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.

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.

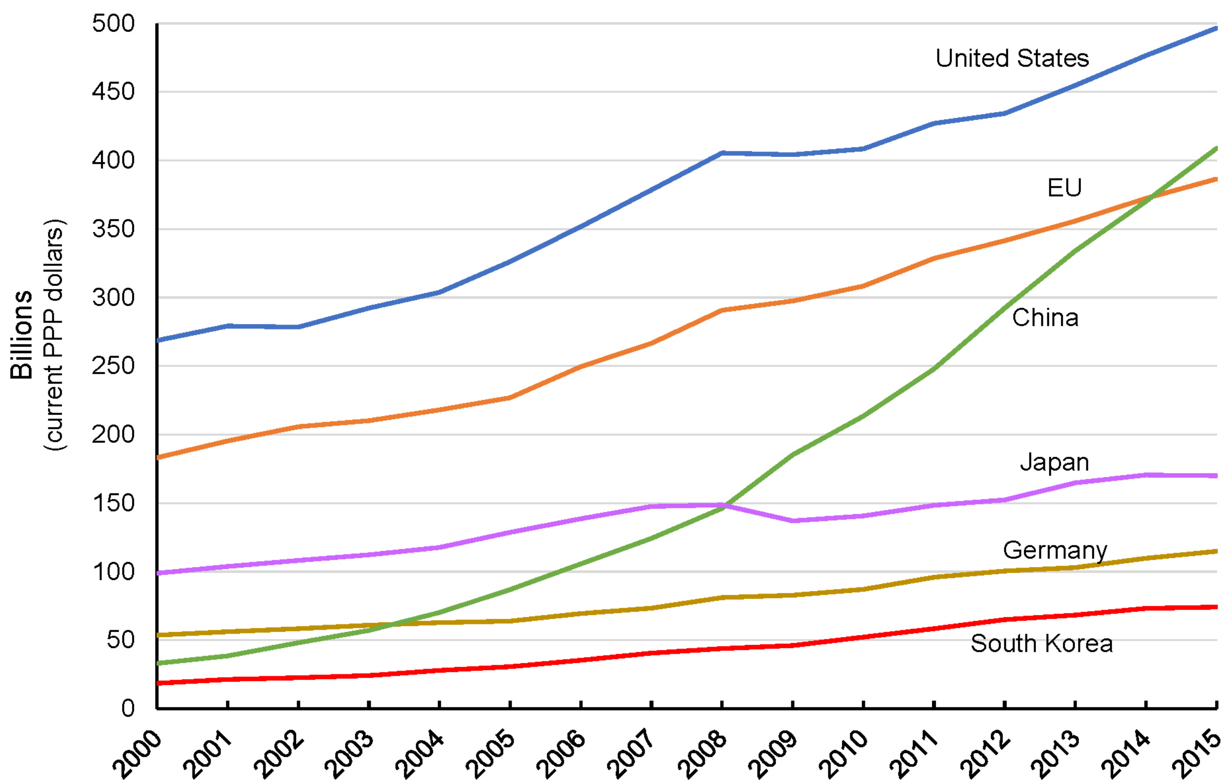
- Businesses should invest in workplace learning programs–such as apprenticeships and internships–that utilize local talent. By leveraging partnerships between academic institutions and industry, such as those catalyzed by NSF's Advanced Technological Education Program (ATE), businesses will be less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

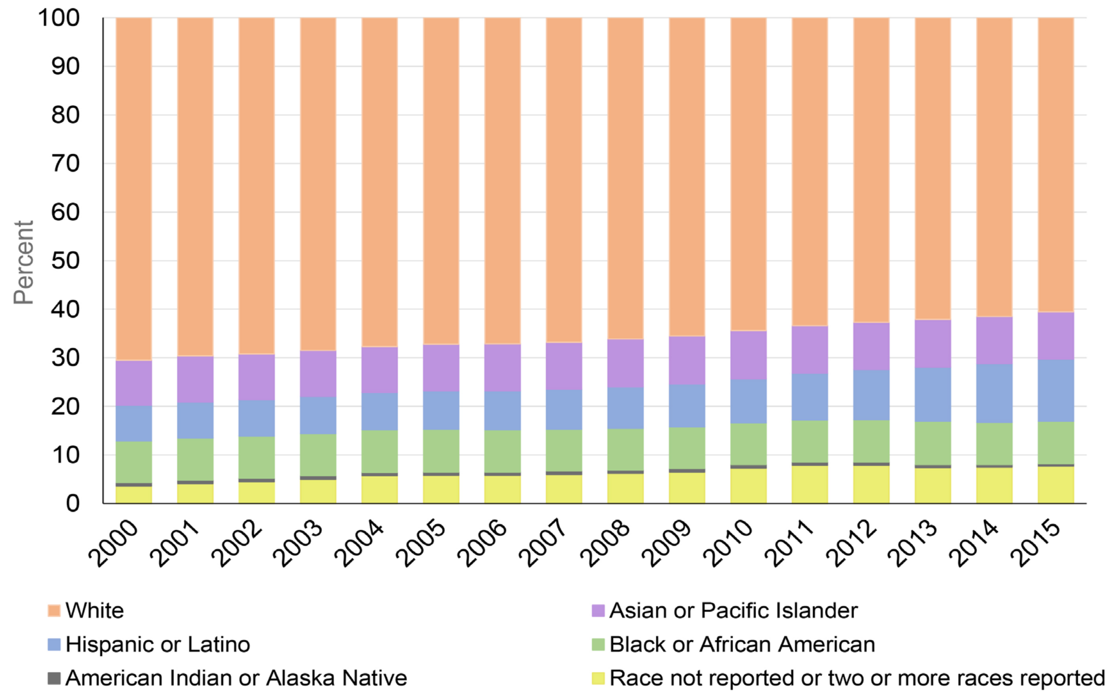


EU = European Union; PPP = purchasing power parity

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.)

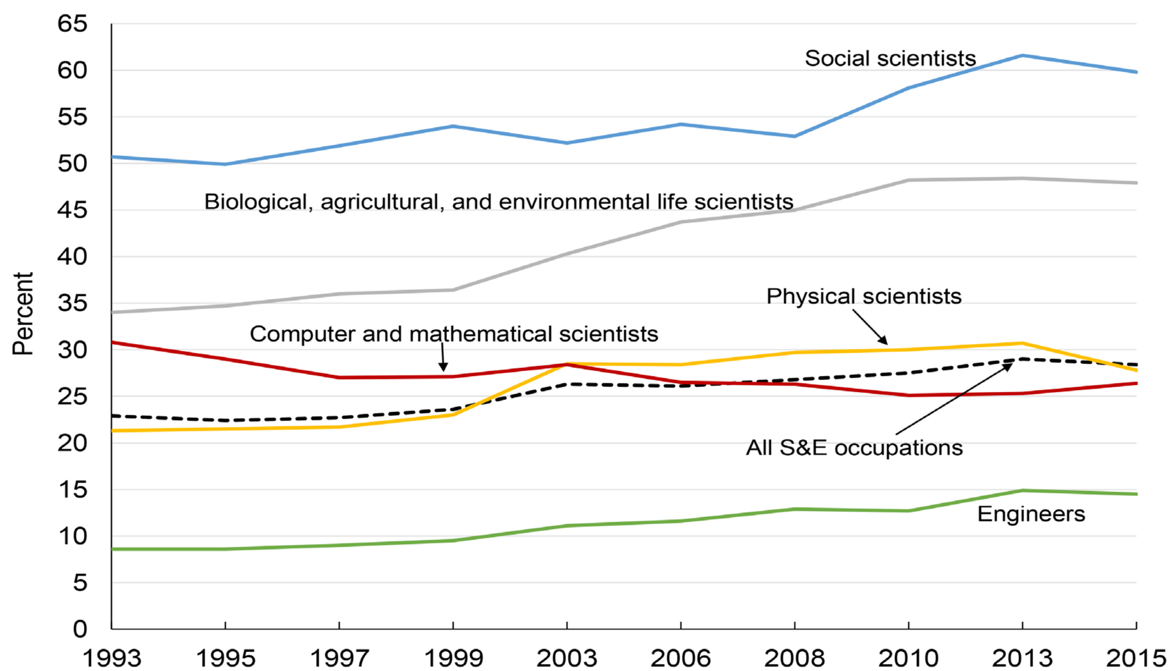
FIGURE 2: Share of S&E bachelor's degrees among U.S. citizens and permanent residents: 2000-15
By race and ethnicity



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).