Securing America's Future: A Renewed National STEM Workforce Strategy

Executive Summary

The United States is facing a chronic STEM workforce crisis — a result of decades of complacency and insufficient funding — that is set to damage our country's competitiveness and economic prosperity. We face challenges at all levels, as evidenced by:

- a growing STEM teacher shortage that fails to meet the needs of millions of American K-12 students;
- a departure of hundreds of thousands of undergraduate STEM majors from their degrees and STEM career path before graduation; and
- a significant nationwide shortage of advanced degree-holding STEM talent.

We've been here before, and we know the solution: a national strategy, with full support and dedicated funding from the federal government, that will deliver the STEM workforce required for the United States to remain a global leader today and for decades to come.

Achieving this goal requires the following components be included in any national STEM workforce strategy:

1. *Expand an improved NSF Noyce program to at least ten times its current annual budget.*
   This will directly grow the STEM K-12 teaching workforce and enable millions of currently excluded American K-12 students access to high quality STEM classes — the first step in joining the U.S. STEM workforce at all levels, from trade-professionals and technicians to PhD researchers and industry leaders.

2. *Support 200,000 research opportunities annually for undergraduate STEM majors at their home institutions.*
   This will directly increase the retention of hundreds of thousands of talented students in STEM majors over time, and deliver much-needed domestic STEM workers into the U.S. economy.

3. *Provide a fivefold increase to the NSF Graduate Research Fellowship Program.*
   This will directly grow the next generation of high-skilled domestic STEM PhD workers.

4. *Reform the F-1 student visa for graduate students to allow for dual-intent and guarantee a pathway to residency for advanced-degree earners from U.S. universities that secure job offers from U.S. organizations.*
   This will directly restore our country as the premiere destination of global talent through intentional STEM visa and immigration policies that encourage the world's best and brightest to pursue their graduate education in the United States and stay here for a successful career.

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Introduction

The passage of the National Defense Education Act (NDEA) in 1958 created, for that moment, an opportunity for all Americans to access a quality education, leading to a growth and strengthening of the country's high-skilled workforce that was unrivaled by competitor nations. By providing full appropriations for NDEA for more than five years, Congress enabled the United States to lay the foundations of a strong innovation economy, which we continue to benefit from today, more than 60 years later.

Notably, NDEA allowed students across the entire country to have access to quality K-12 STEM teachers. Additionally, it allowed students to pursue careers in STEM — empowered by loans that met the costs of higher education — based on the student's academic performance, not their socioeconomic status.

Just three years after NDEA became law, more than twice as many students attended U.S. colleges and universities in that year than did so immediately prior to its passage. NDEA created a system of higher education financial aid and student loan programs that improved the lives of millions of college students for decades [1]. Ultimately, it created our country's most valuable strategic advantage: a skilled and ambitious workforce that built the world's most innovative and impactful industries here in the United States.

Today, our nation faces similar challenges. Millions of U.S. high school students attend schools where many STEM classes are not regularly offered, and, when they are offered, they are most often taught by teachers with no content-area expertise [2,3]. More than 40% of U.S. high schools, for example, currently do not offer physics to their students [4,5].

These students — most often in rural and low-income counties — struggle to access a clear path into the U.S. STEM workforce. Students who persist despite these odds and demonstrate the talent and will to pursue a career in STEM often still face challenges created by inadequate financial support, be it through loans, scholarships or fellowships.

Lack of preparation and socio-economic pressures deter students that begin STEM and teaching degrees from finishing them, weakening the U.S. workforce at all levels. The pace of innovation has accelerated dramatically since 1958. Industries in emerging technologies that will revolutionize our economy and the world are struggling to find adequate workers in the United States [6], weakening

our position in an increasingly competitive international landscape and putting our national security at risk.

If we want to build a future in which the United States maintains global leadership in science and technology and retains the benefits from an innovation economy, we must develop and financially support a national workforce strategy. This new strategy must empower our younger generations to pursue the skills needed to ensure that tomorrow's key industries — *e.g.*, advanced chip design and manufacturing, quantum computing, artificial intelligence, and those spawned from the next wave of scientific discoveries — are developed here in the United States. Any such strategy requires the following four priorities be included:

Priority 1: Ensure quality K-12 STEM education for every student in the U.S.

Today's Challenge

A strong core education in STEM is essential for workers at all levels, from trade-professionals and technicians to PhD researchers and industry leaders. However, this year, millions of U.S. students are attending a high school where many STEM classes are not offered. And for the students attending the remaining schools that do offer some STEM classes, these classes are most often taught by teachers with no content-area expertise [2,3]. This is a systemic, large-scale issue. For example, in the U.S. South, less than 60% of all schools' physical science teachers have a certification in the subjects they are teaching.

Additionally, more than 70% of U.S. schools report having difficulties in filling positions with qualified candidates [9], and enrollment in teaching programs has declined by almost 30% since 2011 [10]. The current shortage of qualified teachers at all K-12 levels is estimated to be more than 150,000 [11], with shortages of high school physics and chemistry teachers estimated to be approximately 25,000 each [12]. These statistics have direct consequences for millions of American students. For example, more than 1.2 million high school students are attending high schools where physics is never offered [2].

The Solution

To build a U.S. STEM workforce that will remain competitive for decades to come, today's K-12 students need to be taught by quality STEM teachers. Over the last 20 years, the NSF Noyce program has built a network of more than 400 teacher preparation programs that trained thousands

of high-quality K-12 STEM teachers across the United States and advanced evidence-based best practices in the education of teachers. NSF Noyce is well positioned for scaling up to tackle the nation's current teacher crisis.

To address the teacher shortage crisis, the federal government should scale the annual appropriations for the Noyce program to ten times its current funding, while also adjusting the amount of funding provided directly to teacher trainees to sufficiently cover the entire cost of their training program. Doing so will ensure the strengthening of teacher preparation programs across the country, support the training of 10,000 qualified K-12 STEM teachers every year, and increase the recruitment and retention of talented people into the teaching profession. To be clear, the funding needed to expand the Noyce program should be appropriated in addition to – and not in place of – the robust funding necessary for the federal science agencies to support world-class research programs.

Priority 2: Dramatically increase the retention of STEM majors through paid research experiences at their home institutions

Today's Challenge

Of the hundreds of thousands of undergraduate students who start a major in STEM each year, only 52% remain in that career path and successfully graduate with a STEM degree. About half of the students who do not persist in their original major ultimately graduate with a non-STEM major [14]. Inadequate high school preparation, financial strain, and a lack of a sense of belonging are among the top reasons why many of these students do not join their peers in the STEM workforce [15]. To give an idea of the sheer scale of the "leakiness" of our STEM pipeline, in 2021-22, an estimated 400,000 young, talented students started but did not finish a STEM degree [16].

The Solution

Professional opportunities related to STEM careers have the potential to radically improve the retention odds of hundreds of thousands of students that start a STEM major but do not currently finish one. Research experiences for undergraduate students have been shown to increase the retention of students pursuing STEM degrees, especially for students from underrepresented groups in STEM. These experiences have an even larger effect when held at the students' home institution, as many students are place-bound and cannot travel far for long periods of time [17].

NSF's Research Experience for Undergraduates, undergraduate internships, and traineeship programs have a long history of supporting research programs at a large and diverse set of institutions of higher education. The federal government should authorize and fund a program at NSF to support at least 100,000 academic-year-long, paid, part-time research positions each year available to undergraduate STEM majors at their home institutions. Such a program would likely cost between $6,000-$10,000 per semester per student, depending on location, and should be funded in addition to robust and sustained funding to the science agencies. Scaling the program to ensure that all enrolled first-year undergraduate STEM students have an opportunity to participate in research at some point during their student-careers would require $1.2B-$2B in annual support for approximately 200,000 positions – generating a substantial annual increase in the US STEM workforce.

Priority 3: Support the growth of the next generation of advanced-degree STEM workers through an expanded NSF GRFP

Today's Challenge

The demand for STEM workers continues to be at an all-time high. The unemployment rate for the STEM occupation class in the U.S. is the lowest of any sector, sitting below 2% in 2021 for STEM workers with a bachelor's degree or higher [18]. Groups across academia, industry, and government have raised the alarm in recent years about a shortage of STEM workers. The lack of domestic advanced-degree holders who support the accelerated pace of innovation and increased international competition is of particular concern.

STEM occupations differ from non-STEM occupations by the unique skills required of their workforce. Only 36% of workers in non-STEM occupations have at least a bachelor's degree, compared to more than 77% of workers in STEM occupations. Approximately one third of STEM workers hold an advanced degree [18].

Between 2017 and 2020, the number of STEM PhD graduates in the United States increased by less than 3%. Meanwhile, in China it increased by 16%, making China the largest producer of STEM PhD holders in 2020 [19]. China has been the largest producer of PhD holders in natural science and engineering fields since 2007 [19].

The U.S. federal government plays a critical role in the creation of the U.S. STEM advanced degree holders [19]. Federal funding of research at higher education institutions is essential in supporting the training of future STEM advanced degree holders. The majority of doctoral trainees across science and engineering in 2021 were supported by the federal government via research assistantships or by fellowships [20]. Unfortunately, the federal government's funding of the federal science agencies has decreased in recent years when accounting for inflation [21].

The Solution

NSF supports doctoral trainees across all scientific and engineering disciplines. Currently, NSF supports almost one-quarter of all the federally supported doctoral trainees in the United States [20]. With demand for domestic advanced degree workers continuing to grow, the U.S. government should increase NSF's Graduate Research Fellowship Program (GRFP) program fivefold while continuing to provide the federal science agencies the robust funding necessary to maintain a world-leading research enterprise.

This investment would, over a period of a few years, increase the number of domestic STEM PhD holders by approximately 8,000, an increase of more than 30% compared to domestic STEM doctorate recipients in 2021 [19]. If the new program is focused on specific emerging STEM disciplines in high demand, the proportionate impact could be much higher.

Scaling up NSF's GRFP to support a growing number of talented domestic PhD workers should be done in close coordination with the federal science agencies, the R&D higher education community, and U.S. industry groups. Awarding fellowships in emerging areas will allow the federal government to more dynamically react to the needs of the innovation economy, and to further enhance U.S. competitiveness.

Priority 4: Reform the F-1 visa for graduate students to attract and retain the best and brightest students

Today's Challenge

For the last several decades, the United States has been the premier destination for talented international students and scholars. The benefit international students and researchers provide to the United States is clear and measurable. As documented in a recent survey of APS members, international students bring fresh perspectives, diverse experiences, expertise, new ideas, and

creativity to our universities, laboratories, and companies [22]. As of 2022, one-quarter of the billion-dollar startup companies in the U.S. have a founder who first came to America as an international student [23]. As a result, they have promoted job growth [24], generated higher average salaries for US workers [25], and become an indispensable part of US high-tech competitiveness[26].

However, outdated federal policies are limiting the opportunities for talented foreign-born students to come to the United States to pursue their studies. The policies also actively push away foreign-born scientists that graduate from U.S. universities instead of encouraging them to stay and pursue their careers in the United States.

For example, a recent APS survey uncovered that foreign-born scientists with a U.S. Ph.D. that received their degree in 2018 are 50% more likely to be considering pursuing their career in a country other than the United States when compared to those that received their degree prior to 2018. When asked about the main factors when considering pursuing a career in a country other than in the United States, the number one identified factor was having a clear pathway to permanent residency or citizenship [27].

The Solution

Competition for top international students is growing, and to encourage the best and brightest students to come and remain in the United States and contribute their skills to our scientific enterprise the federal government should:

- **Authorize declaration of dual intent:** International students pursuing advanced STEM degrees in the U.S. could legally declare their plan to stay and pursue careers here post-graduation.
- **Exempt from green card caps:** International students, along with their spouses and children, would be exempt from green card caps when they earn an advanced STEM degree from an accredited U.S. institution and receive an offer of employment from a U.S. company.
- **Standardize the vetting process:** International students already in the U.S. on a student visa for an undergraduate program would undergo the same strengthened vetting at USCIS that the State Department currently performs for prospective advanced STEM degree students applying for a student visa from outside of the U.S.

About APS

The American Physical Society is a nonprofit membership organization working to advance and diffuse the knowledge of physics through its outstanding research journals, scientific meetings, and education, outreach, advocacy, and international activities. APS represents more than 50,000 members, including physicists in academia, national laboratories, and industry in the United States and throughout the world.

References:

1. IDA, Science and Technology Institute, *The National Defense Education Act of 1958: Selected Outcomes*, 2006
2. American Institute of Physics, *High School Physics Overview*, 2021
3. NSF Science and Engineering Indicators, Elementary and Secondary STEM Education, 2021
4. Ed Weekly, *2 in 5 High Schools Don't Offer Physics, Analysis Finds*, 2016
5. American Physical Society, *Recruiting Teachers in High-Needs STEM Fields*, 2017
6. Semiconductor Industry Association, *Chipping Away: Assessing and Addressing the Labor Market Gap Facing the U.S. Semiconductor Industry*, 2023
7. American Institute of Physics, *High School Physics Overview*, 2021
8. NSF Science and Engineering Indicators, Elementary and Secondary STEM Education, 2021
9. IES, NCSES, *School Pulse Panel: Surveying high-priority, education-related topics*, 2024
10. American Association of Colleges for Teacher Education,*Teacher Preparation Programs Trends 2010-11 to 2020-21*, *2022*
11. Economic Policy Institute, *The teacher shortage is real, large and growing, and worse than we thought*, 2019
12. Toni Feder, *The US is in dire need of STEM teachers*, Physics Today 2022
13. Beyond100k, Advancing Teacher Workforce Data: A Call for Innovative Solutions, 2024
14. U.S Department of Education, STEM Attrition: College Students' Paths Into and Out of STEM Fields, 2013

15. AIP, The time is now, 2020

16. IES, NCES, Fast Facts Science, Technology, Engineering, and Mathematics (STEM) education, by gender, 2023

17. National Academies of Sciences, Engineering and Medicine, Undergraduate Research Experiences for STEM Students, 2017

18. NSF NCSES, The STEM Labor Force: Scientists, Engineers, and Skilled Technical Workers, 2024

19. NSF NCSES, The State of U.S. Science and Engineering, 2024

20. NSF NCES, Survey of Graduate Students and Postdoctorates in Science and Engineering (GSS) 2021

21. AIP, Federal Science Budget Tracker, 2024 ; Inflation multipliers from the Bureau of Labor Statistics, 2024

22. American Physical Society, impact of US ResearchSecurity Policies US Security and the Benefits of Open Science and International Collaborations, 2021

23. National Foundation for American Policy, IMMIGRANT ENTREPRENEURS AND U.S. BILLION - DOLLAR COMPANIES , 2023

24. Partnership for a New American Economy, The H1-B Employment Effect, 2015.

25. American Immigration Council, The H1-B Visa Program: A Primer on the Program and its Impacts on Jobs, Wages, and the Economy, 2019.

26. National Immigration Forum, High Tech: Immigrants are Indispensable to U.S. Workforce, 2019

27. American Physical Society, Survey of APS members, 2023, available upon request.