Testimony of

Victor McCrary, PhD

Member

National Science Board

National Science Foundation

Before the

Subcommittee on Research and Technology

for the

Committee on Science, Space, and Technology

U.S. House of Representatives

February 15, 2018

"Innovations in STEM Mentoring, Training, and Apprenticeships"

Introduction: The Workforce of the Future

Ensuring the long-term strength of the Nation's scientific workforce has always been a core component of NSF's mission. Our workforce has been – and continues to be – the essence of American innovation, economic competitiveness, and national security. In 1950, Vannevar Bush wrote that "the responsibility for the creation of new scientific knowledge - and for most of its application - rests on that small body of men and women who understand the fundamental laws of nature and are skilled in the techniques of scientific research." At that time this meant scientists and engineers engaged in research and development (R&D) in government, academic, or industry laboratories.

But science has progressed and our economy has evolved since NSF's founding. Bush's conception is now far too narrow. While the education and training of scientists and engineers who perform fundamental research—our Nation's "Discoverers"—remain central to NSF's mission, we now recognize that science, technology, engineering, and math (STEM) capabilities are important to the *entire* U.S. workforce **and** that the progress of science depends on more than just PhDs. As we look towards the next 70 years, the

NSB believes that for our Nation to continue to thrive and lead in a globally competitive knowledge- and technology-intensive economy we must do more than create a "STEM workforce"; Congress, the Administration, business leaders, educators, and other decision-makers must work together to create a **STEM-capable U.S. workforce**.

Scientific and technological advances have transformed the workplace, especially in traditionally middle-class, blue-collar jobs such as manufacturing. These and many other jobs now demand higher levels of STEM knowledge and skill. In 2015 about 14.3 million U.S. workers were employed in a STEM job. Yet in a survey of individuals with at least a four-year degree, including many working in sales, marketing, and management, an estimated 19.4 million reported that their job required at least a bachelor's degree level of STEM expertise. This does not include millions of workers who use technical competencies in their job, but who do not have a four-year degree. And the number of jobs requiring these skills is growing across all sectors of our economy.

Creating a STEM-capable U.S. workforce requires a much more expansive vision, one that includes students and workers at all education levels. Workers on the farm, the factory floor, and in the laboratory all need the ability to learn, adapt, install, debug, train, and maintain new processes or technologies. This vision includes women, traditionally underrepresented groups, military veterans, persons with disabilities, and blue-collar workers who were hard hit by transformations in the domestic and global economy.

Addressing the Growing National Need for a STEM-Capable Workforce

As both the policymaking body of NSF and as an independent advisor to Congress and the President on S&E issues, the National Science Board sees an opportunity in this conversation. Every two years, we produce and deliver *Science and Engineering Indicators*; the 2018 edition of the report was delivered last month. In that report, we provide the best available data on the S&E enterprise. The release of the report also provided us with an opportunity to update our understanding of the state of the nation's STEM workforce more broadly, using the latest data on national and international trends in STEM education and employment.

Though the main *Indicators* report is policy neutral, since the early 1990s the Board has published policy "companions" to *Indicators*. These companions draw on the *Indicators* data to highlight opportunities and challenges facing the S&E enterprise, provide policy insights or recommendations, and/or offer commentary on current or emerging trends in science and technology. Over the past several years, these briefs have been focused on various aspects of the Nation's STEM workforce, beginning with our *Revisiting the STEM Workforce* report, released in 2015.[i] I think our motivations are similar to those behind this hearing: we have watched the changes in our economy, in global competition, in education, and in the conduct of research and we want to ensure that our people, our businesses, and our Nation are prepared to adapt and thrive.

Revisiting the STEM Workforce contains three major findings that remain relevant in 2018:

(1) The STEM workforce it heterogeneous—it comprises individuals at all different education levels, working across the country in all sorts of jobs that require STEM know-how;

(2) We should think of transition from formal STEM education into a career and through retirement as a series of pathways with many branches rather than a linear pipeline. In today's knowledge- and technology- intensive economy, workers need to be lifelong learners, adapting and reinventing themselves over the course of a career; and

(3) While STEM capabilities are critical to unlocking many career pathways in today's economy, there are numerous roadblocks, particularly for women and groups underrepresented in STEM. We must overcome these barriers so that all people can thrive in a globally competitive, 21st century economy.

In 2016, the Board examined the STEM doctoral workforce. Over the past twenty years, its size has increased by more than 50%, far outpacing the growth in permanent academic positions. This situation generated conversations in academic and policy circles about a "surplus" of doctorates – yet the unemployment rate for these individuals is extremely low. The Board released a statement and interactive infographic on career paths for these individuals, showing that more than 50% of STEM doctorates are employed outside of the academic sector within ten years of graduation – and this trend has held over at least the last twenty years.[ii] Our brief shows that science and engineering doctorate holders have diverse career paths, bringing scientific thinking, analytical skills, and discipline-specific expertise to every sector of the U.S. economy. Advanced education provides individuals with access to many opportunities for meaningful and impactful careers, and benefits employers who rely on new and better ideas to innovate and compete.

Two weeks ago, the Board released a policy companion statement to *Indicators 2018* entitled, "Our Nation's Future Competitiveness Relies on Building a STEM-Capable U.S. Workforce."[iii] This statement updated and reinforced many of the themes from the 2015 workforce report. I have appended the full policy statement to my testimony, but would like to highlight a few key points here:

- The number of U.S. jobs requiring substantial STEM expertise has grown nearly 34% over the past decade. As of 2015, nearly one in seven workers with at least a four-year degree say that their job requires a "bachelor's level" of STEM expertise.[iv] Another 16 million skilled technical jobs – more than one in nine – do not require a bachelor's degree, yet require significant expertise in at least one technical field.[v]

- Other countries are challenging U.S. leadership in science and technology. Between 2000 and 2014, the number of Americans with a four-year degree in S&E grew by 53% (483,764 to 741,763); in China, this number was 360% (359,478 to 1,653,565).[vi]

Just last week the NSB released a statement predicting that China would surpass the United States in R&D investment later this year.[vii] While this is likely inevitable due to the size of their population and economy, China is investing specifically in education to fuel high-tech growth, targeting up to 15% of GDP at talent development. China is not alone – other countries are increasing investments in R&D and education to compete with the United States.[viii]

NSB's statement underscores that to succeed and compete in this new global landscape our Nation can no longer rely on a distinct and relatively small STEM workforce. We must work together to ensure *all* segments of our population have access to affordable, high-quality education and training opportunities beginning as early as kindergarten and lasting well beyond graduation. Today's workers need "on-ramps" and multiple pathways to develop the STEM expertise and other critical capabilities so they can adapt to constantly evolving workplace demands.[ix] The policy statement also highlights the need to focus on groups that are underutilized, yet essential to our future competitiveness: workers who use technical skills in their jobs but who do not have a four-year degree ("skilled technical workers"), people at all education levels who have been historically underrepresented in STEM, and military veterans returning from deployment.

Developing this STEM-capable U.S. workforce will provide our nation with an enduring competitive advantage – but building and sustaining it is no small feat. It will require cooperation and commitment from local, state, and federal governments, education institutions at all levels, non-governmental organizations, and businesses large and small. Our statement has four recommendations:

(1) Governments at all levels should empower all segments of our population through investments in formal and informal education and workforce development throughout an individual's life-span. This includes redoubling our commitment to training the next generation of scientists and engineers through sustained and predictable Federal investments in graduate education and basic research.

(2) Businesses should invest in workplace learning programs – such as apprenticeships and internships–that utilize local talent. By leveraging partnerships between academic institutions and industry, businesses will be less likely to face a workforce "skills gap."

(3) Governments and businesses should expand their investments in community and technical colleges, which continue to provide individuals with on-ramps into skilled technical careers as well as opportunities for skill renewal and development for workers at all education levels throughout their careers.

(4) To accelerate progress on diversifying the STEM-capable U.S. workforce, the Nation should continue to invest in underrepresented segments of the population and leverage Minority Serving Institutions to this end.[x] The NSF INCLUDES ("Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science") and NIH ASCEND ("A Student-Centered Entrepreneurial Development") programs at Morgan State University are examples of such investments.[xi]

National Science Board Task Force on the Skilled Technical Workforce

A STEM-capable U.S. workforce includes not only traditional scientists and engineers performing research in university, government, or industry labs (a group which has received considerable attention from the NSB and other groups), but also the often-overlooked skilled technical workers who help form the backbone of our economy.

Skilled technical jobs are well-paying, and are found across the United States. They offer opportunities for incumbent workers who have been affected by automation and globalization, and they offer solid career pathways for traditional and nontraditional students who are not interested in, or who are unable to attend, a 4-year university. Businesses large and small across the United States—from Baltimore, Maryland to Livingston, Louisiana to Knoxville, Tennessee —need adaptable, STEM-capable workers at *every* education level and from *all* demographic groups in order to compete. Despite the need for these workers, business say they have difficulty filling these jobs. According to a survey conducted by the Government Accountability Office, employers in 80% of local areas said they had trouble filling jobs in occupations that depend on skilled technical workers.[xii]

One of the reasons for this "skills mismatch" is that that the job market is fast-moving and dynamic. Workers can no longer settle into a job and do the same tasks for years. They must be lifelong learners, adapting and evolving with changing technologies and markets. Education and training efforts aimed at developing the skilled technical workforce can help produce the kind of highly capable and adaptable workers who can fill jobs in critical areas such as healthcare, cybersecurity, research, and defense. At the same time, this education is an increasingly important on-ramp. Community colleges and technical schools, particularly for underrepresented minorities, have served as gateways to bachelors and PhDs in STEM fields.

These reasons led the NSB last November to formally create a Task Force on the Skilled Technical Workforce (STW). This Task Force is now exploring the opportunities and challenges facing students, workers, business, and educators involved with the skilled technical workforce, and identifying ways we can help. I have included the Charge to the Task Force with my written testimony.

So far the Task Force has conducted outreach to learn about the challenges facing students, businesses, educators, and policymakers involved in the skilled technical workforce. For example, last year the NSB visited the Laser Interferometer Gravitational-Wave Observatory (LIGO) in Louisiana. We have heard of the scientists who won the Nobel Prize in Physics for the discovery of gravitational waves at LIGO, but skilled technical workers—HVAC experts, electricians, and other workers without a four-year degree—helped build LIGO and keep it running. In addition to the LIGO visit, the NSB held "listening sessions" at Baton Rouge Community College and Xavier University to learn more about the opportunities and challenges facing the skilled technical workforce from a real-world, outside-of-the-Beltway perspective.

The objectives of the Task Force include:

- Identifying and examining data on the skilled technical workforce, including data on technical occupations, training, career pathways and outcome and identifying gaps in the currently available data.

- Considering strategies to leverage *Science and Engineering Indicators* as a possible outlet for existing and new data on the skilled technical workforce.

- Understanding the incentives and barriers to pursuing skilled technical occupations, including:
  - Secondary school preparation in math and science
  - Alignment of training programs with local and high-priority industry needs
  - Human resources recruitment/hiring practices
  - Cost of and access to education and mid-career retraining
  - Mentoring
  - Students, parents, educators, and other stakeholders' awareness and perception of these jobs

- Identifying strategies to enhance existing and foster new long-term partnerships among community colleges, 4-year colleges and universities, local business, labor and industries, national laboratories, nonprofits, and relevant state and Federal agencies; identify strategies for leveraging these partnerships.

- Exploring opportunities to further leverage current NSF investments in skilled technical workforce specifically, and STEM education and human capital development broadly, including making undergraduate and graduate education more relevant and responsive to changes in the composition and needs of a globally competitive domestic workforce.

- Identifying strategies for the Board and NSF to strengthen the skilled technical workforce that do not require additional Federal appropriations.

- Considering how technological change (e.g., automation) shapes the demands on the skilled technical workforce and the role that different education and training models play in enabling U.S. workers to adapt to these changes.

- Exploring how work on this dynamic and increasingly important segment of the STEM-capable workforce can inform current discussions around undergraduate and graduate education, including the growing importance of lifelong learning and discussions about the impact of skills and competencies assessments.

Current NSF Programs

From the perspective of NSF, helping to create a diverse, STEM-capable, globally competitive workforce is central to our mission. Continued taxpayer support demands that scientific and technological progress creates opportunities and benefits for **all** Americans. As the Board discussed in our recent policy statement, turning this vision into a reality requires the public, private, and nonprofit sectors to work in partnership to ensure that all Americans have access to high-quality, affordable education and training.

NSF remains at the forefront of creating the workforce of the future. Its investments span from kindergarten through graduate school and beyond, with a special emphasis on broadening the base of Americans who are STEM-capable.

The **Advanced Technological Education** (ATE) program, created in the early 1990s, is focused on two-year colleges and supports the education of technicians for the high-technology fields that drive our nation's economy. The program involves partnerships between academic institutions and industry to promote improvement in the education of science and engineering technicians at the undergraduate and secondary school levels. The ATE program particularly encourages proposals from Minority Serving Institutions, where the proportion of underrepresented students interested in advanced technology careers is growing. ATE supports curriculum development; professional development of college faculty and secondary school teachers; pathways to two-year colleges from secondary schools and from two-year to four-year institutions; and other activities. ATE invites research proposals that advance the knowledge base related to technician education and encourages partnerships with other entities that may impact technician education.

To date, ATE has awarded more than $950M total to 492 institutions, with over 65% of awards going to two-year degree granting institutions. Examples of the types of awards made by the ATE program include:

- The ATE Southeast Maritime and Transportation (SMART) Center focuses on increasing the number of well-qualified, skilled technicians in the maritime and transportation industry. The SMART Center leverages an existing registered apprenticeship program at Tidewater Community College (TCC) in preparing students to enter the industry. The Center has facilitated the creation of a new A.A.S. degree in Maritime Technologies at TCC, and has developed innovative training programs to meet employers' workforce development training requirements.

- The Kansas City Kansas Biomanufacturing Training Laboratory (KCKBTL) is working to develop the bioscience/biotechnology workforce for the Kansas City region. Project goals include: (1) defining and developing sequences of industry-validated courses that lead to a Certificate in Biomanufacturing or an Associate Degree in Bioscience and (2) providing professional development opportunities for high school science teachers and community college faculty members in topical areas that facilitate technician education in the life sciences. KCK community college students will be placed into internships at local companies and in academic research laboratories at the University of Kansas Medical Center.

In short, ATE increases knowledge, catalyzes institutional change, and builds capacity.

The **Scholarships for STEM** (S-STEM) program, funded by H1-B petitioner fees, addresses the need for a high-quality STEM workforce and for the increased success of low-income academically talented students with demonstrated financial need who are pursuing associate, baccalaureate, or graduate degrees in STEM.

The program provides awards to Institutions of Higher Education to fund scholarships and to advance the adaptation, implementation, and study of effective evidence-based curricular and co-curricular activities that support recruitment, retention, transfer (if appropriate), student success, academic/career pathways, and graduation in STEM. The S-STEM program encourages collaborations among different types of partners: Partnerships among different types of institutions; collaborations of STEM faculty and institutional, educational, and social science researchers; and partnerships among institutions of higher education and local business and industry. The S-STEM program particularly encourages proposals from two-year institutions, MSIs, HBCUs, HSIs, tribal colleges, and urban public and rural institutions.

The program seeks: 1) to increase the number of low-income academically talented students with demonstrated financial need obtaining degrees in STEM and entering the workforce or graduate programs in STEM; 2) to improve the education of future scientists, engineers, and technicians, with a focus on academically talented low-income students; and 3) to generate knowledge to advance understanding of how factors or evidence-based curricular and co-curricular activities affect the success, retention, transfer, academic/career pathways, and graduation in STEM of low-income students.

The Cybersecurity Enhancement Act of 2014 authorized NSF, in coordination with OPM and the DHS, to offer a scholarship program to recruit and train the next generation of information technology professionals, industry control system security professionals and security managers. The resulting program, **CyberCorps – Scholarship for Service**, funds institutions of higher education to develop and enhance cybersecurity education programs and curricula; and to provide scholarships to undergraduate and graduate students in strong academic cybersecurity programs – an area of key strategic importance to U.S. national security. The students receiving scholarships must be U.S. citizens or lawful permanent residents and must be able to meet the eligibility and selection criteria for government employment. Students can be supported on these scholarships for up to three years, and in return, they agree to take government cybersecurity positions for the same duration as their scholarships. The program also requires a summer internship at a Federal agency. Government agencies eligible for job placement include Federal, state, local, and tribal governments.

The **Community College Innovation Challenge** (CCIC) is a prestigious, two-stage competition where community college teams use STEM to innovate solutions to real-world problems, compete for cash awards, and earn full travel support (students and faculty) to attend an Innovation Boot Camp in Washington, D.C. A highlight of the Boot Camp is the reception for the finalists here on Capitol Hill, at which the teams exhibit their challenge projects. The challenge program strengthens and develops STEM thinking by applying it to solving real-world problems; creates deeper engagement and interactions between students and faculty mentors, and with industry; and promotes the larger ecosystem that carries invention from idea to beneficial innovation.

As part of the Board's fact-finding on the Skilled Technical Workforce, last year we were fortunate to meet with a young man who shared with us his circuitous path into STEM. Talented but rebellious as a teenager, by his late 20s, he found himself stuck in a job that barely paid the bills for his family, but with a yearning to use his brain to work on more challenging problems. Thanks to support through NSF's community college programs, and his participation in the CCIC, this young man won an internship at NASA's Jet Propulsion Laboratory and is now well on his way to fulfilling his dream and contributing to America's science and engineering story. And he is "paying it forward" – he founded an organization in his state that creates opportunities for community college students to build leadership skills, conduct undergraduate research, and do community outreach to local public school students who are interested in STEM careers and academic paths. There are countless other such stories that illustrate the success of NSF's programs in attracting students from diverse backgrounds into STEM education and careers – and which illustrate the fact that individuals do not have to be born to scientists or technicians to become a successful scientist or technician.

NSF contributes to the education and training of the next generation of STEM-capable workers in other critical ways. As Congress emphasized in the *American Innovation and Competitiveness Act*, hands-on research opportunities for undergraduates, especially in the early years of their university education, help to increase student interest and retention in STEM disciplines. NSF supports such experiences in two primary ways. The **Research Experiences for Undergraduates** (REU) program supports active research participation by undergraduate students in the areas of research funded by NSF. **Classroom-based Undergraduate Research Experiences** (CUREs) replace introductory STEM courses or textbook laboratory exercises with discovery-based research problems, potentially delivering research experiences to many more students – including non-STEM majors. Through our Education and Human Resources (EHR) Directorate, NSF is also actively working to develop new strategies to encourage more research experiences for students at two-year institutions.

A STEM-capable U.S. workforce requires workers at every education level, including workers engaged in research and development activities. NSF is a leader in educating the next generation of PhD scientists and engineers through grants awarded via our research directorates and through our signature **Graduate Research Fellowship Program**, which directly supports graduate students in all STEM fields. NSF also has a new internship initiative, the **Graduate Research Internship Program**, which expands opportunities for NSF Graduate Fellows to enhance their professional development by engaging in mission related research experiences with partner agencies across the federal government.

Individuals with advanced degrees in STEM not only generate new knowledge through R&D activities that fuel innovation, but they also add value throughout our economy in STEM and non-STEM jobs alike. The **NSF Research Traineeship** (NRT) program encourages the development and implementation of potentially transformative models for interdisciplinary STEM graduate training that enable diverse cohorts of graduate students develop the skills, knowledge, and competencies to pursue a range of STEM careers, especially in areas of national need, such as cybersecurity and data science, brain research, and the food-energy-water nexus. NRT emphasizes institutional capacity building and encourages partnerships with the private sector, non-governmental organizations, government agencies, national labs, and other relevant groups.

Deeply embedded in the vision of a STEM-capable U.S. workforce is the imperative that all Americans be afforded the opportunity to participate in and reap the benefits of our Nation's great scientific endeavor. NSF supports this goal through its numerous investments aimed at tapping into populations historically underrepresented in STEM. **NSF INCLUDES** is a key national initiative designed to ensure that all Americans have access to educational and career opportunities enabled by STEM.

In addition, NSF's **HBCU-Undergraduate Program** (HBCU-UP) provides awards to strengthen STEM undergraduate education and research at HBCUs. A new component of this program, **HBCU Excellence in Research**, supports projects that enable STEM and STEM education faculty to further develop research capacity at HBCUs and to conduct research. HBCU-UP also funds **Broadening Participation**

Research Centers (BPRC). BPRCs are expected to represent the collective intelligence of HBCU STEM higher education, and serve as national hubs for the rigorous study and broad dissemination of the critical pedagogies and culturally sensitive interventions that contribute to the success of HBCUs in educating African American STEM undergraduates. Centers are expected to conduct research on STEM education and broadening participation in STEM; perform outreach to HBCUs to build capacity for conducting this type of research; and work to disseminate promising broadening participation research in order to enhance STEM education and research outcomes for African American undergraduates across the country.

NSF administers the **Presidential Awards for Excellence in Science, Mathematics and Engineering Mentoring** (PAESMEM), a Presidential award established by the White House in 1995. PAESMEM is the highest honor bestowed upon mentors who work to expand STEM talent. Individuals and organizations in all public and private sectors are eligible including industry, academia, K-12, military and government, non-profit organizations, and foundations. PAESMEM awardees serve as leaders in the national effort to develop fully the Nation's human resources in STEM.

Conclusion

Although it is still early in the work of the Board's STW Task Force, I will conclude by highlighting several key points that have already become clear to us.

As the Captain said in the movie *Cool Hand Luke*: "what we have is a failure to communicate" – or more specifically, coordinate. Businesses desperately need STEM-capable, skilled workers, while students and incumbent workers desperately want well-paying, stable jobs. But too often the students we produce or the training we provide to workers doesn't seem to align with what industry wants. At the same time, industry hiring practices can themselves be a barrier – for example, requiring a 4-year degree for openings where a certification or 2-year degree might be a better fit. In Louisiana, Board members literally sat a table in which industry participants lamented their inability to find workers with specific skills – and a community college student said "that's me!"

Following that point, all too often, this is the message that parents and educators and employers alike are sending: it's 4-year college or bust. There is a stigma associated with community colleges, technical schools, and vocational training in the minds of students, parents, businesses – and yes, academics. We educators need to work towards changes that perception. This is an opportunity the National Science Board is trying to seize.

Next, we must identify multipliers. We must make our public investments do more for us. At NSF, we do this by encouraging partnerships between education institutions and local businesses, or between research intensive universities and local community colleges. We learn what works so others can take these practices to scale.

Most importantly, we need to change the conversation. STEM is not just for elite institutions or for researchers with advanced degrees – it's for all Americans. STEM knowledge and skills are vital for our businesses to compete in today's world, and for bringing better jobs and greater prosperity to every region of this country. Strengthening the skilled technical workforce is an essential way to meet this imperative.

We all have a role to play in this. Technical schools, community colleges, like Howard County Community College, trade and labor organizations, chambers of commerce, industry, and 4-year colleges, research universities and HBCUs like Morgan State are needed to build and expand the STEM workforce at all educational levels. Government and academia need to step up to help change the narrative around the Skilled Technical Workforce.

A STEM-capable U.S. workforce is vital to the well-being of our society and to the economic competitiveness of our Nation. We should care about this workforce because the importance and pervasiveness of science and technology in our economy is growing. We should care because we live in a global economy where knowledge is king, and in this new world we should do all we can to make sure none of our citizens are left behind.

Enclosures:

- Charge to the National Science Board Task Force on the Skilled Technical Workforce
- National Science Board Policy Companion Statement to *Science and Engineering Indicators 2018*: "Our Nation's Future Competitiveness Relies on Building a STEM-Capable U.S. Workforce"

---

[i] https://www.nsf.gov/nsb/publications/2015/nsb201510.pdf
[ii] https://www.nsf.gov/nsb/sei/infographic2/
[iii] https://www.nsf.gov/nsb/sei/companion-brief/NSB-2018-7.pdf
[iv] Survey data collected using the National Survey of College Graduates (NSCG) showed that 19,366,000 respondents stated that their job requires S&E technical expertise at the bachelor's level. See National Science Board, *Science and Engineering Indicators 2018* (Alexandria, VA: National Science Board, 2018), Table 3-3. For more information on the NSCG, see https://nsf.gov/statistics/srvygrads/#sd.
[v] Jonathan Rothwell, "Defining Skilled Technical Work," (Washington, DC: National Academies, 2015). Retrieved from: http://sites.nationalacademies.org/cs/groups/pgasite/documents/webpage/pga_167744.pdf.
[vi] *Indicators 2018*, Appendix Table 2-35.
[vii] https://www.nsf.gov/nsb/news/news_summ.jsp?cntn_id=244465&org=NSB&from=news
[viii] For example, between 2000 and 2010 South Korea experienced 11% average annual growth in R&D spending and 7.3% growth rate between 2010-15 (or 8.6% and 5.5%, respectively, when adjusted for inflation). South Korea now accounts for 4% of global R&D spending. *Indicators 2018*, Appendix Table 4-12.
[ix] Other critical capabilities include communication skills, the ability to work in teams, and problem solving and critical thinking skills.
[x] Minority Serving Institutions include Historically Black Colleges & Universities (HBCUs), Hispanic Serving Institutions (HSIs), and Tribal Colleges and Universities (TCUs).
[xi] For more information on NSF INCLUDES, see https://www.nsf.gov/news/special_reports/nsfincludes/index.jsp. The Morgan State University ASCEND program is part of NIH's BUILD (Building Infrastructure Leading to Diversity) Initiative. For more information on BUILD, see https://www.nigms.nih.gov/training/dpc/pages/build.aspx.
[xii] For example, employers had trouble filling jobs in the following occupational categories: Installation, Maintenance, and Repair; Construction and Extraction; Healthcare Practitioners and Technical Occupations; Production; and Computer and Mathematical Occupations. In the report, the term "local areas" refers to the areas overseen by both local and statewide Workforce Investment Boards (WIBs). For more information, see https://www.gao.gov/assets/660/659322.pdf.

CHARGE TO THE TASK FORCE ON THE SKILLED TECHNICAL WORKFORCE

Action Recommended

The National Science Board (NSB; Board) Task Force on the Skilled Technical Workforce is established and charged to identify the opportunities and challenges facing students, incumbent workers, businesses, educators, and others involved with the skilled technical workforce (STW) and recommend to the NSB strategies, including possible policies, for strengthening the STW.

In fulfilling this charge, the Task Force is expected to work closely with NSF and relevant stakeholders within and outside the government.

Statutory Basis

"The Board shall render to the President and the Congress reports on specific, individual policy matters within the authority of the Foundation (or otherwise as requested by the Congress or the President) related to science and engineering and education in science and engineering, as the Board, the President, or the Congress determines the need for such report." 42 U.S.C. § 1863(j)(2)

Linkage to NSF Mission

NSF is directed to support "…programs to strengthen scientific research potential and science education programs at all levels in the mathematical, physical, medical, biological, social, and other sciences…and programs to strengthen engineering research potential and engineering education programs at all levels in the various fields of engineering…" [42 U.S.C. § 1862(a)(1)]. NSF is also directed to support scientific and technical education by strengthening and expanding the scientific and technical education and training capabilities of associate-degree-granting colleges. [42 U.S.C. § 1862(h)]

Rationale

The National Science Foundation (NSF) has a broad mission with respect to creating a science, technology, engineering, and math (STEM)-capable U.S. workforce. In its 2015 report, *Revisiting the STEM Workforce*, the NSB called for creating a STEM-capable U.S. workforce comprising individuals from all demographic groups, at all education levels, and in all geographical locales who need STEM capabilities to succeed in a knowledge-based, globally competitive economy.

The pervasiveness of science and technology (S&T) in the economy has changed the nature of work for individuals at all education levels, including those without a 4-year degree. There are over 16 million skilled technical jobs for workers with an associate degree, or similar qualification rather than a bachelor's degree. The individuals who use STEM knowledge and skills in their jobs but who do not have a 4-year degree make up the "skilled technical workforce."

Skilled technical workers are important to U.S. economic competitiveness. Businesses cite the availability of highly skilled workers as critical to their ability to compete globally, yet regularly express difficulty in finding workers to fill these jobs. The STW also plays an important role in advancing our national security. Industries that are critical to our national security and defense—including aerospace, advanced manufacturing, information technology, healthcare, and cybersecurity—rely on access to these workers. The STW is also important to scientific progress. Industry representatives estimate that they need between 7–20 skilled technicians for every scientist or engineer with an advanced degree.

There are several ways that individuals gain these skills, including military training, apprenticeships, associate degrees and certificate programs. Because of the flexibility, accessibility, and relative affordability of the programs they offer, community and technical colleges serve as a key entry point into the STW for students from all backgrounds. They provide these students with linkages to local industry, but also empower them to pursue further education and follow multiple pathways into STEM careers. According to National Center for Science and Engineering Statistics (NCSES) data, 47% of all recent S&E graduates had done some coursework in a community college.

Community and technical colleges serve a diverse student body. More than half (56%) of all community college students are female. The majority of Native American (56%) and Hispanic (52%) undergraduates choose to pursue a college education at community colleges. African Americans (43%) and Asian Pacific Islanders (40%) undergraduate students also enroll in community college programs at high rates.[1]

Objectives

The Task Force on the Skilled Technical Workforce will assess how the Board and Foundation might strengthen the STW in the United States. The Task Force may:

- Identify and examine data on the STW, including data on technical occupations, training, career pathways and outcomes; identify gaps in the currently available data.
- Consider strategies to leverage *Science and Engineering Indicators* (*Indicators*) and *Indicators*-related resources as a possible outlet for existing and new data on the STW.
- Understand the incentives and barriers to pursuing skilled technical occupations, including:
  - Secondary school preparation in math and science
  - Alignment of training programs with local and high-priority industry needs
  - Human resources (HR) recruitment/hiring practices
  - Cost of and access to education and mid-career retraining
  - Mentoring
  - Students, parents, educators, and other stakeholders' awareness and perception of these jobs

[1] See Fast Facts published by the American Association of Community Colleges, http://www.aacc nche.edu/AboutCC/Pages/fastfactsfactsheet.aspx.

- Identify strategies to enhance existing and foster new long-term partnerships among community colleges, 4-year colleges and universities, local business, labor and industries, national laboratories, nonprofits, and relevant state and Federal agencies; identify strategies for leveraging these partnerships.
- Explore opportunities to further leverage current NSF investments in STW specifically, and STEM education and human capital development broadly, including making undergraduate and graduate education more relevant and responsive to changes in the composition and needs of a globally competitive domestic workforce.
- Identify strategies for the Board (full Board and standing committees) and NSF to strengthen the skilled technical workforce that do not require additional Federal appropriations.
- Consider how technological change (e.g., automation) shapes the demands on the STW and the role that different education and training models play in enabling U.S. workers to adapt to these changes.
- Explore how work on this dynamic and increasingly important segment of the STEM-capable workforce can inform current discussions around undergraduate and graduate education, including the growing importance of lifelong learning and discussions about the impact of skills and competencies assessments.

WORKPLAN

The Task Force will host two to three listening sessions in areas of the country with diverse stakeholders (e.g., industries, technical occupations, and two-year educational systems). The first listening session will take place at Baton Rouge Community College on October 26, 2017.
The Task Force will also host a stakeholder symposium in the first half of 2018. The purpose of the symposium will be to convene experts and representatives from various employment sectors to better understand the opportunities and challenges for those in or involved with the STW.

Potential outcomes for the Task Force's activities include the following:

- A NSB report that captures the major findings of the Task Force that will enable better policy decisions relating to the STW.
- Recommendations for additions/changes to *Science and Engineering Indicators* and *Indicators*-related resources to improve our ability to understand the STW, including recommendations regarding data collection efforts.
- Materials (e.g., one-pagers, infographics, talking points) for NSB members to engage with key stakeholders (e.g., Congress, Administration) on the skilled technical workforce.

Duration of the Task Force

The Task Force is expected to complete its major activities within 18 months of approval of this Charge. The Task Force is also expected to provide the NSB with an interim report of its activities, including any modifications to its objectives and a list of expected deliverables, following the Stakeholder Symposium.

OUR NATION'S FUTURE COMPETITIVENESS RELIES ON BUILDING A STEM-CAPABLE U.S. WORKFORCE

A Policy Companion Statement to *Science and Engineering Indicators 2018*

The number of jobs in the United States (U.S.) requiring substantial science, technology, engineering, and mathematics (STEM) expertise has grown nearly 34% over the past decade. As of 2015, nearly one in seven workers with at least a four-year degree say that their job requires a "bachelor's level" of STEM expertise.[1] Another 16 million skilled technical jobs–more than one in nine–do not require a bachelor's degree, yet require significant expertise in at least one technical field.[2]

At the same time, other countries are challenging U.S. leadership in science and technology. Between 2000 and 2014, the number of Americans with a four-year degree in S&E grew by 53% (483,764 to 741,763); in China, this number was 360% (359,478 to 1,653,565).[3] China's investments in higher education and research and development (R&D) have fueled the rapid growth of its high-technology industries.[4] Their high-tech manufacturing output now ranks number two in the world, trailing only the U.S.[5] China is not alone–other countries are increasing investments in R&D and education to compete with the U.S. (Figure 1).[6]

We Must Take Advantage of our Nation's Greatest Asset–Our People

As science and technology transform our economy and global competition grows, our Nation must focus on its greatest asset–our people. The U.S. can no longer rely on a distinct and relatively small "STEM workforce."[7] Instead, we need a STEM-capable U.S. workforce that leverages the hard work, creativity, and ingenuity of women and men of all ages, all education levels, and all backgrounds.[8] We need scientists searching for cures for genetic disorders, engineers revolutionizing and securing our electrical grid, skilled technicians improving the operations of our research facilities and hospitals, and farmers producing healthier crops utilizing new technologies that at the same time consume fewer resources.

A STEM-capable workforce provides the U.S. with an enduring competitive advantage. Building and sustaining it will require cooperation and commitment from local, state, and federal governments, education institutions at all levels, non-governmental organizations, and businesses large and small. As a nation, we must work together to ensure *all* segments of our population have access to affordable, high-quality education and training opportunities beginning as early as kindergarten and lasting well beyond graduation. Today's workers need "on-ramps" to develop the STEM expertise and other critical capabilities so they can adapt and thrive.[9] Most of all, we must ensure that no Americans are left behind. All our people must be armed with the skills and knowledge to meet the future head on.

Among the groups that are underutilized, yet essential to our future competitiveness, are workers who use technical skills in their jobs but who do not have a four-year degree ("skilled technical workers") and people at all education levels who have been historically underrepresented in STEM. Growing the skilled technical workforce and reducing barriers to participation in STEM will increase individual economic opportunity and support our Nation's leadership in science and technology.

Advance Publication Copy, NSB-2018-7

National Science Board NationalScienceBrd@nsf.gov | 703.292.7000
NSB Indicators Resource Page | nsf.gov/nsb/sei

National Science Foundation
nsf.gov/statistics/indicators | NSB-2018-7

The Skilled Technical Workforce

The most important and defining feature of a STEM-capable U.S. workforce is that it leverages the talents of people at all education levels and in all sectors. It not only includes traditional scientists and engineers performing research in university, government, or industry labs, but also "skilled technical workers" who can install, repair, debug, and build, but who do not have four-year degrees.[10]

Though sometimes overlooked, the skilled technical workforce is large and diverse. These workers can be found in cities, towns, and rural areas throughout the U.S. Estimates of the size of the skilled technical workforce vary from just over 6.1 million to over 16.1 million. The size of this workforce is growing. The composition of this segment of the U.S. workforce closely mirrors U.S. population demographics. In 2015, about 13% of skilled technical workers in STEM jobs were black, 10% were Hispanic, 4% were Asian, and about 11% were foreign born.[11]

These workers are a crucial component of almost every sector of the U.S. economy, ranging from "blue collar" occupations, such as installation, maintenance, and repair, to healthcare and computer occupations. Skilled technical workers are also critical to the operation of our Nation's research infrastructure. The Nobel-Prize winning discovery of gravitational waves at NSF's Laser Interferometer Gravitational-Wave Observatory (LIGO) would not have been possible without the invaluable expertise of the people who assemble and maintain the facility's large and complex heating, ventilation, vacuum, air conditioning, and electronic systems.

Skilled technical jobs are in high demand and pay well. In 2015, the median earnings of skilled technical workers in S&E ($60,000) or S&E-related ($45,000) occupations were significantly higher than the median earnings in other occupations ($29,000).[12] These occupations are expected to have the fastest growth over the next decade.[13] Despite this, employers in 80% of local areas said they had trouble filling jobs in occupations that depend on skilled technical workers, according to a survey conducted by the Government Accountability Office.[14] Coordinated policies and investments aimed at building and strengthening on-ramps into skilled technical careers will help address labor market demands, increase the number of STEM-capable workers, and provide workers with the knowledge and skills needed to adapt to an evolving workplace.

Groups Underrepresented in STEM

The National Science Board believes that America's demographic diversity is a distinct competitive advantage. Research shows that diverse companies have better strategies, are more innovative, and win economically.[15] Numerous entities, including the National Science Foundation (NSF), have undertaken a myriad of initiatives spanning decades aimed at leveraging the talents of all segments of our population, especially groups historically underrepresented in STEM. Yet, in spite of some progress, crippling disparities in STEM education remain (Figure 2).

Although women have earned about half of all science and engineering (S&E) bachelor's degrees since the late 1990s, their levels of participation vary widely across S&E fields (Figure 3). The proportion of bachelor's degrees awarded to women in high demand fields such as computer sciences (18%) and engineering (20%) remain low.[16] Overall, while women occupy half of all jobs in the U.S. workforce, they constitute slightly less than 28% of workers in S&E occupations.[17]

The talents of minority groups in the U.S. are perhaps our greatest untapped resource. Hispanics, blacks, and American Indians or Alaska Natives together make up 27% of the U.S. population age 21 and older, but only 15% of those who hold their highest degree in S&E and 11% of workers in S&E occupations.[18] The proportion of S&E bachelor's degrees awarded to blacks remained flat at 9% between 2000 and 2015 (32,993 to 53,649).[19] These gaps are even more pronounced at the doctoral level where blacks earned 4% of all S&E doctoral degrees awarded in 2015.[20] In 2015, blacks accounted for 12% of the U.S. population 21 or older but only 5% of S&E job holders.[21] The negative consequences of these gaps will only grow: according to a recent report, nearly 25% of black workers are concentrated in 20 occupations that are at high risk of automation, such as cashiers, cooks, security guards, drivers, and administrative assistants.[22]

The share of bachelor's degrees in S&E awarded to Hispanics increased from 7% (27,980) to 12% (79,203) between 2000 and 2015.[23] Despite these gains, Hispanics accounted for 6% of employment in S&E occupations in 2015, well below their share of the U.S. population age 21 and older (15%).[24] The proportion of bachelor's degrees earned by Hispanics in high-demand fields such as computer science (10%) and engineering (10%) remain low.[25] The changing demographics of the U.S. population will amplify the consequences of these gaps since increased enrollment in higher education is expected to come mainly from minority groups, particularly Hispanics.

Military veterans returning from deployment are another group whose skills are often underutilized. Many possess technical training and have significant experience with advanced technologies and systems.[26] Several initiatives focused on academic advising, internships, networking services and peer support are underway to alleviate the roadblocks that veterans encounter as they enter the civilian workforce.[27] To help inform these efforts, the National Science Foundation's National Center for Science and Engineering Statistics is beginning to collect data that will reveal the relationship between education and career pathways for veterans with four-year degrees.

Attracting and Retaining the Best Internationally Mobile Students

Up to this point, our Nation has compensated for the failure to take full advantage of all segments of the population by attracting the best students from around the globe. This is especially true at the graduate degree level, where foreign-born[28] students earn over one-third of all U.S. STEM doctorates, including nearly half of the degrees in engineering and computer science.[29] While the U.S. remains the top destination for internationally mobile students, its share of these students declined from 25% in 2000 to 19% in 2015 as other countries increasingly compete for them.[30]

Our Nation's ability to attract students from around the world is important, but our competitive advantage in this area is fully realized when these individuals stay to work in the United States post-graduation. The overall "stay rates" for foreign-born non-citizens who received a Ph.D. from U.S. institutions have generally trended upwards since the turn of the century, reaching 70% for both the 5-year and 10-year stay rates in 2015.[31] However, the percentage of new STEM doctorates from China and India—the two top countries of origin—with *definite plans to stay* in the U.S. has declined over the past decade (from 59% to 49% for China and 62% to 51% for India).[32] As other nations build their innovation capacity through investments in R&D and higher education, we must actively find ways to attract and retain foreign talent and fully capitalize on our own citizens.

Building the U.S. Workforce of the Future Requires Our Collective Effort

STEM knowledge and skills will continue to play a critical role in fostering individual opportunity and national competitiveness. Strengthening a diverse STEM-capable U.S. workforce that leverages the talents of all segments of our population has never been more important. Considering the increasing demands placed on students, workers, businesses, and government budgets, institutions must partner to build the U.S. workforce of the future. These joint efforts are necessary in order to prosper in an increasingly globally competitive knowledge- and technology- intensive world.

- Governments at all levels should empower all segments of our population through investments in formal and informal education and workforce development throughout an individual's life-span. This includes redoubling our commitment to training the next generation of scientists and engineers through sustained and predictable Federal investments in graduate education and basic research.

NSF must continue to do its part.

In recognition of the importance of catalyzing cross-sector partnerships, NSF launched the *Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science* (INCLUDES) program in 2016. INCLUDES aims to expand the composition of the STEM-capable workforce by developing scalable ways to grow the STEM-capable workforce by building new and strengthening existing partnerships.

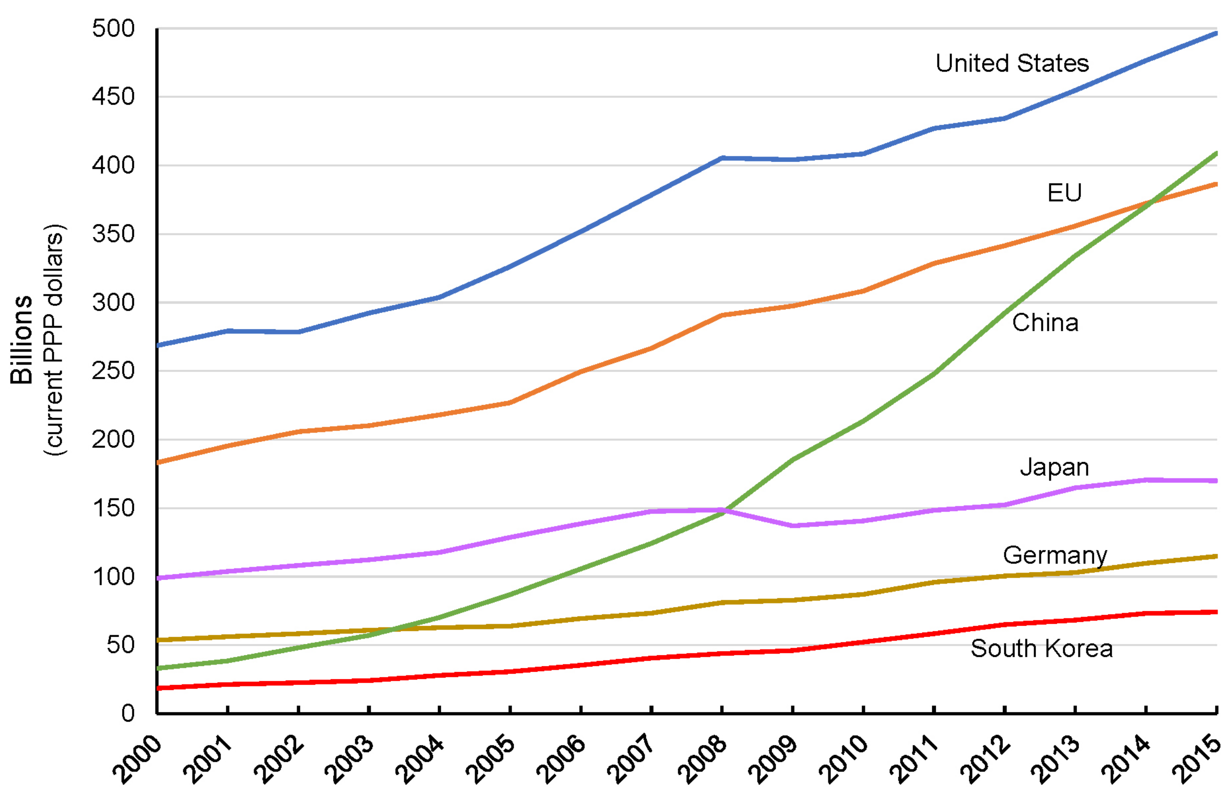
- Businesses should invest in workplace learning programs–such as apprenticeships and internships–that utilize local talent. By leveraging partnerships between academic institutions and industry, such as those catalyzed by NSF's Advanced Technological Education Program (ATE), businesses will be less likely to face a workforce "skills gap."

- Governments and businesses should expand their investments in community and technical colleges, which continue to provide individuals with on-ramps into skilled technical careers as well as opportunities for skill renewal and development for workers at all education levels throughout their careers.

- To accelerate progress on diversifying the STEM-capable U.S. workforce, the Nation should continue to invest in underrepresented segments of the population and leverage Minority Serving Institutions to this end.[33]

Collectively, we must proceed with urgency and purpose to ensure that this Nation and all our people are ready to meet the challenges and opportunities of the future.

FIGURE 1: Gross domestic expenditures on R&D, by the U.S., China, and selected other countries: 2000–2015

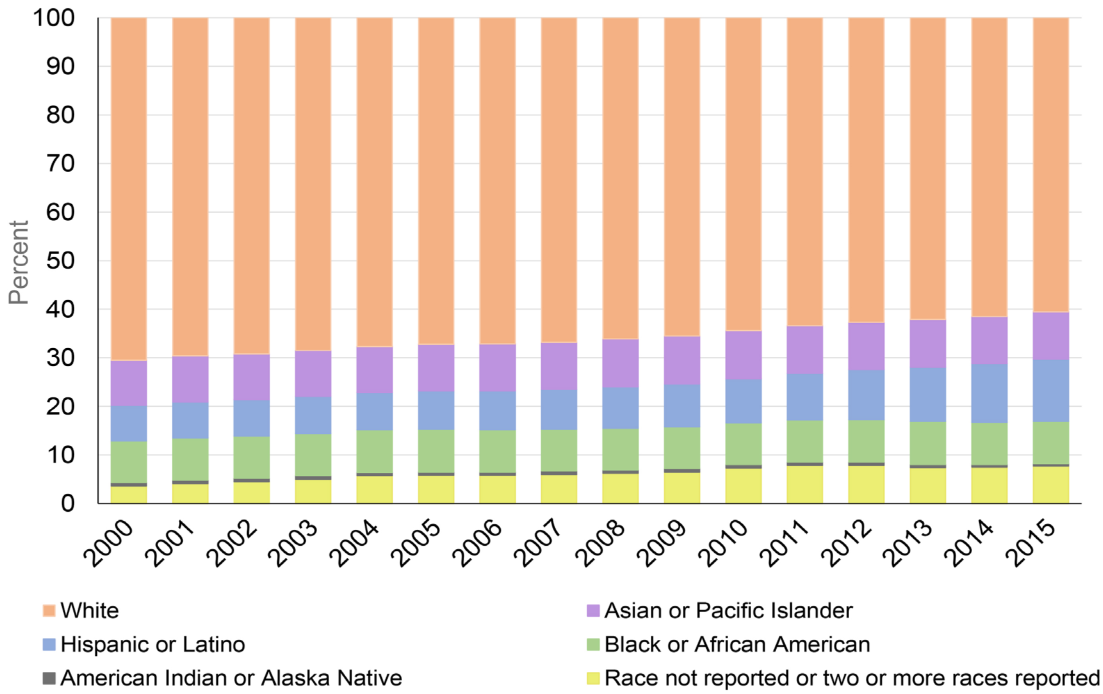


EU = European Union; PPP = purchasing power parity

Notes: Data are selected R&D-performing countries and the EU. Data are not available for all countries for all years. Data for the United States in this figure reflect international standards for calculating gross expenditures on R&D, which vary slightly from the National Science Foundation's protocol for tallying U.S. total R&D.

Sources: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series); Organisation for Economic Co-operation and Development, Main Science and Technology Indicators (2017/1); United Nations Educational, Scientific and Cultural Organization Institute for Statistics Data Centre, data.uis.unesco.org, accessed 13 October 2017. Adapted from Figure 4-6, *Science and Engineering Indicators 2018*. (Also see Appendix Table 4–12.)

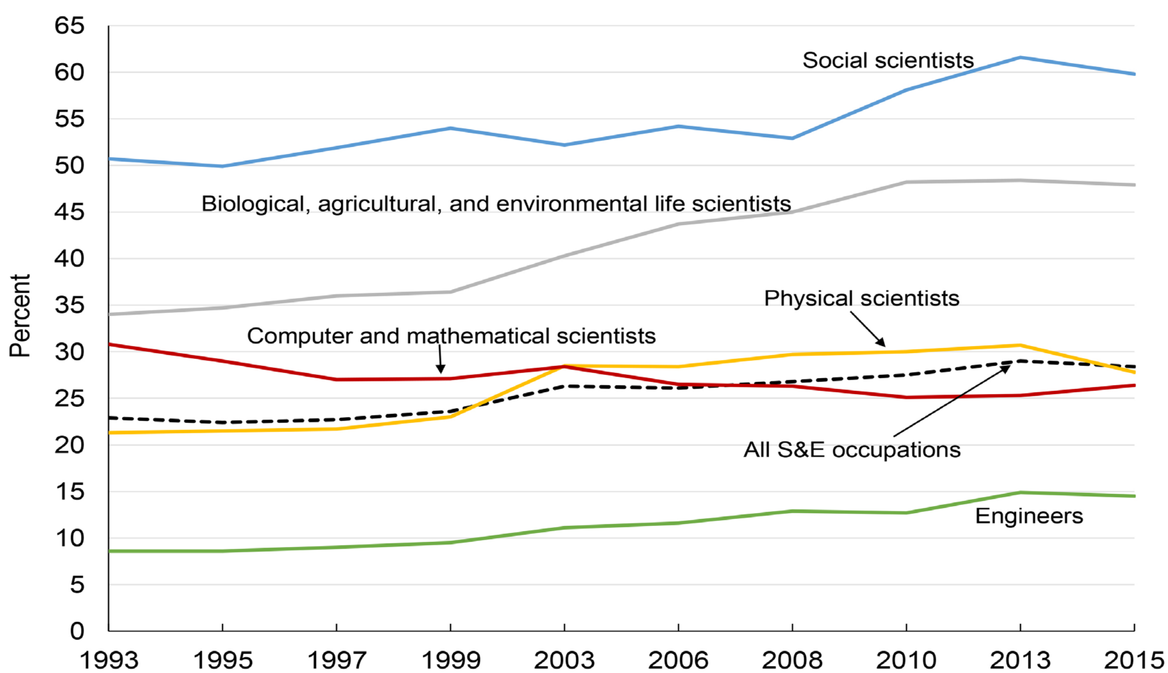
FIGURE 2: Share of S&E bachelor's degrees among U.S. citizens and permanent residents: 2000-15
By race and ethnicity



Notes: Hispanic may be any race. American Indian or Alaska Native, Asian or Pacific Islander, black or African American, and white refer to individuals who are not of Hispanic origin.

Sources: National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS), Completions Survey; National Science Foundation, National Center for Science and Engineering Statistics, WebCASPAR database, https://ncsesdata.nsf.gov/webcaspar/. Adapted from Figure 2-12, *Science and Engineering Indicators 2018*.

FIGURE 3: Women in S&E occupations: 1993–2015



Notes: National estimates were not available from the Scientists and Engineers Statistical Data System (SESTAT) in 2001.

Sources: National Science Foundation, National Center for Science and Engineering Statistics, SESTAT (1993–2013), https://www.nsf.gov/statistics/sestat/, and the National Survey of College Graduates (NSCG) (2015), https://www.nsf.gov/statistics/srvygrads/. Adapted from Figure 3-27, *Science and Engineering Indicators 2018*.

Endnotes

1 Survey data collected using the National Survey of College Graduates (NSCG) showed that 19,366,000 respondents stated that their job requires S&E technical expertise at the bachelor's level. See National Science Board, *Science and Engineering Indicators 2018* (Alexandria, VA: National Science Board, 2018), Table 3-3. For more information on the NSCG, see https://nsf.gov/statistics/srvygrads/#sd.

2 Jonathan Rothwell, "Defining Skilled Technical Work," (Washington, DC: National Academies, 2015). Retrieved from: http://sites.nationalacademies.org/cs/groups/pgasite/documents/webpage/pga_167744.pdf.

3 *Indicators 2018*, Appendix Table 2-35.

4 The pace of China's increase in R&D performance (measured as expenditures) has been exceptionally high over numerous years, averaging 20.5% annually over 2000–10 and 13.9% for 2010–15 (or 18.0% and 12.0%, respectively, when adjusted for inflation). This represents an increase in gross expenditures on R&D and expenditures for R&D (GERD) from $40.4 billion in 2000 to $371.6 billion in 2015 (2009 constant PPP $ billions). *Indicators 2018*, Appendix Table 4-12.

5 *Indicators 2018*, 6-5.

6 For example, between 2000 and 2010 South Korea experienced 11% average annual growth in R&D spending and 7.3% growth rate between 2010-15 (or 8.6% and 5.5%, respectively, when adjusted for inflation). South Korea now accounts for 4% of global R&D spending. *Indicators 2018*, Appendix Table 4-12.

7 According to the Bureau of Labor Statistics (BLS), the majority of net job openings (57%) and largest growth rate (15%) in NSF-identified S&E occupations for the period 2014-2024 are projected to be in computer and mathematical science occupations. Engineering occupations, the second largest subcategory of S&E occupations, are expected to generate about one-fourth (27%) of all job openings in S&E occupations during the same period. It is important to note that projected changes in the labor force and employment do not necessarily imply a labor shortage or surplus. For more on BLS occupational projections, see https://www.bls.gov/emp/.

8 Paul M. Romer, "Human capital and growth: Theory and evidence," *Carnegie-Rochester Conference Series on Public Policy* 32, no. 1 (Spring 1990): 251-286; Eric A. Hanushek and Ludger Woessmann, "Do better schools lead to more growth? Cognitive skills, economic outcomes, and causation," *Journal of Economic Growth* 17, no. 4 (December 2012): 267-321.

9 Other critical capabilities include communication skills, the ability to work in teams, and problem solving and critical thinking skills.

10 In November 2017, the National Science Board established a Task Force on the Skilled Technical Workforce. For more information, see https://nsf.gov/nsb/committees/stwcmte.jsp.

11 In 2015, the corresponding shares among workers in STEM occupations with four-year degrees were 7% black, 6% Hispanic, 17% Asian, and 24% foreign born. *Indicators 2018*, 3-84.

12 *Indicators 2018*, 3-84.

13 For more information on employment projections published by the Bureau of Labor Statistics, see https://www.bls.gov/emp/ep_table_103.htm.

14 For example, employers had trouble filling jobs in the following occupational categories: Installation, Maintenance, and Repair; Construction and Extraction; Healthcare Practitioners and Technical Occupations; Production; and Computer and Mathematical Occupations. In the report, the term "local areas" refers to the areas overseen by both local and statewide Workforce Investment Boards (WIBs). For more information, see https://www.gao.gov/assets/660/659322.pdf.

15 See Robin J. Ely and David A. Thomas, "Cultural Diversity at Work: The Effects of Diversity Perspectives on Work Group Processes and Outcomes," *Administrative Science Quarterly* 46, 2 (June 2001): 229-273; David A. Thomas, "Diversity as Strategy," *Harvard Business Review* 89, no. 9 (September 2004): 98; Sylvia Ann Hewlett, Melinda Marshall, and Laura Sherbin, "How diversity can drive innovation," *Harvard Business Review* 91, no. 12 (December 2013): 30; Vivian Hunt, Dennis Layton and Sara Prince, *Diversity Matters* (McKinsey & Company, 2015). Retrieved from: https://www.mckinsey.com/business-functions/organization/our-insights/why-diversity-matters.

16 National Science Foundation, *Women, Minorities, and Persons with Disabilities in Science and Engineering* (Arlington, VA: National Center for Science and Engineering Statistics, 2017). Retrieved from: https://www.nsf.gov/statistics/2017/nsf17310/digest/about-this-report/.

17 *Indicators 2018*, 3-8.

18 *Indicators 2018*, 3-8.

19 *Indicators 2018*, Appendix Table 2-22.

20 *Indicators 2018*, Appendix Table 2-32.

21 *Indicators 2018*, Table 3-19.

22 Spencer Overton, "The Impact of Automation on Black Jobs," (Washington, DC: Joint Center for Political and Economic Studies, 2017). Retrieved from: http://jointcenter.org/sites/default/files/The%20Impact%20of%20Automation%20on%20Black%20Jobs.pdf. For the impact on innovation, see David Leonhardt, "Lost Einsteins: The Innovations We're Missing," *New York Times*, 3 December 2017. Retrieved from: https://www.nytimes.com/2017/12/03/opinion/lost-einsteins-innovation-inequality.html.

23 These rates are for U.S. citizens and permanent residents as a proportion of all earned bachelor's degrees awarded in S&E. *Indicators 2018*, Appendix Table 2-22.

24 *Indicators 2018*, 3-116.

25 *Indicators 2018*, Appendix Table 2-22.

26 Numerous programs designed to maximize employment opportunities for veterans have focused on helping veterans transition from the military to the civilian workforce. These programs range from changes to the GI Bill, the Transition Assistance Program, and Vocational Rehabilitation and Employment services. For an overview of the range of transition programs for veterans as well as key challenges, see National Academies, "Building America's Skilled Technical Workforce," (Washington, DC: National Academies Press, 2017), 115-121.

27 See H.R.3218 - Harry W. Colmery Veterans Educational Assistance Act of 2017, https://www.congress.gov/bill/115th-congress/house-bill/3218/text?q=%7B%22search%22%3A%5B%22hr+3218%22%5D%7D&r=1.

28 *Foreign-born* is a broad category, ranging from long-term U.S. residents with strong roots in the United States to recent immigrants who compete in global job markets and whose main social, educational, and economic ties are in their countries of origin.

29 *Indicators 2018*, Appendix Table 2-29.

30 According to data from UNESCO/UIS, the number of internationally mobile students who pursued a higher education degree more than doubled between 2000 and 2014, to 4.3 million. For discussion of internationally mobile students see *Indicators 2018*, 2-96.

31 Long-term stay rates indicate the degree to which foreign-born non-citizens recipients of U.S. S&E doctorates enter and remain in the U.S. workforce to pursue their careers. The 10-year and 5-year stay rates in 2015 refer to the proportion of 2005 and 2010 graduating cohorts, respectively, who reported living in the United States in 2015. See *Indicators 2018,* Table 3-27.

32 *Indicators 2018*, Appendix Table 3-21.

33 Minority Serving Institutions include Historically Black Colleges & Universities (HBCUs), Hispanic Serving Institutions (HSIs), and Tribal Colleges and Universities (TCUs).

Victor R. McCrary, Jr. is the first Vice President for Research and Economic Development at Morgan State University, Baltimore, MD. He is a change agent and serial innovator responsible for developing a comprehensive research strategy, fostering cross-disciplinary research, expanding research programs via engagement with federal and state agencies, increasing the University's intellectual property portfolio, and positioning Morgan State as Maryland's Public, Urban Research University. Previously, he was the Business Area Executive for Science & Technology at The Johns Hopkins University Applied Physics Laboratory (APL), where he developed technology investment strategies for basic and applied research targeted for national security and space applications. In 2005, Dr. McCrary was selected to the rank of Principal Professional Staff at The Johns Hopkins University Applied Physics Laboratory. He is a former national president of the National Organization for the Professional Advancement of Black Chemists and Chemical Engineers (NOBCChE), and a Fellow of the American Chemical Society.

McCrary serves on numerous committees including the subcommittee for the U.S. Air Force Institute of Technology (AFIT), the Intelligence Science and Technology Experts Group of the National Academies of Science, Engineering and Medicine, the advisory board for electrical and computer engineering at The Citadel, the board of the Maryland Innovation Initiative of the Maryland Technology Development Corporation (TEDCO), and the PubMed Central National Advisory Committee for the National Institutes of Health.

He has authored or co-authored over 60 technical papers and co-edited two books. He is blessed to have received a number of honors and awards during his career including: Most Promising Black Engineer in 1990; co-recipient of the U.S. Department of Commerce's Gold Medal in 2000; the 2002 NOBCChE Percy Julian Award; in 2005, he was featured in Science *Spectrum* Magazine as one of the Top 50 Minorities in Science, and elected to the 2007 DVD Association's Hall of Fame. In 2011, he was honored as Scientist of the Year by the Annual Black Engineer of the Year Award-STEM Conference. In 2015 he received the Alumni Award for Research Excellence from The Catholic University of America.

He is married to Captain Mercedes Benitez-McCrary (USPHS), and they are blessed with two children, Francesca and Maximilian. McCrary is a member of the National Science Board's Class of 2016 – 2022