

NATIONAL SCIENCE BOARD

THE SKILLED TECHNICAL WORKFORCE:

Crafting America's Science & Engineering Enterprise

3.4M

Why do the National Academies expect 3.4 million unfilled skilled technical jobs by 2022?



What did 139 stakeholders from across the country say the U.S. should do to improve opportunities for skilled technical workers?



What 4 recommendations do we offer for building the Skilled Technical Workforce of the future?



Cover Photo Credit: Darryl Estrine



THE SKILLED TECHNICAL WORKFORCE:

Crafting America's Science & Engineering Enterprise

> September 2019 Report #: NSB-2019-23

THE SKILLED TECHNICAL WORKFORCE



DIANE L. SOUVAINE

NSB Chair Professor of Computer Science and Adjunct Professor of Mathematics *Tufts University*

JOHN L. ANDERSON

President National Academy of Engineering

ROGER N. BEACHY

Professor Emeritus of Biology Washington University, St. Louis

ARTHUR BIENENSTOCK

Professor Emeritus of Photon Science Stanford University

VICKI L. CHANDLER Dean of Faculty *Minerva Schools at KGI*

MAUREEN L. CONDIC

Associate Professor of Neurobiology and Anatomy University of Utah, School of Medicine

W. KENT FUCHS President *University of Florida*

SURESH V. GARIMELLA President University of Vermont

ROBERT M. GROVES

Provost and Executive Vice President; Gerard J. Campbell, S.J. Professor in the Math and Statistics Department; Professor in the Sociology Department *Georgetown University*

ELLEN OCHOA

NSB Vice Chair Director (retired) Lyndon B. Johnson Space Center

JAMES S. JACKSON

Daniel Katz Distinguished University Professor of Psychology; Professor of Afro-American and African Studies; Research Professor, Research Center for Group Dynamics, Institute for Social Research University of Michigan

STEVEN LEATH

President (retired) Iowa State University and Auburn University

W. CARL LINEBERGER

Fellow of JILA and E. U. Condon Distinguished Professor of Chemistry *University of Colorado*

VICTOR R. MCCRARY

Vice President for Research and Graduate Programs; Professor of Chemistry University of the District of Columbia

EMILIO F. MORAN

John A. Hannah Distinguished Professor of Global Change Science *Michigan State University*

SETHURAMAN PANCHANATHAN

Executive Vice President and Chief Research and Innovation Officer of Knowledge Enterprise Development; Director of the Center for Cognitive Ubiquitous Computing *Arizona State University*

G.P. "BUD" PETERSON

Professor Woodruff School of Mechanical Engineering *Georgia Institute of Technology*

JULIA M. PHILLIPS

Executive Emeritus Sandia National Laboratories

DANIEL A. REED

Senior Vice President for Academic Affairs (Provost) *University of Utah*

GERALDINE L. RICHMOND

Presidential Chair in Science and Professor of Chemistry *University of Oregon*

ANNEILA I. SARGENT

Ira S. Bowen Professor of Astronomy California Institute of Technology

S. ALAN STERN

Associate Vice President and Special Assistant to the President Southwest Research Institute

STEPHEN H. WILLARD CEO

Cellphire, Inc.

MARIA T. ZUBER

Vice President for Research Massachusetts Institute of Technology



Dear Colleague:

For many years, the National Science Board (NSB, Board) has had a keen interest in the state of the STEM-capable workforce in the United States. The health of that workforce is vital to America's economic prosperity, our scientific and technological competitiveness, and our national security. Building on the Board's past work, this report focuses on a crucial but underappreciated part of the science and engineering enterprise: the Skilled Technical Workforce (STW), the millions of men and women with STEM skills and knowledge who do not have a bachelor's degree. This report is the culmination of our 18-month effort to identify the opportunities and challenges facing students, incumbent workers, businesses, educators, and others involved with the STW. It offers recommendations for how federal policymakers and educators can work together to foster the STW, so that all Americans can participate in and benefit from advances in science and technology.

The NSB's engagement with this topic is not over. The work of the Task Force will continue to influence and inform our thinking as we craft the STEM-capable workforce of the future.

We welcome feedback on this report. If you have comments or questions, please contact Dr. John Veysey II, Executive Officer to the Board at (703) 292-7000 or at jveysey@nsf.gov.

Sincerely,

Diane & Arriane

Diane L. Souvaine Chair, NSB

FRANCE A. CÓRDOVA Director National Science Foundation JOHN J. VEYSEY II Executive Officer National Science Board National Science Foundation

MEMBERS OF THE STW TASK FORCE

Victor R. McCrary, Chair Vicki L. Chandler Robert M. Groves James S. Jackson W. Carl Lineberger Geraldine L. Richmond





o grow our nation's science, technology, engineering, and mathematics (STEM) capacity and ensure that Americans nationwide can participate in a science and engineering (S&E) intensive economy, the United States must foster its Skilled Technical Workforce (STW)—individuals who use S&E skills in their jobs but do not have a bachelor's degree. Rapid

changes in the nature of work, education, technology, workforce demographics, and international competition have led the National Science Board (NSB, Board) to conclude that our competitiveness, security, and research enterprise require this critical, but often overlooked segment of our STEM-capable workforce. Adding to the near-term urgency, a National Academies of Sciences, Engineering, and Medicine report predicts a shortfall of nearly 3.4 million skilled technical workers by 2022.¹

Expanding the diversity and inclusivity of science and engineering is vital to the future of the S&E enterprise and crucial to maintaining the broad public support for S&E that has fueled American prosperity and national security for the past 70 years. It is in the nation's interest that all Americans, including the two in three U.S. adults who do not have a bachelor's degree, have the opportunity to participate in and benefit from our scientific and technological progress. To achieve this, the Board believes that the United States should increase the emphasis on cultivating the STW as part of continued robust support for the education of scientists and engineers.

Over the past two years, the NSB Task Force on the Skilled Technical Workforce has identified opportunities and challenges facing students, incumbent workers, businesses, educators, and others involved with the STW.² In the course of our activities, four systemic issues surfaced that will necessitate new partnerships among various types of educational institutions, all levels of government, and industry to strengthen this critical segment of the workforce. By focusing on these areas, we seek to build on the efforts of the White House,³ Congress, and others⁴ to create STW opportunities for more Americans. We offer the following recommendations: **CHANGE THE MESSAGE:** The NSB and the National Science Foundation (NSF), and other S&E leaders should communicate the importance of the STW to our nation's S&E enterprise, individual economic prosperity, national security, and U.S. global competitiveness. Raising awareness about STW career and educational pathways can also help to address misperceptions and lack of awareness of skilled technical career opportunities among parents, educators, guidance counselors, and students. Key messages include:

- Skilled technical work is crucial to the nation and its S&E enterprise.
- The multiple educational pathways into the S&E enterprise are complementary and interdependent. Together they produce the educated, skilled, and diverse workforce the United States needs in today's knowledge-and technology-intensive world.
- Skilled technical work is a pathway that can lead in a variety of educational and career directions.
- Pursuit of skilled technical work is about personal preferences and choices.

The multiple educational pathways into the S&E enterprise are complementary and interdependent. Together they produce the educated, skilled, and diverse workforce the U.S. needs in today's knowledge- and technology-intensive world. FOCUS ON THE DATA: To understand and begin to address data gaps, NSF's National Center for Science and Engineering Statistics (NCSES), with additional federal resources and collaborating with other statistical agencies, should collect nationally representative data on the education, skills, and workforce characteristics of the STW. NSF should promote partnerships between governmental and non-governmental (industry, academia) stakeholders in the STW to share data and develop tools for public use and workforce planning.

LEVERAGE THE PORTFOLIO OF FEDERAL

INVESTMENTS: There is an opportunity for the Federal agencies that support STW-related programs to leverage one another's activities and maximize the nation's federal investments in the STW through a holistic, coordinated approach. NSF can lead by example by conducting a full portfolio analysis that will value and categorize its STW investments across all directorates in the areas of education, research, infrastructure, data collection, and analysis. The analysis of NSF's portfolio of STW-related investments could publicize and inform stakeholders about the breadth of NSF's contributions to the STW, build awareness of funding opportunities, and help maximize and leverage the impact of these investments.

BUILD PARTNERSHIPS: In strengthening educational pathways for the STW, policymakers and educational institutions should recognize that K-12 school systems, two-year colleges, four-year colleges and universities, and other post-secondary education and workforce development programs are integral, synergistic parts of a whole. These institutions should work as partners together with business and industry to grow the STEMcapable U.S. workforce via STW programs that are tailored to the needs of their local communities. Policymakers can encourage the creation of such partnerships by developing federal programs that require partnership participation from stakeholders from multiple sectors.



NOSPERITV

We must "step up" our game and nurture and expand our domestic talent along the entire S&E worker-value chain from the STW to the Ph.D. if our workforce is to remain competitive.



Our skilled workforce is foundational and essential to U.S. leadership in science and engineering (S&E) and the economic prosperity and security that flow from it. Yet on a near daily basis, headlines emphasize that we are not doing enough to develop and sustain our nation's human capital. For the United States to compete and thrive in today's S&E-driven world, our country must nurture a workforce that can lead in every phase of research and development (R&D), from discovery to innovation to product realization and sustainability. A key component of this workforce is the Skilled Technical Workforce (STW), the roughly 17 million workers who use S&E expertise and technical knowledge in their jobs but who do not possess a bachelor's degree.⁵

For several years, the National Science Board (NSB, Board) has stressed the need to think differently about the science and engineering workforce. In *Revisiting the STEM Workforce* (2015) and *Our Nation's Future Competitiveness* Relies on Building a STEM-Capable U.S. Workforce (2018), the Board called for including workers at all educational levels in the STEM-capable workforce, and sought to move away from an older, outdated, and narrower concept of the STEM workforce based solely on academic degrees and occupations. This report reinforces and builds on the Board's prior work by calling attention to the STW's essential role in the S&E enterprise.

Since our 2015 report, the need for a STEMcapable U.S. workforce at all educational levels has become more apparent—and urgent. Technologically, we are on the cusp of revolutions in data and artificial intelligence, developments that will continue to accelerate changes in the workplace and intensify our need for citizens who excel at using data, information, and technology in their work. Other nations are investing substantially in human capital. We must "step up" our game and nurture and expand our domestic talent along the entire S&E worker-value chain



There are indications that we, as a nation, are not doing enough.

from the STW to the Ph.D. if our workforce is to remain competitive. As the Administration's STEM Education Strategic Plan states, "the country must prepare the STEM Workforce for the future —both college-educated STEM practitioners and those working in skilled trades that do not require a four-year degree... A diverse talent pool of STEM-literate Americans prepared for the jobs of the future will be essential for maintaining the national innovation base that supports key sectors of the economy and for making the scientific discoveries and creating the technologies of the future."⁶

Yet, there are indications that we, as a nation, are not doing enough. According to a 2017 National Academies of Sciences, Engineering, and Medicine (NASEM) report, by 2022, "the percentage of skilled technical job openings is likely to exceed the percentage of skilled technical workers in the labor force by 1.3 percentage points or about 3.4 million skilled technical jobs."⁷ Due to the continuing retirement of the Baby Boomers and the tendency of job skill requirements to increase over time, NASEM believes that the number of skilled technical workers will likely fall short of demand, even when accounting for how technological innovation may change workforce needs.⁸ Shortages of highly skilled tool and die makers, electricians, welders, and programmers could threaten our ability to maintain unique facilities for basic research, sophisticated military assets (e.g. materials for nuclear submarines and hypersonic weapons systems utilizing artificial intelligence), and the future of the nation's automobile industry (e.g. autonomous vehicles).

At the same time, economic shifts toward jobs that put a premium in many lines of work on S&E knowledge and skills are leaving behind too many of our fellow Americans. Given the prominent role of S&E as a driver of 21st century economic activity, our nation must do a better job of growing our STEM-capacity and ensuring that millions of hardworking Americans at all educational levels and in all regions of the country have the opportunity to contribute to and benefit from today's and tomorrow's S&E-intensive workplaces. This is not merely the right thing to do; it is necessary for the future of our economy, national security, the health of our S&E enterprise, and to ensure the broad public support for S&E that has fueled American security and prosperity for the past 70 years.



THE WORKFORCE T **BUILT THE SPACE S** FOUR-YEAR DEGRE WERE SKILLED TEC NEED TO MAKE SUR REPRESENTED. - DR. M. STARS

HAT ACTUALLY HUTTLE WERE NOT E ENGINEERS, THEY HNICIANS_WE **ETHOSE JOBS ARE** AE JEMISON, PRINCIPAL, 100 YEAR **HIP; NASA ASTRONAUT (RETIRED)**

One way to prepare more of our citizens for the high-tech jobs of today and tomorrow, live up to the ideal that America is a land of opportunity for all, connect more Americans with the S&E enterprise, and help secure our nation's future S&E leadership is to strengthen the Skilled Technical Workforce—a crucial, but often overlooked, segment of our STEM-capable workforce.

Representing 13 percent of the U.S. workforce age 25 and older, skilled technical workers contribute to all parts of the economy and the S&E enterprise.⁹ They bring critical thinking, design, digital, math, and coding skills to work as auto mechanics, health care technicians, electricians, welders, computer systems analysts and administrators, and operators of "smart" infrastructure. They also make crucial contributions to the nation's R&D enterprise, accounting for more than half of all workers in many of America's "advanced industries."¹⁰ These "R&D-intensive" industries, which include advanced manufacturing, pharmaceuticals, motor vehicles, and aerospace, energy-providing industries such as oil and gas extraction and power generation, and critical service activities such as telecommunications and software design, account for 17 percent of U.S. Gross Domestic Product.¹¹ All told, these industries generate \$2.7 trillion in output annually, outpacing any other sector.¹² A growing number of jobs critical to our national security, in such areas as cybersecurity and defense-related technologies, require both S&E skills and U.S. citizenship. In addition, many of our national research facilities—including those funded by NSF, the Department of Energy (DOE), the Department



of Defense (DOD), and the National Aeronautics and Space Administration (NASA)—as well as research laboratories at colleges and universities rely on skilled technical workers to help advance the frontiers of basic science and engineering.¹³

With fewer barriers to entry than jobs requiring a bachelor's degree, skilled technical work offers a pathway into S&E for the approximately two in three U.S. adults who have some education beyond high school and less than a bachelor's degree.¹⁴ As such, the STW has the potential to connect millions more Americans to the S&E enterprise. Employment in skilled technical jobs also offers millions of Americans competitive salaries, benefits, and a discernible career path.¹⁵ These jobs tend to be higher paying and have lower unemployment rates relative to other jobs at a comparable education level.¹⁶ Compared to those S&E jobs which require at least a bachelor's degree, STW occupations tend to be more widely distributed geographically.¹⁷

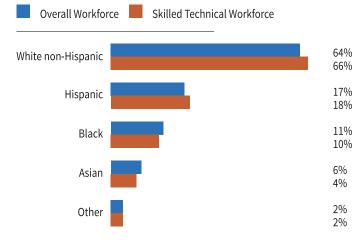
In today's environment where post-secondary work and educational pathways are less linear than they were several decades ago and where options for post-secondary education and career preparation have proliferated, skilled technical education and employment are important ends in themselves as well as a launching pad for further STEM study. In the listening sessions that the NSB conducted around the country, we heard from students and workers about the paths that led them to STW education and skill development programs and about how they moved between such programs and work



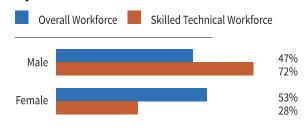
environments. A common theme was that the experiential learning associated with many STW education and skill development programs and their shorter duration relative to a bachelor's degree make Career and Technical Education (CTE) programs (including CTE schools, coding boot camps, apprenticeship programs, and associate degree programs) appealing avenues for exploring interests, developing STEM skills, and preparing for employment. Many individuals with whom the Board spoke found their "STEM spark" through STW education and employment, and some subsequently obtained a bachelor's degree or higher in a STEM field.

Expanding the STW also provides an opportunity to build a STEM-capable workforce that reflects our country's people. As the 2019 National Academies of Sciences, Engineering, and Medicine report on the critical role of Minority Serving Institutions in advancing the Nation's STEM workforce notes, demographic trends suggests that overall STEM readiness of students of color will have a significant impact on America's economic growth, security, and global prosperity.¹⁸ Federal data show that the STW is the most diverse segment of the STEM-capable workforce; its racial and ethnic composition is similar to the overall U.S. workforce age 25 and older.¹⁹ In contrast, there is work to be done to increase women's participation in the STW, which in most occupations remains predominantly male—less than 28% of STW workers overall are female.²⁰ The exception to this is in healthcare occupations, in which women have a high rate of participation. Gender disparity is not specific to the STW; women compose 29% of the S&E workforce, making them underrepresented in the STEM-capable workforce at all levels.²¹

The Skilled Technical Workforce By Race and Ethnicity: 2017



The Skilled Technical Workforce By Sex: 2017



National Science Board, "Science and Engineering Labor Force," *Science and Engineering Indicators 2020* (forthcoming). Data source: Census Bureau, American Community Survey 2017, public use microdata



Given the importance of STW education and skill development as on-ramps to job opportunities, further STEM education, and to building a workforce that reflects the nation's diversity, it is essential that S&E leaders and policymakers step up and do more to support the STW and integrate it within a framework of S&E education and workforce development that spans from primary and secondary school through post-secondary education and beyond. Bridging the divide between skilled technical and other S&E pathways matters not just for the progress of science, and for developing the robust, technologically-savvy workforce of the future, but also for ensuring that S&E is an inclusive enterprise that actively welcomes all Americans and benefits from their participation and perspectives.

COMMUNITY COLLEGE AS A PATHWAY INTO THE STEM-CAPABLE WORKFORCE

Community colleges welcome all students and are an important educational pathway into many parts of the STEM-capable workforce. In addition to educating the STW, community colleges prepare students to pursue bachelor's and advanced degrees. Between 2010 and 2017, 18% of those earning bachelor's degrees in STEM fields also earned associate's degrees. During that same period, 47% of STEM bachelor's degree earners reported doing some coursework at a community college. At the doctoral level, 20% of the U.S. citizens and permanent residents who received S&E doctoral degrees in 2017 reported having attended a community college at some point in their educational careers, and 6% earned an associate's degree along the way.

As a critical access point for groups historically underrepresented in STEM, community colleges also play an important role in broadening participation. In particular:

- 50% of all Hispanic undergraduates are enrolled in community colleges.
- 11% of Black and 8% of Hispanic or Latino S&E doctoral degree recipients in 2017 had previously earned an associate's degree. In comparison, only 6% of whites and 3% of Asians who earned doctoral degrees in S&E fields in 2017 had previously earned an associate's degree.
- 29% of community college students are first generation college students.

In 2015, 55% of Minority Serving Institutions (MSIs) were community colleges. MSIs, which are defined by legislation or enrollment, include Historically Black Colleges and Universities (HBCUs), Hispanic Serving Institutions (HSIs), and Tribal Colleges and Universities (TCUs).

These data highlight the importance of MSIs and community colleges for engaging groups historically underrepresented in STEM and building a STEM-capable workforce that reflects America's diversity.

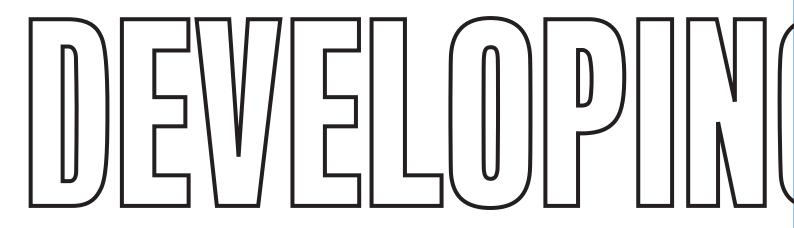
THE STW AND BREAKTHROUGH SCIENCE

One of the greatest scientific achievements of the 21st century—the detection of gravitational waves at the Laser Interferometer Gravitational-Wave Observatory (LIGO)—would not have been possible without the skill and dedication of hundreds of scientists, engineers, and skilled technical workers. The National Science Board appreciated this firsthand at LIGO's Livingston, Louisiana site.

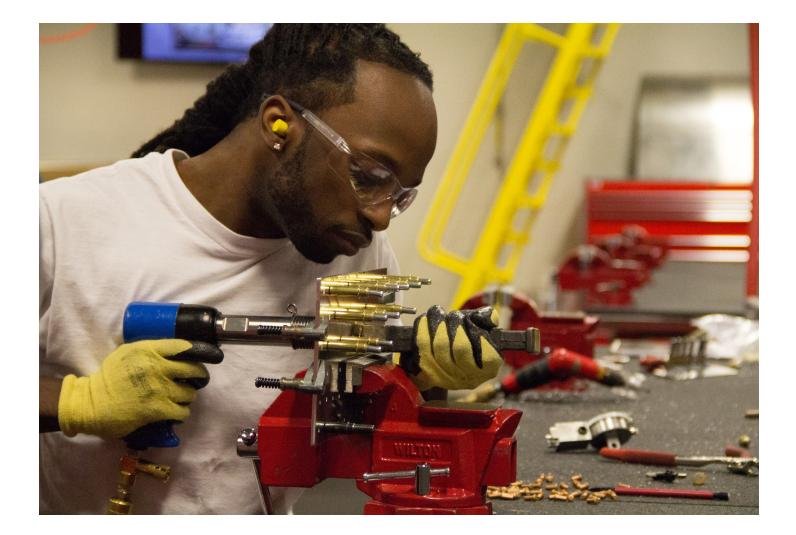
There, the Board met David Barker, who describes himself as a skilled technical worker. David works side-by-side with a team of operators and scientists to monitor and maintain the temperature in the 19,000 square foot laser vacuum equipment area within 2/10ths of a degree. A temperature change of one-degree Fahrenheit would cause the laser to lose lock, forcing a shutdown and halting data collection. David playfully notes that he tells people that he is "a famous air conditioning man." Without experienced and dedicated skilled technical workers like David, fundamental scientific breakthroughs that require complex technologies and facilities would not be possible.







DEVELOPING THE SKILLED TECHNICAL WORKFORCE THAT OUR NATION NEEDS



BTHE STW

Over the past two years, the NSB's Task Force on the Skilled Technical Workforce heard from numerous stakeholders about the challenges the nation faces as it seeks to strengthen the STW. In this section, we highlight four systemic challenges and opportunities to create the vibrant skilled technical workforce that the United States needs:

- 1. Designing STW education and preparation to meet the needs of individuals;
- Building partnerships among education, industry, non-profit, and government sectors to leverage resources and knowledge, and meet the needs and circumstances of local communities;
- 3. Conveying accurate information about employment and career opportunities in the STW;
- 4. Addressing data gaps and data silos so that government, industry, and educational institutions can maximize the effectiveness of programs and initiatives.

By focusing on these issues, we seek to build on and encourage others' efforts to create STW opportunities for more Americans. Policymakers are already making progress on these issues. In 2018, the White House issued an executive order establishing the President's National Council for the American Worker and released a five-year strategic plan for STEM education, Charting a Course for Success: America's Strategy for STEM *Education*, which includes a focus on the STW. Congress also passed STW-related legislation, including the Strengthening Career and Technical Education for the 21st Century Act of 2018 (Pub. Law. 115-224) and the Innovations in Mentoring, Training, and Apprenticeships Act of 2018 (Pub. Law. 115-402). 2018 was also an active year at the state level, with legislation in various states related to data collection, funding of workforce development programs, and creating infrastructure for state-level coordination of education and workforce efforts.²²



To develop the skilled technical workforce that our country needs, we must do more to address the barriers that prevent individuals from embarking on and/or completing skilled technical education. In conversations with stakeholders, the Task Force heard repeatedly about these barriers and how approaches that "meet students where they are" can make a difference in persistence, program completion, and pursuit of additional STW-pathways.

We frequently heard about the importance of centering programs around students—not institutions, educators, and employers. This student-centric approach starts with the competencies and skills that students need. Are curricula pitched at a level consistent with students' math skills? Do they teach STEM knowledge and concepts in the context of their application? Are they focused on the skills that students will need to secure employment? Has a close look been taken at the full curriculum to minimize the need for pre-requisites/other coursework that could create a barrier to entry?

One example of this "student-centered" approach comes from the work of Dr. Kevin Cooper, Assistant Dean of Applied Technology at Indian River State College in Fort Pierce, Florida. Dr. Cooper and his team have designed a highly successful education program for skilled technical workers in the nuclear energy field. Traditionally, entry into the nuclear program required students to be college algebra ready. After observing that math was a barrier for many students, Dr. Cooper set out to learn more about the specific math skills required of workers in that industry. Following conversations with industry leaders, Dr. Cooper revamped the math curriculum for the nuclear technology program, targeting the algebra, trigonometry, and statistics skills necessary to

work safely and successfully at a nuclear energy plant. As part of his effort to teach math skills in a practical and applied way, he invites industry representatives to his class to demonstrate how the inverse square laws and exponential decay matter to workplace safety. With a 90% math course success rate, the new curriculum has successfully eliminated pre-existing math barriers while maintaining high educational standards that prepare students for success in the workforce. Dr. Cooper is hoping that this pilot program will become a permanent program and that other faculty will focus on what students "need" to get out of their math courses to be successful in the workplace and redesign their curricula accordingly.

We also heard about the need for education and skill development programs to work with the constraints on students' lives. With an average age of 28, community college students often have bills to pay, children to raise, and, in some cases, parents who rely on them for support.²³ For many of the students with whom we met, leaving the workforce for one to two years—or even a few months-to complete a degree or participate in a research opportunity or internship was a nonstarter. Both students and faculty stressed the importance of designing programs with flexible schedules and providing students opportunities to "earn while you learn" through apprenticeships and other work-based learning programs. We also heard about the need for "wrap-around services" including transportation and affordable and highquality childcare either on campus or nearby. Such services made the difference between students staying in or leaving the program.

A student who participated in our Community College Innovation Challenge (CCIC) Listening session attributed his ability to return to college to flexible scheduling at his local community college. After having been forced to leave a fouryear college following his parents' bankruptcy, he worked as a teacher's aide in K-12 STEM classes. This work experience continued to fuel his passion for STEM. After several years in the workforce,





"It is not about having a college degree. It is about learning the specific skills of being a tech support person."

Lisa Gevelber,
Vice President of
Global Marketing,
Google

"There are so many possibilities still in the future. There are jobs that haven't even been labeled yet. You can create your own job in this field and that is what I love about it."

Erika Bim, Student,
Oakton Community
College







he began studying at a local community college so that he could transition into a career in the aerospace industry. By this time, he also had a family of his own. He credits the structures at his community college for the ability to pursue his studies, participate in extracurricular programs, and connect with industry.

Employers play an important role in meeting students and workers where they are. We heard from students and employers that human resource departments often require a bachelor's degree for work that can be done by someone without a bachelor's degree. A few years ago, Google re-examined how it defines "qualified candidates." For Google, qualified does not always mean having a college degree; it means having the specific skills necessary to do the job. Like Google, other employers have started to reexamine their hiring practices and focus on skills rather than degrees.

The importance of meeting people where they are continues even after a worker lands his or her first skilled technical job. Lifelong learning is the new standard; this is particularly crucial in the STW fields where technology changes rapidly. As Mike Reichenbach, president of Mike Reichenbach Ford, Lincoln, VW, and Chevrolet of Florence, South Carolina, said, "the type of worker who is successful in the skilled technical workforce is that individual who understands that the status quo isn't able to be maintained for very long. Either you are moving forward and embrace that change or you find yourself left behind."²⁴

COORDINATION AND PARTNERSHIPS AMONG STW STAKEHOLDERS ARE ESSENTIAL

As the National Academies of Sciences, Engineering, and Medicine have noted, skilled technical workforce development in the United States is decentralized and consists of "many, often competing sources of authority in government, business, civil society, and private life."25 Students; workers; labor unions and other worker associations; families; educators; industry associations; employers; as well as government at all levels play a role in educating and preparing the STW.²⁶ Funding for STW education and preparation is equally varied and can include user fees, state and local government resources, philanthropic contributions, and grants. At the federal level alone, STW education and preparation is administered by 43 different government programs across nine different federal agencies, including NSF.27

Greater coordination and partnerships among government, industry, and educational institutions will be crucial to strengthening the STW. As the Board heard from listening session participants, coordination and partnerships take many forms. Many successful partnerships avoid "one size fits all approaches" and respond to the workforce needs in a specific region or industry.

At various listening sessions, the Board learned about a number of thriving partnerships among community colleges, industry, and four-year colleges and universities.

THE POWER OF PARTNERSHIPS: STANDARDIZED CURRICULA

After spending several years in industry as an engineer, Dr. Kevin Cooper, Assistant Dean of Applied Technology at Indian River State College, saw an opportunity to meet the nuclear industry's workforce needs by developing a standardized curriculum. To develop this curriculum, Dr. Cooper forged partnerships within his institution, and with industry, labor unions, and other community colleges offering similar programs. After a startup period of about five years, the NSF-funded Regional Center for Nuclear Education and Training (RCNET) was educating and delivering technicians into well-paying jobs in nuclear technology. Dr. Cooper subsequently worked with industry to establish the Nuclear Uniform Curriculum Program (NUCP) certificate. Students who graduate from a program that offers the NUCP certificate do so with a nationally recognized credential that gives them access to jobs that can start at \$40/hour. Dr. Cooper stresses that forming these partnerships took time, persistence, a willingness to learn from failure, and a commitment to talking with students, workers, and industry to design a program that truly meets their needs.

FARD



These partnerships shared the following key ingredients:

- leveraged familiarity with a region and its industries;
- secured buy-in from all partners and cultivated champions at the highest levels of the participating organizations;
- developed a clear sense of the value proposition for all parties involved; and
- committed the time and resources to see their collaborations through to fruition.

For example, when visiting the Center for Advanced Automotive Technology (CAAT), an NSF-funded Advanced Technological Education Center at Macomb Community College in Warren, Michigan, the NSB learned about Macomb's partnerships with major automakers to educate and prepare auto workers. Automakers play a key role in shaping Macomb's programs by providing adjunct faculty for the college's automotive education/workforce development programs and donating equipment for use in its facilities. Additionally, when Macomb created a new interdisciplinary degree program in vehicle development, it did so by bringing together

THE POWER OF PARTNERSHIPS: UNIVERSITIES AND COMMUNITY/TECHNICAL COLLEGES

Partnerships between bachelor's and graduate degree granting universities and community and technical colleges can improve diversity, broaden pathways into higher education, support regional workforce development, and help accelerate the translation of research conducted at universities to market. As Dr. Anand Gramopadhye, Professor and Dean of the College of Engineering, Computing and Applied Sciences at Clemson University, notes, "partnerships provide opportunities for all while making sure our students and workforce are set for success in today's technologically changing landscape." As a Principal Investigator on an NSF Advanced Technological Education grant that supports the Center for Aviation and Automotive Technological Education Using Virtual E-Schools (CA2VES), Dr. Gramopadhye and his team have cultivated a community of practice that includes numerous community colleges in South Carolina, automotive and aviation industry leaders, and four-year colleges and universities.

The state of South Carolina is an important partner in these efforts. In 2015, the state created the Coordinating Council for Workforce Development. Comprised of members from South Carolina's Department of Commerce, Commission on Higher Education, presidents of research universities and community colleges, school superintendents, and members of the business community, the Council was charged with coordinating workforce development efforts throughout the state. In addition, South Carolina has appropriated resources to support education and training for indemand industries and to spread the message about STW pathways.

At Clemson, fostering partnerships and connections with industry, technical colleges, and community colleges has proven to be a way to pursue world class research, workforce development, and education while furthering the core mission of this modern, public, research, land-grant university.



content experts who understood the skills and competencies needed in the workplace and the experience of educators at the community college. Establishing the new degree program took three years and countless meetings between Macomb and industry leaders. According to Bob Feldmaier, a retired auto industry engineer and Director of CAAT, the new degree program would have been "nearly impossible without industry help."

Increasingly, four-year colleges and universities are also embracing partnerships with community colleges to help support educational and career pathways and fuel local and regional economic development. Working with industry, both twoyear and four-year educational institutions are creating integrated learning environments that link education, skill development, and work.

INCREASE AWARENESS AND UNDERSTANDING OF STW CAREERS AND EMPLOYMENT OPPORTUNITIES

Various media and policy reports have identified the focus in recent decades on "college for all" as a barrier to encouraging STW pathways.²⁸ All too often, "college for all" has been equated with the message that a bachelor's degree is the only route to a good career. In reality, while some postsecondary education has become increasingly necessary to secure a "good job," not every career track requires a four-year degree.²⁹ The cultural emphasis on four-year educational pathways has created the unintended consequence of portraying two-year and four-year post-secondary educational pathways as oppositional. As postsecondary educational and workforce pathways become increasingly non-linear, it is crucial that the variety of post-secondary options be discussed, that two- and four-year paths not be placed in opposition, and that the STW be highlighted in discussions of post-secondary educational and career options.

Many students with whom the NSB spoke emphasized that lack of information and awareness about STW careers help perpetuate misperceptions and play a significant role in discouraging individuals from pursuing skilled technical education and employment. They noted that skilled technical education and pathways were not presented to them in high school as post-secondary education and career options. As a result, a number of students described finding their preferred career opportunity required technical education after having begun or completed a four-year degree.

In the course of the Task Force's activities, NSB met students who were pursuing skilled technical education by choice. Many noted that they loved the hands-on work with modern technologies, the small classes, the focus on applicable skills, and the prospect that their education would lead to immediate employment. As a student in Macomb Community College's (MCC) Controls Technician Program explained, his familiarity with Programmer Logic Control (PLC) is widely applicable. "Everyone is switching over to robotics now." Workers with programming skills are regularly "fixing [robots], programming them, and telling them what to do. Training in PLC opens up avenues to a bunch of opportunities. Once you get into an industry you can start to move up as you know more people."

The narrative around the STW is starting to change. Work-based learning programs, including registered and non-registered apprenticeships, are growing in popularity. Organizations like the American School Counselors Association, the leading professional association for high school counselors, are speaking out about career readiness and building awareness about a range of educational and career pathways. Some high schools are re-integrating or building up CTE programs and making them part of the educational offerings for all students. Still other



"You are working on very high-tech systems with excellent pay, excellent benefits, and long-term opportunities."

Bob Feldmaier,
Director of
the Center
for Advanced
Automotive
Technology,
Macomb
Community College

high schools are establishing partnerships with local community colleges and industry to create viable and rewarding pathways for students seeking to enter the STW. More and more students and families are also discovering that the STW is a pathway to well-paying jobs, career opportunities in cutting edge industries, as well as an avenue that can lead to additional postsecondary STEM education.





INSUFFICIENT DATA AND DATA COORDINATION CONTRIBUTE TO STW-RELATED CHALLENGES

In the past few years, policymakers, industry, and educational institutions have taken steps to address changing workforce needs by introducing new policies and programs geared toward the STW. Much of this activity is, however, occurring in the context of limited or siloed data. Addressing data gaps and silos will be essential if the United States is to take a strategic, systemslevel approach to cultivating the STW.

Relative to S&E workers who have earned a bachelor's degree or more, the data portrait of the STW remains very limited. We heard from multiple stakeholders about the pressing need for policy-relevant data to address STW-related data gaps, including:

- How/where skilled technical workers acquire their skills and education.
- Which programs are most effective at preparing students for the workforce.
- How people use their skills once they enter the workforce.
- Longitudinal measurements of how people move from education and workforce preparation programs to their first job, and subsequent jobs and/or additional education.
- Information on the links among postsecondary credentials (degrees, certificates, certifications, badges, micro-credentials), training, and wages.
- Characterization of the skills that people use in a given occupation.
- Information on how individuals and employers are investing in STW education and skill building.

These data gaps pose a number of challenges. First, the lack of data makes it difficult to assess the supply and demand for skilled technical workers nationally and in local labor markets. This makes workforce planning and national policymaking difficult. Second, it is challenging for policymakers, employers, and educators to design programs and determine how to attract and retain skilled technical workers without information on how people enter the STW, how they maintain and update their skills, and how they advance along a career pathway. Third, limited data also affect partnership formation. Better information on skill requirements could help spur partnerships between industry and educational entities that are crucial to ensuring that students who complete programs are job ready. Fourth, the current dearth of reliable, transparent information about job preparation and educational opportunities and outcomes makes it hard for consumers to make informed choices and understand the likely return on their educational investments. The need for such information is becoming increasingly vital as post-secondary education and skill development opportunities as well as credentials and certificates proliferate.³⁰

Collecting and disseminating robust data on the STW will be a multi-year effort. It will require the participation of industry, private sector data providers, state and local government, and coordination among federal statistical agencies including the Bureau of Labor Statistics, the Census Bureau, National Center for Education Statistics (NCES), and NSF's National Center for Science and Engineering Statistics (NCSES).



In response to interest from the National Academies' Committee on National Statistics, and further motivated by the establishment of the Board's Task Force and the Innovations in Mentoring, Training, and Apprenticeships Act of 2018, NSF's NCSES is working with the Census Bureau and the NCES to develop information and data analysis tools, explore survey and administrative data on the STW, and collect comprehensive information on STW employers. NCSES is also communicating with the Bureau of Labor Statistics about its data products and how the two federal statistical agencies can work together more effectively. The NSB believes that these efforts are laying the groundwork for creating a coordinated federal approach to addressing STW data gaps.

The Board is also disseminating existing STW data. The 2020 edition of NSB's congressionallymandated report, *Science and Engineering Indicators*, will include some data and discussion of the STW. The efforts by NSF, NSB, and federal statistical agencies to improve the data portrait of the STW can enable policymakers, consumers, industry, and other entities that work to support the STW to channel resources and energy more efficiently.





NATIONAL COUNCIL ON THE AMERICAN WORKER

In July 2018, <u>Executive Order 13845</u> established the President's National Council for the American Worker (NCAW) to "provide a coordinated process for developing a national strategy to ensure that America's students and workers will have access to affordable, relevant, and innovative education and job training that will equip them to compete and win in the global economy." This Executive Order also established the American Workforce Policy Advisory Board.

In June 2019, the Workforce Policy Advisory Board announced four focus areas:

- Develop a campaign to promote multiple pathways to career success
- Increase data transparency to better match American workers to American jobs
- Modernize candidate recruitment and training practices
- Measure and encourage employer-led training investments

As NCAW tackles near-term employment and workforce development needs, it has independently identified messaging and data as areas for action. The Administration's convening and coordination power can catalyze national progress on these challenges. NCAW's deep engagement with industry stakeholders is also essential, complementing this report's focus on the role of educational institutions and government. Given that the business sector conducts most of our country's R&D, attention to skilled technical workers in industry settings is critical.

We offer the following recommendations to policymakers and S&E leaders to strengthen the STW and the S&E enterprise. The recommendations presented here are interconnected, each addressing aspects of one or more of the big picture, systemic challenges identified in this report.

CHANGE THE MESSAGE

A lack of awareness among students, parents, and mentors about the nature of skilled technical work and the doors that it opens were recurring themes of Task Force listening sessions. Understanding and countering negative perceptions and raising awareness of the broad range of viable and attractive careers for STEM-capable individuals are crucial to the future of the STW and the U.S. S&E enterprise. We need individuals at all levels to be part of the STEM-capable workforce.

RECOMMENDATION: The NSB and NSF, and other S&E leaders should communicate the importance of the STW to our nation's S&E enterprise, individual economic prosperity, national security, and U.S. global competitiveness. Key messages include:

- Skilled technical work is crucial to the nation and the S&E enterprise.
- The multiple educational pathways into the S&E enterprise are complementary and interdependent. Together they produce the educated, skilled, and diverse workforce the United States needs in today's knowledge-and technology-intensive world.
- Skilled technical work is a pathway that can lead in a variety of educational and workforce directions.
- Pursuit of skilled technical work is about personal preferences and choices.



FOCUS ON THE DATA

It is critical that policymakers, employers, and individuals considering STW education and career pathways have high-quality data and information on the characteristics, educational needs, and career opportunities of the STW. Gathering these data will require additional federal resources, including funding and personnel, as well as coordination across federal statistical agencies and input from states and industry. These efforts will improve our understanding of STW characteristics and the design of policies, education, and skill development programs, including those developed in response to the Innovations in Mentoring, Training, and Apprenticeships Act of 2018.

RECOMMENDATION: To understand and begin to address data gaps, NSF's NCSES, with additional federal resources and collaborating with other statistical agencies, should collect nationally representative data on the education, skills, and workforce characteristics of the STW. NSF should promote partnerships between governmental and non-governmental (industry, academia) stakeholders in the STW to share data and develop tools for public use and workforce planning.



LEVERAGE THE PORTFOLIO OF FEDERAL INVESTMENTS

Given the number of federal agencies that address aspects of the STW, an opportunity exists for all federal agencies to think holistically about how to leverage resources and complement one another's activities. To do so effectively, a full inventory and understanding of the programs and activities that relate to the STW is needed.

For example, while the Advanced Technical Education (ATE) program is NSF's best known STW-related program, NSF also makes other STW research and education investments. Research on K-12 STEM education, digital literacy, the future of work, as well as research into effective pedagogy in mathematics and computer science at community colleges can all help inform preparation of the STW. A portfolio analysis of NSF's current STWrelated investments across all directorates could help the Board and NSF convey to stakeholders NSF's contribution to strengthening the STW, engage in strategic discussions about how these STW investments fit with other parts of NSF's portfolio, and better communicate STW-related funding opportunities to principal investigators.

RECOMMENDATION: NSF should conduct a full portfolio analysis of its STW investments. The analysis could publicize and inform stakeholders about the breadth of NSF's contributions to the STW, build awareness of funding opportunities, and maximize and leverage the impact of these investments.

BUILD PARTNERSHIPS

A one-size-fits-all approach to creating fruitful, sustainable partnerships does not exist. Partnerships must meet the needs of local employers and respond to the community, leveraging locally available educational resources at the high school and post-secondary level. For four-year institutions, building partnerships with other local entities (business/industry, high schools, community colleges, state and local governments) provides a way to broaden participation in higher education and the base of support for the institutional mission. Partnerships can take considerable trust, time, and resources to establish and sustain. Local and state governments, federal policymakers, and funding agencies must support and encourage partnerships formation.

RECOMMENDATION: In strengthening educational pathways for the STW, policymakers and educational institutions should recognize that K-12 school systems, two-year colleges, fouryear colleges and universities, and other postsecondary education and workforce development programs are integral, synergistic parts of a whole. These institutions should work as partners together with business and industry to grow the STEM-capable U.S. workforce via STW programs tailored to the needs of their local communities. Policymakers can encourage the creation of such partnerships by developing federal programs that require partnership participation from stakeholders from multiple sectors.

TIMELINE		NSB POLICY STATEMENT "Our Nation's Future Competitiveness Relies on Building a STEM-Capable U.S. Workforce" <i>February 1, 2018</i>	LISTENIP Macomb Co Warren, MI April 19, 20.
		BOARD MEETING "Grow with Google" Presentation <i>February 22, 2018</i>	
	BOARD MEETING Skilled Technical Workforce Panel <i>August 16, 2017</i>	LISTENING SESSIONS Baton Rouge Community College Listening Session and Xavier University Listening Session Baton Rouge and New Orleans, LA October 26, 2017	LISTEI Co Inno
NSB ACTIVITIES	BOARD MEETING First NSB discussion on the Skilled Technical Workforce Project <i>February 21, 2017</i>	BOARD MEETING Task Force on the Skilled Technical Workforce Established and Charge Approved <i>November 9, 2017</i>	

2017 JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 2018 JAN FEB MAR APR

NATIONAL ACADEMIES OF SCIENCES, ENGINEERING, AND MEDICINE REPORT

"Building America's Skilled Technical Workforce"

May 18, 2017

SENATE HEARING

"Closing the Skills Gap and Boosting U.S. Competitiveness" - Senate Committee on Commerce, Science, and Transportation

March 29, 2017

CONGRESSIONAL HEARING

NCD DOLLOV CTATEMENT

LICTENI

"Innovations in STEM Mentoring, Training, and Apprenticeships" - U.S. House of Representatives, Committee on Science, Space, and Technology *February 15, 2018*

BLUE COLLAR STEM 2017 CONFERENCE

Baltimore, MD November 7, 2017

CONGRESSIONAL BRIEFING

"Blue Collar STEM: The Future of the U.S. Workforce" - Congressional Black Caucus Briefing

November 7, 2017

NG SESSION

ommunity College

18

VING SESSION

ommunity College ovation Challenge

> Alexandria, VA June 12, 2018

LISTENING SESSION

Florence-Darlington Technical College

Florence, SC September 26, 2018

LISTENING SESSION

Advanced Technological Education Conference

Washington, D.C. October 25, 2018

NATIONAL SCIENCE BOARD REPORT

"The Skilled Technical Workforce: Crafting America's Science & Engineering Enterprise"

September 2019

MAY JUN JULY AUG SEP OCT NOV DEC 2019 JAN FEB MAR APR MAY JUN JUL AUG SEP

EXECUTIVE ORDER

"Establishing the President's National Council for the American Worker" July 19, 2018

BUSINESS-HIGHER EDUCATION FORUM WORKSHOP

On "Reskilling America's Workforce"

> Alexandria, VA September 24-25, 2018

BLUE COLLAR STEM 2018 CONFERENCE

Baltimore, MD November 5, 2018

STEM EDUCATION PLAN

White House Unveils Five-year Strategic Plan - "Charting a Course for Success: America's Strategy for STEM Education"

DEAR

LETTER For NSF's

Convergence

Accelerator Pilot

Future Jobs" and

"National Talent

Ecosystem"

March 15, 2019

tracks: "AI and

COLLEAGUE

December 4, 2018

NATIONAL ACADEMIES OF SCIENCES, ENGINEERING, AND MEDICINE REPORT

"Minority Serving Institutions: America's Underutilized Resource for Strengthening the STEM Workforce"

December 13, 2018

H.R. 5509 PASSES

Innovations in Mentoring, Training, and Apprenticeships Act December 31, 2018

AMERICAN WORKFORCE POLICY ADVISORY BOARD MEETING

Release of Working Group Priorities

June 18, 2019









o meet its charge, the Task Force undertook a number of activities, including:

Stakeholder engagement: The Task Force met with relevant organizations

in the Washington, D.C. area, including the Department of Labor, Department of Education, the American Association of Community Colleges, NCSES, the Georgetown University Center on Education and the Workforce, and the American School Counselors Association to learn about their work and efforts to strengthen the STW.

Listening Sessions: The Board held five listening sessions that included 203 participants from 65 locations dispersed throughout the United States (see Figure on Page 44). Participants shared experiences and insights about the STW in their local and regional communities. Although much of what we heard is documented in a growing body of literature, the workers, students, businesses, and educators we met with shared personal stories, providing a compelling human portrait of the challenges and opportunities facing the STW as outlined in the body of this report.

More detailed information about the five listening sessions is included below:

• **Baton Rouge Community College (BRCC):** BRCC is located in Baton Rouge, Louisiana, in a region where the oil and gas industries fuel some 260,000 jobs. Like many community colleges, Baton Rouge Community College is an essential education center for students entering the skilled technical workforce.

- Macomb Community College (MCC): MCC is located in Warren, Michigan, in the heart of the rejuvenated automobile industry and home to the Center for Advanced Automotive Technology (CAAT), a NSF-funded Advanced Technological Education (ATE) center. CAAT's mission is to meet the expanding workforce needs of the automotive industry by increasing the pool of skilled technical workers in advanced automotive technology including automated and connected vehicles, and vehicle electrification.
- Community College Innovation Challenge (CCIC): NSF's Community College Innovation Challenge is a two-stage competition in which students use STEM to find innovative solutions to real-world problems. NSF brings student finalists and their faculty mentors from around the country to Alexandria, Virginia, each year to participate in an Innovation Boot Camp. The Board met with these students and faculty mentors who echoed many of the themes that came to light at BRCC and MCC.
- Florence Darlington Technical College (FDTC): FDTC is a two-year technical college located in Florence, South Carolina, a region that is home to a variety of industry sectors including advanced manufacturing, advanced materials, aerospace, and automotive. The South Carolina Advanced Technological Education (SCATE) Center of Excellence, located at FDTC, is NSF's longest running ATE initiative. The SCATE Center offers a variety of resources supporting industrial and engineering technology programs and related STEM programs nationwide, including recommendations for faculty development best practices, strategies for recruiting and retaining students, and methods for effective instruction.



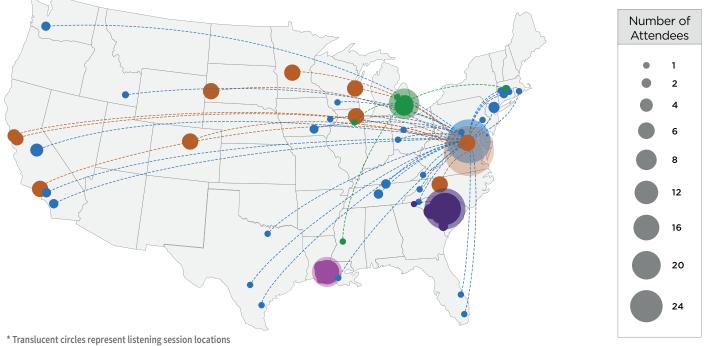
Advanced Technological Education (ATE) Principal Investigators' Conference: NSF's ATE program focuses on educating technicians for the high-technology fields that drive our nation's economy. The annual ATE conference brings together over 800 people to focus on the critical issues related to advanced technological education. Forty-five participants joined NSB's listening session, which included community college students and faculty, and recent ATE program alums. Participants represented 30 community colleges across the country. The Task Force shared its observations with the public, scientific community, and policymakers through communication pieces, Hill testimony, panel discussions, and a resource website. NSB's activities occurred simultaneously with other federal efforts, such as the National Council for the American Worker, the release of the Administration's five-year STEM Education plan, and congressional legislation focused on the Skilled Technical Workforce.

Resources developed from the activities of the NSB Task Force on the Skilled Technical Workforce are available online at <u>https://www.nsf.gov/nsb/</u> <u>NSBActivities/skilled-technical-workforce.jsp</u>.





LISTENING SESSION & PARTICIPANT LOCATIONS



* Solid circles represent attendee locations

Advanced Technological Education Conference	Community College Innovation Challenge	Florence Darlington Technical College	Macomb Community College	Baton Rouge Community College
Washington, D.C. 45 Attendees 31 Participant Locations	Alexandria, Virginia 56 Attendees 10 Participant Locations	Florence, South Carolina 40 Attendees 9 Participant Locations	Warren, Michigan 22 Attendees 10 Participant Locations	Baton Rouge, Louisiana 21 Attendees 2 Participant Locations
Academia 45	Academia 55	Academia 20	Academia 10	Academia 12
	Industry 1	Industry 14	Industry 8	Industry 5
		Government 2	Government 3	Non-Profit 4
		Non-Profit 4	Non-Profit 1	









n important element of NSF's mission is to prepare the STEM workforce of the future, including the STW. In 1992, Congress passed the Scientific and Advanced-Technology Act

(SATA) (Pub. Law. 102-476) explicitly adding support for the STW to NSF's statutory functions. This legislation directed NSF to award grants to associate-degree granting colleges in order to expand the pool of skilled technicians, increase the productivity of the nation's industries, and improve U.S. competitiveness.³¹ Since then, NSF has helped strengthen the STW through a variety of mechanisms, including:

Education and Workforce Development:

The Advanced Technological Education (ATE) program, which was a direct response to the SATA legislation, educates highly qualified science and engineering technicians for advanced technology fields that drive our nation's economy. ATE is NSF's single largest investment in the STW, providing approximately \$60-\$65 million annually in grants to public, two-year, community and technical colleges.

Improving Undergraduate STEM Education (IUSE) supports a suite of investments to address immediate challenges and opportunities facing undergraduate education. IUSE also supports new structures (e.g. organizational changes, new methods for certification or credentialing, course re-conception, cyberlearning, etc.) and functions of undergraduate learning and teaching.

Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) addresses the need for a high-quality workforce in the STEM disciplines supported by the program and for 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 higher education institutions for scholarships and to advance the adaptation, implementation, and study of effective evidence-based curricular and co-curricular activities.

Computer Science (CS) For All aims to provide all U.S. students the opportunity to participate in CS and computational thinking at the pre-K-12 level. NSF's current solicitation focuses on researcherpractitioner partnerships that foster the research and development needed to bring CS and computational thinking to all schools.

Fundamental Research: In March 2019, NSF issued a Dear Colleague Letter inviting proposals for convergent research on the topics of "Artificial Intelligence (AI) and the Future of Jobs" and a "National Talent Ecosystem." The former will support research and development to understand and influence the impact of AI on workers and work and foster lifelong learning. The latter supports research and development of innovative approaches for employers to support workers seeking the skills for 21st century work related to AI, data science, predictive analytics, and other technologies of the future. Approaches of interest include re-envisioning the concepts, structures, and technologies needed for employers to support continuous learning for dynamic, digitallyintensive work, and providing access to skilled talent. NSF also funds research relevant to the STW such as research on math pedagogy for nontraditional students, computer science education, and barriers facing women and persons of color



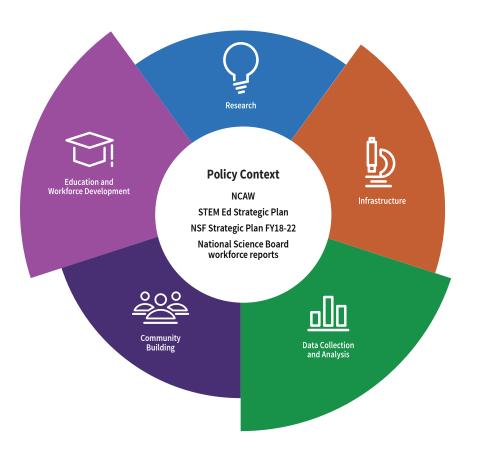


in STEM. This research is funded through NSF's Directorate on Education and Human Resources (EHR) and NSF's science directorates.

Infrastructure: NSF's Science of Learning program supports basic research that expands fundamental knowledge about learning principles, processes, and constraints. See also ATE above.

Data Collection and Analysis: The National Center for Science and Engineering Statistics (NCSES), a federal statistical agency housed within NSF, collects high quality data on the S&E enterprise, including statistics related to the education and career pathways of all STEM workers. New NCSES data and analysis on the STW will be included in the 2020 edition of the Board's Science and Engineering Indicators report. **Community Building:** NSF supports the annual Community College Innovation Challenge (CCIC), a competition in which community college teams use STEM to create solutions for real-world problems. Teams earn full travel support to attend an Innovation Boot Camp in Washington, D.C. and discover how to transform ideas into reality by learning entrepreneurship strategies, customer discovery, start-up business and product developing methodology, and designcentered thinking.

NSF INVESTMENTS IN SKILLED TECHNICAL Workforce development



Research

Educational Research NSF Convergence Accelerator Tracks AI and the Future of Jobs

Infrastructure

Advanced Technological Education Science of Learning Data and Tools

Data Collection and Analysis

Stakeholder Outreach to Identify Data Gaps New National Tradining Education and Private Sector Data Sources

Community Building

Career Compass Challenge Community College Innovation Challenge

Education and Workforce Development

Advanced Technological Education S STEM CS for All

The National Science Board wishes to thank the numerous individuals who gave their time and thoughtful input to this report. The Board thanks Victor McCrary, who chaired the Task Force on the Skilled Technical Workforce (STW), and the NSB Task Force members Vicki Chandler, Robert Groves, James Jackson, Carl Lineberger, and Geraldine Richmond who led the development of the report on the Board's behalf. The NSB would also like to acknowledge the current Chair and Vice Chair of the Board, Diane Souvaine and Ellen Ochoa, and former Board Chair Maria Zuber for their vision and leadership on this important and timely policy issue. NSF Director, France Córdova provided insights throughout the process and connected us with resources within NSF and beyond.

Staff from the National Science Foundation and NSF's National Center for Science and Engineering Statistics (NCSES) graciously lent their expertise to this report. In particular, Amy Burke, Senior Analyst and author of the *Science and Engineering Indicators 2020* thematic report on the "Science & Engineering Labor Force," was instrumental in helping to define the STW and provided helpful input on S&E workforce data throughout the process. The Board also wishes to thank Emilda Rivers, Division Director for NCSES; Beethika Khan, Program Director for the *Science and Engineering Indicators* (SEI, *Indicators*) program; John Finamore, Program Director for the Human Resources Statistics program; and Carol Robbins, Senior Analyst.

From the project's inception, Celeste Carter, Program Director of the Advanced Technological Education (ATE) program in NSF's Division of Undergraduate Education served as an invaluable content expert on community colleges and the skilled technical workforce. James Hamos, Senior Advisor in the Office of the Director, provided helpful guidance throughout the process and Lloyd Whitman, Assistant to the Director for Policy and Planning, lent his perspective on synergies with other government activities related to the skilled technical workforce.

Karen Marrongelle, Assistant Director of the Directorate of Education and Human Resources, and Arthur Lupia, Assistant Director of the Directorate of Social and Behavioral Sciences provided insights into NSF's current investments in the STW. Their feedback on drafts was instrumental in clarifying and strengthening the message and content of this report.

The Board would also like to thank the many external experts and stakeholders who spoke with the Task Force and staff: Robin E. Fernkas, Acting Deputy Administrator in the Office of Workforce Investment in the Department of Labor and her staff; Diane Auer Jones, Principal Deputy Under Secretary at the Department of Education; Mary Heiss, Senior Vice President of Academic and Student Affairs and Kent Phillipe, Associate Vice President of Research and Student Success at the American Association of Community Colleges; Stephen DeWitt, Deputy Executive Director at the Association for Career and Technical Education; Richard Wong, Executive Director at the American School Counselor Association; and Anthony Carnevale, Director and Research Professor at the Georgetown University Center on Education and the Workforce and his staff. The Board also benefited from the insights shared by the speakers who presented at Board meetings: Lisa Gevelber, Vice President of Global Marketing at Google; Dallas Elleman, Tulsa Community College Graduate and product development engineer at XWorks; Imelda Cossette, Executive Director and Principal Investigator for the National Resource Center for Materials Technology Education and Project; and Matt Glover, Chief Technology Officer at Le-Vel.

This report could not have been written without the stories and experiences of students, faculty, administrators, business leaders, and government representatives from across the country who participated in the Task Force's Listening Sessions. In particular, the Board would like to thank the faculty and staff at Listening Session host institutions, including: Baton Rouge Community College, particularly Laura Younger, Vice Chancellor for Academic and Student Affairs, Jacqueline Jones, Associate Dean and Associate Professor of Learning Resources, Toni Manogin, Vice Chancellor for Academic and Student Affairs (interim); Macomb Community College, particularly, Bob Feldmaier, Director of the Center for Advanced Automotive Technology and Joseph Petrosky, Dean of the Engineering and Advanced Technology Department; and Florence Darlington Community College, Rick Roberts, Managing Director of the South Carolina Advanced Technical Education Center of Excellence, Teressa Gardner, Associate Vice President of Southern Institute of Manufacturing Technology (SiMT), and Mike Roth, Vice President of SiMT. The Board would also like to thank the students and faculty who participated in the listening sessions held at the annual ATE Principal Investigators' Conference in Washington, D.C. as well as the inspiring students and faculty who attended the Community College Innovation Challenge Listening Session in Alexandria, Virginia. In additional to Listening Sessions, the Task Force also interviewed skilled technical workers and faculty/staff who support the STW including: David Barker, Lead Systems Engineer at the LIGO Livingston Observatory; Kevin Cooper, Assistant Dean at Indian River State College; and Anand Gramopadhye, Professor and Dean of the College of Engineering at Clemson University.

NSB also expresses its thanks to the National Science Board Office staff. Kim Silverman, Kathy Jacquart, DeMonica Parks, Brandon Powell, Ann Bushmiller, Turquoise Bowen, and Kyscha Slater-Williams helped organize and staff our Listening Sessions. Acacia Reed created the NSB's STW webpage. Chris Blair proofread the final draft of this report. NSB's American Association for



the Advancement of Science S&T Policy Fellows Mateo Muñoz and Christina Maranto supported all aspects of the Task Force's work. Reba Bandyopadhyay brought to the project her knowledge of *Indicators* and her skills in policy communication. Matthew Wilson played a leading role in the project from its inception until he started his detail at the Office of Science and Technology Policy. Elise Lipkowitz guided the report across the finish line with skill and dedication. Nadine Lymn and Brad Gutierrez provided their insights and editorial contributions throughout the project. Finally, we thank John Veysey for his guidance and the many roles that he has played in ensuring the Task Force's success.



ENDNOTES

- 1 National Academies of Sciences, Engineering, and Medicine (NASEM), "<u>Building America's Skilled</u> <u>Technical Workforce</u>," (Washington, D.C.: The National Academies Press, 2017), 26.
- 2 Task Force on the Skilled Technical Workforce (STW), National Science Board (NSB).
- 3 White House activities include the President's National Council for the American Worker and release of a <u>five-year strategic plan</u> for STEM education in 2018.
- 4 For example, the Business-Higher Education Forum's 2019 report, "<u>Reskilling America's Workforce:</u> <u>Exploring the Nation's Future STEM Workforce Needs.</u>"
- 5 National Science Board, "Science and Engineering Labor Force," *Science & Engineering Indicators* 2020, (forthcoming). The definition for the STW used in the *Indicators* report builds on the definition introduced in Jonathan Rothwell's 2015 publication "<u>Defining Skilled Technical Work</u>." The National Center for Science and Engineering Statistics (NCSES) has added to Rothwell's definition by adding occupations that NCSES designates as S&E and S&E-related.
- 6 Subcommittee on Federal Coordination in STEM Education, "<u>Charting A Course for Success: America's</u> <u>Strategy for STEM Education</u>," (Washington, D.C.: NSTC, 2018), v.
- 7 As both our 2015 report and the 2017 National Academies of Sciences, Engineering, and Medicine report on "Building America's Skilled Technical Workforce" noted, there is intense debate over the nature of labor market shortages, skills gaps, and mismatches. Labor market shortages in the STEM-capable workforce tend to be specific to field, type of work, and location. In fact, "Building America's Skilled Technical Workforce" observed that there was not, in the aggregate, a shortage of skilled technical workers in the United States. The report's authors noted, however, that this did not preclude localized shortages in specific lines of skilled technical work or more widespread shortages in the future. NASEM, "Building America's Skilled Technical Workforce," (Washington, D.C.: The National Academies Press, 2017), 26.
- 8 Ibid., 26.
- 9 NSB, "Science and Engineering Labor Force," Science & Engineering Indicators 2020, (forthcoming).
- Mark Muro, Jonathan Rothwell, Scott Andes, Kenan Fikri, and Siddharth Kulkarini, "<u>America's</u> <u>Advanced Industries: What They Are and Why They Matter</u>," (Washington, D.C.: Brookings Institution), 4.
- 11 Ibid., 4.
- 12 Ibid., 23.
- 13 For an overview of Federal investments in STW Education, including the role of the National Laboratories, see Daniel Kuehn and Diane Auer Jones, "<u>Sub-baccalaureate STEM Education and</u> <u>Apprenticeship</u>," (Washington, D.C.: Urban Institute, 2018).
- 14 Data collected by the National Center for Education Statistics (NCES) show that in 2017, 34.6% of all persons age 25 and over had a bachelor's degree. NCES, Digest of Education Statistics, <u>Table</u> <u>104.10</u>. "Rates of high school completion and bachelor's degree attainment among persons age 25 and over, by race/ethnicity and sex: Selected years, 1910 through 2017."
- 15 NASEM, "Building America's Skilled Technical Workforce," 8.
- 16 In 2017, the median earnings of skilled technical workers (\$45,000) was significantly higher than the median earnings of workers with less than a bachelor's degree in other occupations (\$29,000). The unemployment rate for skilled technical workers was 3% rather than 5% for other nonbaccalaureate jobs. See NSB, "Science and Engineering Labor Force," Science & Engineering Indicators 2020 (forthcoming).

ENDNOTES

- 17 A small number of geographic areas account for a considerable proportion of S&E jobs. Twenty metropolitan areas with the largest S&E employment account for 42% of nationwide employment in S&E jobs, compared to 31% of employment in all occupations. See NSB, "Science and Engineering Labor Force," *Science & Engineering Indicators 2020* (forthcoming).
- 18 NASEM, "<u>Minority Serving Institutions: America's Underutilized Resource for Strengthening the STEM</u> <u>Workforce</u>," (Washington, D.C.: The National Academies Press, 2019), 1.
- 19 NSB, "Science and Engineering Labor Force," *Science & Engineering Indicators 2020* (forthcoming).
- 20 Ibid.
- 21 NCSES defines S&E occupations as occupations that require at least a bachelor's level of STEM skills. See NSB, "<u>Science and Engineering Labor Force</u>," *Science and Engineering Indicators 2018* (Alexandria, VA: National Science Board, 2018), 12.
- 22 Lexi Anderson, "<u>Priority Areas in 2018 Workforce Development Legislation</u>," Ed Note (blog), October 15, 2018.
- 23 "Fast Facts 2019," American Association of Community Colleges, last modified March 2019.
- 24 NSB video, 2018. "Industry Perspectives," Youtube.
- 25 NASEM, "Building America's Skilled Technical Workforce," (2017), 39.
- 26 Ibid, 39.
- 27 Council of Economic Advisors, "<u>Government Employment and Training Programs: Assessing the</u> <u>Evidence on their Performance</u>," (Washington, D.C.: CEA, 2019), 6.
- 28 For a sample of recent media reports on this topic see: "Post-secondary education: And who—who will take the road less traveled by?" Minneapolis Star Tribune, May 31, 2019; "The Stigma of Choosing Trade School Over College," The Atlantic, March 2019; "The State of American Trade Schools," Popular Mechanics, March 2019; "High-Paying Trade Jobs Sit Empty, While High School Grads Line Up for University," NPR, April 25, 2018; "Spotlight on Vocational Training," Inside Higher Education, April 25, 2017. The National Academies of Sciences, Engineering, and Medicine's report, "Building the Skilled Technical Workforce" (2017) also notes this issue on pages 102-103.
- 29 Anthony P. Carnevale, Jeff Strohl, Neil Ridley, and Artem Gulish, "<u>Three Educational Pathways to</u> <u>Good Jobs: High School, Middle Skills, and Bachelor's Degree</u>," (Washington, D.C.: Georgetown University Center on Education and the Workforce, 2018).
- 30 Anthony P. Carnevale, Stephen J. Rose, and Andrew R. Hanson, "<u>Certificates: Gateway to Gainful Employment and College Degrees</u>," (Washington, D.C.: Georgetown University Center on Education and the Workforce, 2012). With funding from the Lumina Foundation, JP Morgan Chase and other major businesses, <u>Credential Engine</u> is tracking the growing landscape of post- secondary credentials.
- 31 Scientific and Advanced-Technology Act of 1992.

NOTES

NOTES



Photo credits:

National Science Board NSF photos from Advanced Technological Education Impacts 2018-2019 <u>https://ateimpacts.net/book</u> LIGO photo: Matt Heintze/Caltech/MIT/LIGO

To download this report, go to:

https://www.nsf.gov/nsb/NSBActivities/ skilled-technical-workforce-report.pdf



NATIONAL SCIENCE BOARD

2415 Eisenhower Avenue, Alexandria, VA 22314 Phone: (703) 292-7000