at San Antonio          |

University of the District of Columbia  
University of Washington  
University of West Alabama  
University of Wisconsin–La Crosse  
University of Wisconsin–Platteville  
University of Wisconsin–Madison  
Vanderbilt University Graduate School  
Winston-Salem State University

### **Federal Agencies**

Los Alamos National Lab, Department of Energy  
National Aeronautics and Space Administration  
National Institutes of Health, National Center on Minority Health and Health Disparities  
National Institutes of Health, Office of Science Education  
National Oceanic and Atmospheric Administration  
United States Department of Education  
United States Department of Energy  
White House Domestic Policy Council

### **Professional Organizations and Associations**

American Association for the Advancement of Science (AAAS)  
American Chemical Society  
American Indian Science and Engineering Society  
Building Engineering & Science Talent (BEST)  
Hispanic Association of Colleges and Universities  
National Action Council for Minorities in Engineering  
Quality Education for Minorities (QEM) Network  
Virginia Latino Higher Education Network  
Society of Hispanic Professional Engineers  
Hispanic Association of Colleges and Universities  
Frida Kahlo Institute

### **Corporations**

Intel Corporation  
CNA  
BAE Systems Inc.

## A Broadening Participation in STEM Publication

### Authors |

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