

Policy Priorities to Build and Sustain the US Semiconductor Manufacturing Workforce

[Constanza M. Vidal Bustamante](#)¹, [Victoria J. Hernandez](#)¹,
[Ishita Kamboj](#)^{1,2}, [Aparajita Datta](#)^{1,3}, [Joiné Taylor](#)^{1,4}

¹National Academies of Sciences, Engineering, and Medicine, Christine Mirzayan Science and Technology Policy Fellowship, Washington, DC, USA

²North Carolina State University, Department of Materials Science and Engineering, Raleigh, NC, USA

³University of Houston, Department of Political Science, Houston, TX, USA

⁴Florida International University, Department of Teaching and Learning and STEM Transformation Institute, Miami, FL, USA

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Corresponding Author: cvidal@g.harvard.edu

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Executive Summary: Enhancing the United States' global competitiveness in semiconductor manufacturing hinges on addressing the country's substantial shortages of skilled technicians, scientists, and engineers. An initial focus on building the technician workforce offers a critical opportunity to develop advanced manufacturing capacity underlying multiple strategic technologies and to expand economic opportunities to broader sections of the population. The National Center for the Advancement of Semiconductor Technology (Natcast), a non-profit created to operate the public-private National Semiconductor Technology Center established by the CHIPS Act, is uniquely positioned to break down silos and maximize the value of workforce development (WFD) efforts within and outside government and across the US. In this role, Natcast should promptly roll out the announced Workforce Center of Excellence and prioritize activities that individual WFD stakeholders cannot accomplish on their own, including: 1) provide centralized information on semiconductor labor market dynamics and existing resources for WFD; 2) regularly convene communities of practice among government, industry, and educational institutions to boost cross-sectoral alignment and share best practices; 3) fund awareness campaigns about semiconductor career pathways to increase public engagement; and 4) establish program evaluation mechanisms to guide the scaling up of successful WFD efforts. Together, these strategic policy priorities can seize on today's historical investments and political momentum to build the foundation for a resilient US manufacturing workforce.

I. Workforce gaps in US manufacturing are a threat to national and economic security

The United States currently produces roughly 10% of the world's semiconductors, a substantial decline from 37% in 1990, and below China's 15% and Taiwan's 22% (Varas et al. 2020). Moreover, none of the semiconductors made in the US are "leading-edge" chips required to support advanced dual-use technologies such as artificial intelligence and quantum computing (Raimondo 2024). A reliance on foreign countries, including geopolitical adversaries, for the supply of critical goods like semiconductors

leaves the US vulnerable to global supply chain disruptions that threaten national and economic security, as demonstrated during the COVID-19 pandemic (Helper and Soltas 2021).

The CHIPS and Science Act, signed into law in 2022, is a major bipartisan effort to build domestic capacity in semiconductor manufacturing. The Act funds the Department of Commerce's CHIPS for America program, which is distributing \$39 billion in grants, along with additional loans and investment tax credits, to incentivize companies like Intel, Micron, and

Taiwan Semiconductor Manufacturing Company (TSMC) to create and expand semiconductor manufacturing facilities in the US (US Senate Committee on Commerce, Science, and Transportation n.d.). This program also received \$11 billion for cutting-edge semiconductor research and development.

However, major workforce shortages pose a critical threat to the success of these investments. Achieving the government's ambitious goals, including manufacturing 20% of leading-edge chips by 2030 hinges on filling the nearly 115,000 technician, engineer, and computer scientist jobs that will become available in the semiconductor industry over the next few years (Raimondo 2024; The Semiconductor Industry Association and Oxford Economics 2023). Approximately 58% of these jobs are projected to go unfilled due to skilled worker shortfalls, with technicians comprising 39% of the vacant roles. Filling these workforce gaps is thus an urgent step toward strengthening US semiconductor supply chains.

II. A historical opportunity to develop the technician workforce

The CHIPS and Science Act devotes substantial resources to strengthening the US domestic manufacturing workforce at all education levels (US Senate Committee on Commerce, Science, and Transportation n.d.). The Act's manufacturing grants earmark funds for workforce development (WFD) and applicants must submit comprehensive workforce plans (CHIPS Program Office 2023). Moreover, WFD is one of three primary goals for the new National Semiconductor Technology Center (NSTC). The NSTC recently announced the launch of a Workforce Center of Excellence that will receive \$250 million in funding over 10 years (US Department of Commerce 2024a), a fraction of the total \$5 billion announced for NSTC activities (The White House 2024a). The CHIPS Act also grants an additional \$200 million to the National Science Foundation (NSF) for semiconductor workforce and education activities, which NSF is using to fund a National Network for Microelectronics Education regional nodes led by their own Network Coordination Hub (National Science Foundation 2024a).

These resources should be promptly and strategically leveraged. An initial prioritization of technicians could rapidly grow the

manufacturing workforce and broaden economic opportunities for job seekers. Technician jobs, which represent 60% of the semiconductor workforce, require specialized knowledge but not a bachelor's degree, making training programs shorter and more affordable (National Academies of Sciences 2017; Muro, Brachman, and You 2023). Additionally, entry-level pay starts at \$20/hour and can progress to \$45+/hour upon completion of additional training (Long, Ryssdal, and Hollenhors 2024). These jobs provide accessible, well-paid career options for diverse populations, from high school graduates to adults interested in career changes or those rejoining the labor force (The Semiconductor Industry Association and Oxford Economics 2023).

Ultimately, an initial focus on technicians could ensure a robust manufacturing workforce beyond the semiconductor industry. The knowledge, skills, and abilities (KSAs) acquired by technicians are broadly transferable across advanced manufacturing industries, from electric vehicles to biotechnology, thus enabling workers to pivot to other strategic technology fields as hiring cycles fluctuate (The Ohio Manufacturers' Association 2024). Moreover, these jobs can be a stepping stone towards more advanced roles and encourage individuals to pursue bachelor's, master's, and doctoral degrees (Bonvillian and Sarma 2021).

A rapid expansion and diversification of the technician workforce requires non-traditional educational approaches. "Earn and learn" models, like apprenticeships and internships, combine learning at community colleges or career and technical education (CTE) centers with on-the-job training, allowing individuals to make an income while completing their programs (Westerman, Bonvillian, Nelson 2022, Goger and Sinclair 2021). Stacking credentials towards degrees and enabling online learning where possible provides additional flexibility. Moreover, continued financial and professional development support is important for trainee engagement and retention (Robinson, Barber, and Kirya 2023).

III. Policy recommendations for Natcast

The WFD strategies outlined above are already being adopted in parts of the US. However, these efforts are largely fragmented, leading to duplicative work and other inefficiencies that

hinder collective progress. Diverse federal agencies have WFD mandates, from the NSF to the Departments of Labor, Education, Defense (DOD), and Commerce (DOC). Additionally, several grassroots networks of educational institutions lead programming to boost semiconductor WFD.¹ However, these programs, especially those led by 2-year institutions, do not receive steady attention or earmarked financial resources from the industry, struggle to navigate available resources, and often compete with each other and other local stakeholders for limited funding (Ashcroft 2024). Meanwhile, semiconductor manufacturers are pursuing their own WFD programs, including Micron and TSMC's new apprenticeships and Intel's 1-year certificate, which are not readily transferable across companies (Newton-Klitz 2023; Stadler 2023; The White House 2024b).

The National Center for the Advancement of Semiconductor Technology (Natcast), a non-profit created to operate the CHIPS Act-funded NSTC, is uniquely positioned to break down silos and maximize the value of WFD initiatives within and outside of government and across the country. With WFD as one of the NSTC's primary objectives, Natcast can provide an enduring, centralized infrastructure that regional WFD leaders can leverage to enhance the success of their programs. In this role, we call on Natcast to promptly roll out the recently announced Workforce Center of Excellence. This Center should prioritize the adoption of the following four policy recommendations, none of which can be successfully accomplished by individual stakeholders.

¹ For example, see the Micro Nano Technology Education Center led by Pasadena Community College (<https://micronanoeducation.org/>), the Support Center for Microsystems Education led by University of New Mexico (<https://scme-support.org/index.php/about-us>), and the Nanotechnology Applications and Career Center led by the Pennsylvania State University (<http://nano4me.org/aboutus>). For a more recent initiative inspired by the CHIPS Act, see the academia-industry WFD partnership between the SEMI Foundation and the newly created American Semiconductor Academy (<https://semi.org/en/workforce-development/ASA>)

I. Inform: Compile key information on semiconductor labor market, WFD resources, and funding opportunities

Natcast should provide centralized information and resources for semiconductor WFD on a website accessible to all stakeholders, expanding on related repositories such as the National Talent Hub of the National Institute for Innovation and Technology and the Network for Computational Nanotechnology's nanoHUB. The repository should include:

Semiconductor labor market dynamics

This information will help educational institutions adjust their program content, timelines, and class sizes based on industry needs. The repository should include periodic updates on jobs created and filled from the recipients of CHIPS Incentives awards, as well as broader labor market trends gleaned from the Bureau of Labor Statistics and similar sources.

Competency models and sample educational curricula

The Department of Labor has released Semiconductor- Nanotechnology and Advanced Manufacturing Competency Models detailing core KSAs needed in these industries (US Department of Labor's Employment and Training Administration 2022). Community colleges, universities, and industry associations have developed additional models, some specific to technicians.² The repository should gather these models as well as educational curricula and accessible training materials incorporating those KSAs, organized by education level. These resources will guide WFD stakeholders and facilitate the standardization of foundational competencies offered by educational institutions and expected by semiconductor companies.

Funding opportunities

To facilitate program development, the repository should gather funding opportunities for WFD initiatives from federal agencies (e.g.,

² For example, see the Micro Nano Technology Education Center's "Microsystems Process Technician – Knowledge, Skills & Abilities". <https://micronanoeducation.org/resource/microsystems-process-technician-knowledge-skills-abilities/> and the Ohio Manufacturers Association's Manufacturing Competency Model https://ohiomfg.informz.net/ohiomfg/pages/Ohio_MFG_Competency_Model_

the CHIPS R&D program, NSF's Advanced Technological Education program and the new National Network of Microelectronics Education, DOD's Microelectronics Commons, etc.), state government, industry, and philanthropic organizations. Including opportunities for grant writing support would help increase participation from under-resourced education leaders at community colleges and CTE centers.³

ii. Convene: Foster communities of practice among critical stakeholders

To facilitate knowledge-sharing and alignment, Natcast should exert its convening power and facilitate the official establishment of regional and national communities of practice that bring together industry, community colleges, universities, government, and other local stakeholders. For industry, these exchanges would help communicate workforce needs and understand the KSAs imparted by educational programs. Educational institutions would gain consistent insights into industry trends and skill requirements and identify opportunities for collaboration. State and local governments would identify where to streamline bureaucratic requirements and provide financial incentives. Ultimately, these exchanges can lead to resilient regional ecosystems able to sustain WFD programs beyond the federal investments in the CHIPS Act (Johnson and Muro 2024). To this end, Natcast should implement the following:

Regional communities of practice

Building on the CHIPS for America Teaming Partner List, the NSTC Community of Interest mailing list, the DOC's Tech Hubs and the DOD's Microelectronics Commons Hubs, Natcast should help unify and integrate regional communities of practice to more systematically facilitate relationship-building and the tailoring of WFD efforts to local needs and characteristics (National Institute of Standards and Technology 2024; National Center for the Advancement of Semiconductor Technology 2024; US Department of Commerce 2024b; US Department of Defense 2024). These communities of practice would deepen existing

³ For example, "Mentor-Connect" (led by Florence-Darlington Technical College) offers support to STEM Faculty at two-year colleges for NSF ATE Grant Writing & Implementation (<https://www.mentor-connect.org/mentor-connect>)

regional work and maximize the value of the various investments made across federal and state agencies. Meaningful representation from community college and CTE leaders, not just universities, will ensure technician workforce needs receive greater attention (Ashcroft 2024). Convenings should occur at least quarterly to provide frequent opportunities for information-sharing.

National WFD summits and network

To facilitate nationwide strategies and communication, Natcast should convene annual WFD summits to share best practices and lessons learned, recognize excellence through awards, and foster continuous collaboration. These summits might be integrated within existing industry convenings (e.g., SEMI Foundation's Workforce Development Pavilion at the annual SEMICON West industry show). Natcast should also consider establishing a national WFD network, such as the proposed but not yet funded American Semiconductor Academy, which aims to bring together four-year universities and community colleges across the US to collaborate with each other and to collectively partner with industry through the SEMI Foundation (SEMI and American Semiconductor Academy 2022).

iii. Engage: Run public awareness campaigns

A generalized lack of awareness about career opportunities in semiconductor manufacturing might be driving a substantial portion of workforce shortages. About 60-70% of those unfamiliar with manufacturing jobs still associate them with blue-collar, dirty, and dangerous occupations (The Manufacturing Institute and Deloitte 2022). To combat these issues of public knowledge and perception, Natcast should:

Run public awareness campaigns

These campaigns should share information and generate enthusiasm about high-technology manufacturing jobs, training opportunities, and career pathways, and about semiconductors' critical contributions to modern life and national goals. To support worker retention, an additional campaign should inform the current workforce of upskilling and career growth opportunities. Natcast is well-positioned to scale up existing resources created to lift industry image and awareness. The cost of these campaigns is prohibitive for independent WFD actors

(especially those at educational institutions) but is feasible for centralized organizations with substantial budgets like the NSTC.

Tailor campaigns to regional needs

These campaigns should prioritize US regions with existing and planned manufacturing facilities presenting the greatest workforce needs. Natcast should partner with WFD boards and other local stakeholders to deliver multimodal campaigns tailored to the target audience's aspirations and include success stories and information on how to engage.⁴ Innovative approaches will be needed to reach broad sectors of the population, such as recruiting popular social media influencers that can help demystify semiconductor manufacturing jobs, e.g., by touring fabrication facilities and target sites where the workforce frequents or is being trained, including community colleges and trade schools.

iv. Evaluate: Develop mechanisms for workforce program evaluation

Natcast should lead efforts to collect and share evaluative data on semiconductor workforce training programs. These data would help stakeholders identify successful programs and attract additional funding beyond CHIPS Act investments (Johnson and Muro 2024). Evaluative data would empower individuals to choose programs based on quality and enhance general trust in semiconductor manufacturing as a viable career path. Program evaluations should gather data on:

Short-term outcomes

Relevant short-term data includes program enrollment, retention, and completion statistics; percentage of graduates who obtain semiconductor jobs; and trainee characteristics and testimonials.

Long-term outcomes

Additional data should assess the fulfillment of national workforce shortages, worker retention, and opportunities for career progression. Data should further assess curriculum quality, including teaching transferable skills and

alignment between the imparted KSAs and those needed for industry jobs.

Program evaluation efforts could be modeled after existing resources, such as the Department of Education's program evaluation toolkit (Stewart et al. 2021). They could also be guided by workforce needs outlined in recent reports, including the CHIPS Office's guidelines for Incentive applicants (US Government Accountability Office 2022; The Manufacturing Institute and Deloitte 2022; CHIPS Program Office 2022). Evaluation efforts must create sufficient incentives for educational institutions and the industry to share their WFD programs' data, e.g., by tying funding to data-sharing compliance and rewarding successful programs with awards and visibility.

IV. Conclusions and additional considerations

Our recommendations for Natcast to promptly roll out the Workforce Center of Excellence (WCOE) to inform, convene, engage, and evaluate highlight policy priorities to rapidly expand and sustain the skilled technical workforce and to ultimately advance US competitiveness in semiconductor manufacturing. These recommendations align with those proposed by the National Science and Technology Council's Subcommittee on Microelectronics Leadership, the CHIPS for America Industrial Advisory Committee, the American Semiconductor Academy, and semiconductor industry associations, demonstrating increasing momentum behind these goals (National Science and Technology Council 2024, National Institute for Standards and Technology 2024, SEMI and American Semiconductor Academy 2022, Semiconductor Industry Association 2024). Timely utilization of the resources allocated for WFD in the CHIPS and Science Act is the foremost priority. The implementation of the recommendations outlined here will streamline and synergize short and long-term efforts from national, regional, and local stakeholders across government, industry, and educational institutions to meet the needs of the current and future workforce. Throughout, it will be critical for the NSTC's WCOE to fulfill its commitment to coordinate activities with the NSF's National Network for Microelectronics Education and other related initiatives to maximize their respective investments and avoid duplication (National Science Foundation 2024b).

⁴ For example, see the "Talking Technicians" podcast hosted by the Micro Nano Technology Education Center (<https://micronanoeducation.org/students-parents/talking-technicians-podcast/>)

Periodic evidence-based evaluation of these recommendations will facilitate continued finetuning of these activities and enhanced funding opportunities from all levels of the government and the industry. Although not the focus of this memo, our recommendations should be considered in light of additional policy

considerations critical to the development of a resilient workforce for advanced manufacturing, including strengthening the educator workforce, expanding the pool of scientists and engineers with advanced degrees, and attracting and retaining foreign talent to complement domestic workforce development efforts.

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Constanza M. Vidal Bustamante, Ph.D. is a Technology and National Security Fellow at the Center for a New American Security. She was formerly a Science and Technology Policy Fellow with the National Academies of Sciences, Engineering, and Medicine. Constanza completed her Ph.D. at Harvard University, where she leveraged digital technologies to study human behavior and health. She was also a researcher with the Belfer Center and President of the Harvard Science Policy Group. Constanza has led multiple research projects on the policy implications of critical and emerging technologies and the domestic and global factors shaping the U.S. technology leadership strategy.

Victoria J. Hernandez, Ph.D. is an Associate Science Writer and Analyst at Rose Li & Associates. She was formerly a Science and Technology Policy Fellow at the National Academies of Sciences, Engineering, and Medicine. She recently obtained her Ph.D. in Biochemistry from the Massachusetts Institute of Technology, where she studied TorsinA, a protein implicated in a heritable form the neuromuscular movement disorder Dystonia. Victoria is currently transitioning to a career in science policy, where she hopes she can leverage her skills in science communication to address issues in diverse areas including health, education, and the bioeconomy.

Ishita Kamboj is a Ph.D. candidate in Materials Science & Engineering at North Carolina State University, where her dissertation focuses on cathode materials and architectures for lithium-ion batteries. She was formerly a Science & Technology Policy Fellow with the Board on Chemical Sciences and Technology at the National Academies of Sciences, Engineering, and Medicine and an NSF Graduate Research Fellow. Ishita is an applied materials electrochemist by training and has broad career interests in systems to spur R&D innovation in the interplay between materials sustainability and clean energy technology.

Aparajita Datta is a Ph.D. candidate in Political Science at the University of Houston and a UH Chevron Energy Graduate Fellow. She was formerly a Science and Technology Policy Fellow with the Board of Energy and Environmental Systems at the National Academies of Sciences, Engineering, and Medicine. Aparajita holds a bachelor's in computer science and engineering from the University of Petroleum and Energy Studies, India, and master's degrees in energy management from the C. T. Bauer College of Business, in public policy from the Hobby School of Public Affairs, and in Political Science from the College of Liberal Arts and Social Sciences at UH.

Joineé Taylor is a Ph.D. candidate in Physics Education at Florida International University (FIU) and a Preeminent Grad Scholar working on active learning reform with the STEM Transformation Institute at FIU. She was formerly a Science and Technology Policy Fellow at the National Academies of Sciences, Engineering, and Technology. Currently, Joineé works at the intersection of science and education as a physics education researcher on the national project "STEP UP for Women". Her doctoral dissertation focuses on enhancing student engagement in physics, particularly for traditionally marginalized groups, including female, Black, and Hispanic individuals.

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