FEDERAL STRATEGIC PLAN FOR ADVANCING STEM EDUCATION AND CULTIVATING STEM TALENT

A Report by the

COMMITTEE ON SCIENCE, TECHNOLOGY, ENGINEERING, and MATHEMATICS (STEM)

of the

NATIONAL SCIENCE & TECHNOLOGY COUNCIL

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Abbreviations and Acronyms[1]

AI	Artificial Intelligence
CoSTEM	Committee on STEM
CHIPS	Creating Helpful Incentives to Produce Semiconductors (CHIPS) and Science Act of 2022
COMPETES	America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science (COMPETES) Reauthorization Act of 2010
EDA	DOC Economic Development Administration
ERIs	Emerging Research Institutions
EPSCoR	Established Program to Stimulate Competitive Research
FDA	HHS Food and Drug Administration
HBCUs	Historically Black Colleges and Universities
HSIs	Hispanic-Serving Institutions
IP	Intellectual Property
IWG	Interagency Working Group
MSIs	Minority-Serving Institutions
NAEP	National Assessment of Educational Progress
NIH	HHS National Institutes of Health
NIST	DOC National Institute of Standards andTechnology
NOAA	DOC National Oceanic and Atmospheric Administration
NSTC	National Science and TechnologyCouncil
R&D	Research and Development
STEM	Science, Technology, Engineering, and Mathematics
TCUs	Tribal Colleges and Universities
USGS	DOI United States Geological Survey
USPTO	DOC United States Patent and Trademark Office

[1] See the list of CoSTEM agencies (p. iii) for the acronyms of federal agency names.

Executive Summary

Fostering the capabilities of learners, workers, educators, researchers, mentors, innovators, and community members—or STEM talent—across the country is critical both to enable all individuals to achieve their own aspirations in STEM fields and careers and to ready the nation to pursue new opportunities. Individuals, families, communities, educational and academic institutions, industry, nonprofit and philanthropic organizations, and government must all work together to advance STEM education and to engage and expand the nation's STEM talent.

The National Science and Technology Council (NSTC) Committee on STEM (CoSTEM), and its constituent federal research and science agencies, play a key role in coordinating, developing, and guiding federal STEM education and talent development. This document presents a plan for how the federal STEM community can advance STEM education and grow and develop STEM talent throughout the nation.

The plan's three cross-cutting principles serve as a framework for the national STEM community to contribute to this strategy's success. The principles recognize that:

- **Access and opportunity** for all can only be achieved if the country acknowledges and takes action in ways that are consistent with the values of serving each and every individual, from every community, all across the nation.
- The federal government alone cannot produce the STEM talent needed for the entire country. Multi-agency and multi-sector **partnerships and ecosystem development**, including with international counterparts, are necessary to achieve a vision for STEM in America.
- Collaboration, coordination, and advancement of federal efforts require **transparency and accountability**. Being transparent about federal actions and progress, promoting accountability within the federal government, and sharing knowledge and resources enable the nation to achieve more collectively.

In tandem with these principles, this plan pursues progress on five interdependent pillars to advance STEM education and cultivate STEM talent across the nation:

- **STEM Engagement:** Addresses the need to engage learners of all ages, their families and communities, and the entire STEM ecosystem. Objectives aim to foster youth, community, and public engagement that support inspiration and belonging, connect research and practice, and build STEM skills and STEM literacy for lifelong learning.
- **STEM Teaching and Learning:** Addresses the need to end disparities in educational outcomes by effectively preparing learners of all ages and developing a STEM teacher workforce at all educational levels. Objectives aim to improve the opportunities and outcomes for learners and educators in and across all STEM disciplines.
- **STEM Workforce:** Addresses the need to build an agile federal and national workforce with the STEM skills and expertise to meet critical and emerging scientific and technological needs facing the nation, which includes tackling global challenges with consideration of international talent needs. Objectives aim to support the training and recruitment of the nation's federal and national STEM workforce while cultivating global talent mobility and opportunity.
- **STEM Research and Innovation Capacity:** Addresses the need to advance research related to teaching and learning in STEM fields and expand research and innovation capacity to individuals, communities, and institutions. Objectives aim to drive cutting-edge STEM education research

and innovation, build and advance STEM research capacity, and cultivate innovation and entrepreneurial talent development.

- **STEM Environments:** Addresses the need to remove barriers that prevent STEM learners, researchers, and workers from remaining in STEM fields and careers. Objectives aim to remove barriers to participation and retention by supporting research career trajectories in STEM learning environments, enhancing career flexibilities in STEM working environments, and promoting safe STEM research environments.

By organizing federal efforts around five major interdependent pillars and three cross-cutting principles, this strategic plan provides a framework for cultivating the full continuum of STEM education and talent development as a national priority. Innovative and inclusive agency programs and policies, multi-agency initiatives, and new partnerships will be required to make meaningful progress toward this plan's objectives. This five-year strategic plan on STEM guides how the government, in coordination with multi-sector partners throughout the STEM ecosystem, aim to prepare the nation to be inspired, to teach and to learn, to be trained and recruited, to discover and innovate, and to remove barriers to retention within and across STEM learning, working, and research settings.

Introduction

Today, the possibilities across STEM are endless. The United States is the global leader in basic research, with increases in funding from business and the federal government over the past decade.[2] Advances in fields like artificial intelligence (AI) and biotechnology are creating more opportunities for discovery and innovation. The number of workers in STEM occupations is on the rise and is expected to continue to increase in the years to come.[3] Leveraging all of this growth is key to ensuring the prosperity, security, and health of the nation. To reach the nation's greatest potential, the United States must draw on its richest resource—its people.

Fostering the capabilities of learners, workers, educators, researchers, mentors, innovators, and community members—or STEM talent—across the country is critical both to ready the nation to pursue new opportunities and to enable all individuals to achieve their own aspirations in STEM fields and careers. Government, educational and academic institutions, industry, nonprofit and philanthropic organizations, individuals, families, and communities must all work together to advance STEM education and cultivate the nation's STEM talent.

A Vision for STEM in America

The United States will inspire, educate, train, and innovate in STEM fields and STEM careers, so that through unparalleled access and opportunity, the nation can leverage the full potential of its STEM talent and ensure the country's national security, economic prosperity, and global competitiveness.

The national STEM ecosystem[4] works best when everyone is able to participate in it and benefit from it. Tackling the great challenges of our time—from combating the climate crisis, to realizing the benefits of AI while managing its risks, to improving health outcomes for all—requires the contributions of people of all backgrounds. However, barriers continue to stand in the way of equitable access to STEM opportunities and participation.[5]

Nurturing STEM abilities in all individuals, regardless of their career paths, is essential. STEM skills and STEM literacy are increasingly vital to everyday life, as they support informed personal and community decision making on matters ranging from health and finances to privacy and environmental stewardship. Ending disparities in educational outcomes, by striving for all students to meet or exceed

[2] U.S. National Science Foundation. 2024. National Science Board. Talent is the Treasure. https://www.nsf.gov/nsb/publications/2024/2024_policy_brief.pdf

[3] U.S. National Science Foundation. 2024. National Science Board. The STEM Labor Force: Scientists, Engineers, and Technical Workers. Science and Engineering Indicators 2024. NSB-2024-5. https://ncses.nsf.gov/pubs/nsb20245/

[4] STEM ecosystem: a local, regional, or statewide network, consortium, or multi-sector partnership, which may be led or co-led by a nonprofit organizational entity, that is operating with the goal of supporting participation in STEM study, activities, and career pathways. Derived from CoSTEM's definition of STEM education ecosystems: STEM education ecosystems consist of multi-sector partners united by a collective vision of supporting participation in STEM through the creation of accessible, inclusive STEM learning opportunities spanning all education stages and career pathways. A STEM education ecosystem continuously evaluates its activities and adapts as needed, plans for the long-term, and communicates its work to build broad support and advance best practices. https://www.congress.gov/117/plaws/publ167/PLAW-117publ167.pdf.

[5] https://www.whitehouse.gov/ostp/news-updates/2022/12/12/equity-and-excellence-a-vision-to-transform-and-enhance-the-u-s-stemm-ecosystem/

grade level achievement outcomes, will facilitate tapping into and preparing talent from all across the nation. Ensuring the science and technologies of the future aim to benefit all of society in ways that are safe, secure, ethical, and responsible will further attract talent. Leveraging our country's greatest asset—its people, STEM talent—is key to creating more effective solutions for a sustainable future.

Broader participation in STEM fosters closer alignment between societal needs and research, enhances public understanding and trust in science, facilitates uptake of research results throughout society, and supports evidence-based policymaking. As participation in STEM expands, so does the opportunity to leverage STEM to improve lives. A country with a STEM-engaged public and a strong STEM workforce—inclusive of people from all education levels, such as skilled technical workers—can produce groundbreaking ideas, drive cutting-edge research, and bridge the gap between theoretical advancements and real-world practical solutions so that all people can benefit from research and development (R&D) investments.

Agencies across the federal government are united in their commitment to developing STEM talent so that all individuals and communities can grow, aspire, and thrive, allowing the United States to reach its full potential. With this commitment comes action to address persistent inequities in access to learning and research opportunities as well as to the benefits derived from innovations and advanced technologies.

This document establishes a federal plan for how the federal government, in coordination with multisector partners throughout the STEM ecosystem, aims to prepare the nation's talent to be inspired and connected (STEM engagement); to learn and teach (STEM teaching and learning); to be trained and recruited (STEM workforce); to discover and innovate (STEM research and innovation capacity); and to thrive in learning, working, and research settings (STEM environments) across the country.

Developing a New Federal Strategic Plan

Congressional Priorities Guiding a New Plan

This federal five-year strategic plan reflects several Congressional mandates, including the America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science (COMPETES) Reauthorization Act of 2010;[6] the American Innovation and Competitiveness Act of 2017;[7] the Supporting Veterans in STEM Careers Act of 2020;[8] and the Creating Helpful Incentives to Produce Semiconductors (CHIPS) and Science Act of 2022.[9]

The America COMPETES Reauthorization Act of 2010 originally charged OSTP with establishing a committee under the NSTC to coordinate federal programs and activities in support of STEM education. In 2011, OSTP established the Committee on STEM Education to fulfill this requirement. This plan fulfills CoSTEM's requirement to issue a five-year strategic plan once every five years. This plan advances the work beyond the two previous strategic plans, the *Federal STEM Education 5-Year Strategic Plan*[10] and *Charting a Course for Success: America's Strategy for STEM Education*.[11]

More recently, the CHIPS and Science Act of 2022 called on CoSTEM and/or federal agencies to address STEM issues historically considered outside of CoSTEM's original tasking, such as reducing the prevalence of sex-based harassment and sexual harassment in research environments, improving agency policies for STEM researchers who have caregiving responsibilities, and enhancing the research capacity of minority-serving institutions (MSIs)[12] and/or emerging research institutions (ERIs).[13] In 2023, the Committee on STEM Education was renamed the Committee on STEM, and this plan aims to support these newer legislated priorities to further develop STEM talent.

Voices from Across America Informing a New Plan

Given that this strategic plan will serve the American people, it is essential that they see themselves reflected in it. Enabling early and consistent public participation and community engagement in government[14] is important. For this reason, the development of this strategic plan included an unprecedented amount of Tribal and public engagement. It started with the American Innovation and Competitiveness Act of 2017 and the establishment of the STEM Education Advisory Panel,[15] who

[6] https://www.congress.gov/111/plaws/publ358/PLAW-111publ358.pdf
[7] https://www.congress.gov/114/statute/STATUTE-130/STATUTE-130-Pg2969.pdf
[8] https://www.congress.gov/116/plaws/publ115/PLAW-116publ115.pdf
[9] https://www.congress.gov/117/plaws/publ167/PLAW-117publ167.pdf
[10] https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/stem_stratplan_2013.pdf
[11] https://trumpwhitehouse.archives.gov/wp-content/uploads/2018/12/STEM-Education-Strategic-Plan-2018.pdf
[12] Minority-serving Institutions: Institutions of higher education that serve minority students, which are either statutorily defined based on their historical designation, such as Historically Black Colleges and Universities (HBCUs) and Tribal Colleges and Universities/Tribally Controlled Colleges and Universities (TCUs/TCCUs), or designated based on enrollment of minority students, which includes Hispanic-Serving Institutions (HSIs), Asian American and Native American Pacific Islander Serving Institutions (AANAPISIs), Alaska Native and Native Hawaiian Serving Institutions (ANNHs), Native American Serving Non-Tribal Institutions (NASNTIs), and Predominantly Black Institutions (PBIs). https://crsreports.congress.gov/product/pdf/R/R43237
[13] Emerging Research Institution (ERI): Institutions of higher education with an established undergraduate or graduate program that has less than $50,000,000 in federal research expenditures. https://www.congress.gov/117/plaws/publ167/PLAW-117publ167.pdf
[14] https://www.whitehouse.gov/wp-content/uploads/2023/07/Broadening-Public-Participation-and-Community-Engagement-in-the-Regulatory-Process.pdf
[15] https://www.nsf.gov/news/news_summ.jsp?cntn_id=295999

advised and assessed CoSTEM efforts to carry out the previous strategic plans and guided discussions in 2021 and 2022 around the development of the new strategic plan.

Additional public engagement activities occurred in 2023 with a series of listening sessions,[16] meetings, and roundtable discussions. Listening sessions were attended by nonprofit STEM organizations, philanthropic organizations, university professors and administrators, students, teachers, parents, labor unions, Tribal community members, and other interested individuals. Meetings were also offered which allowed organizations and individuals more time to communicate the challenges they face and share how the federal government is uniquely positioned to address their concerns. Over 20 meetings were held, with attendees from universities, nonprofit groups, and state governments. CoSTEM also co-hosted with federal agencies over 10 roundtable discussions with subject matter experts from outside the federal government invited to present and discuss specific topics such as disability and accessibility in the STEM workforce, the emerging role of AI in STEM education, emerging issues in entrepreneurial and intellectual property (IP)[17] education, and more. The roundtable discussions centered around perspectives, challenges, needs, and proven solutions in various sectors of the broader STEM ecosystem. Most importantly, the panelists discussed how the federal government and this strategic plan could potentially meet those challenges and implement lasting and impactful solutions. Over 1,300 individuals were involved in CoSTEM's engagement activities to inform the development of this strategic plan.

By incorporating essential voices from across the STEM ecosystem, this strategic plan aims to be inclusive and representative of the STEM challenges and opportunities faced across the nation. Engaging with the public has illuminated the opportunities the federal government has to strengthen STEM engagement, education, workforce, research, and innovation for all.

Executive Priorities Uplifting a New Plan

This federal strategic plan leverages priorities of the Biden-Harris Administration that promote the advancement of and equitable access to education and workforce opportunities for all across the nation, such as:

- Efforts strengthening the teaching profession[18]
- Pledging to support education and job training programs that can provide people across the country with the skills to safely interact with emergent technologies like AI and access the opportunities that AI creates.[19]
- Releasing a comprehensive approach aimed at addressing both immediate and long-term cyber workforce needs and focusing on empowering and educating individuals across the nation to pursue career paths in cyber-related professions or technologies.[20]

[16] https://www.whitehouse.gov/ostp/news-updates/2023/03/31/readout-from-ostps-public-listening-sessions-in-support-of-the-next-federal-stem-strategic-plan/

[17] Intellectual Property: IP refers to creations of the mind, such as inventions; literary and artistic works; designs; and symbols, names and images used in commerce. IP is protected by law, for example, patents, copyright and trademarks, which enable people to earn recognition or financial benefit from what they invent or create. https://www.wipo.int/about-ip/en/

[18] https://www.whitehouse.gov/briefing-room/statements-releases/2024/05/02/fact-sheet-biden-%e2%81%a0harris-administration-announces-new-actions-to-support-and-strengthen-the-teaching-profession/

[19] https://www.whitehouse.gov/briefing-room/presidential-actions/2023/10/30/executive-order-on-the-safe-secure-and-trustworthy-development-and-use-of-artificial-intelligence/

[20] https://www.whitehouse.gov/wp-content/uploads/2023/07/NCWES-2023.07.31.pdf

- Issuing executive orders directing federal agencies to create and implement: equity action plans that expand investments in, and support for, underserved communities[21] across numerous areas including in pre-K through postsecondary education; plans for advancing equality for lesbian, gay, bisexual, transgender, queer, and intersex (LGBTQI+) individuals, and advancing gender equity; and strategies for tackling the climate crisis.[22]
- Strengthening accessibility of facilities, information and communication technology, programs, and services by issuing an executive order,[23] an Office of Management and Budget memo,[24] and Department of Justice regulations on web and mobile accessibility.[25]
- Providing historic levels of support for historically Black colleges and universities (HBCUs) via the American Rescue Plan, grant funding, debt relief, and by re-establishing the White House Initiative on Advancing Educational Equity, Excellence, and Economic Opportunity through HBCUs.[26]
- Re-establishing the White House Initiative on Asian Americans, Native Hawaiians, and Pacific Islanders, with a charge to end disparities in educational outcomes for youth and students in these communities and address barriers to learning.[27]
- Establishing the White House Initiatives on Advancing Educational Equity, Excellence, and Economic Opportunity for Hispanics,[28] for Black Americans,[29] and for Native Americans,[30] including efforts to strengthen Tribal colleges and universities (TCUs).

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[21] Underserved Communities: The term refers to populations sharing a particular characteristic, as well as geographic communities, who have been systematically denied a full opportunity to participate in aspects of economic, social, and civic life. In the context of the federal workforce, this term includes individuals who belong to communities of color, such as Black and African American, Hispanic and Latino, Native American, Alaska Native and Indigenous, Asian American, Native Hawaiian and Pacific Islander, Middle Eastern, and North African persons. It also includes individuals who belong to communities that face discrimination based on sex, sexual orientation, and gender identity (including lesbian, gay, bisexual, transgender, queer, gender non-conforming, and non-binary (LGBTQ+) persons); persons who face discrimination based on pregnancy or pregnancy-related conditions; parents; and caregivers. It also includes individuals who belong to communities that face discrimination based on their religion or disability; first-generation professionals or first-generation college students; individuals with limited English proficiency; immigrants; individuals who belong to communities that may face employment barriers based on older age or former incarceration; persons who live in rural areas; veterans and military spouses; and persons otherwise adversely affected by persistent poverty, discrimination, or inequality. Individuals may belong to more than one underserved community and face intersecting barriers. https://www.whitehouse.gov/briefing-room/presidential-actions/2021/06/25/executive-order-on-diversity-equity-inclusion-and-accessibility-in-the-federal-workforce/

[22] https://www.whitehouse.gov/equity/; https://www.whitehouse.gov/briefing-room/presidential-actions/2021/06/25/executive-order-on-diversity-equity-inclusion-and-accessibility-in-the-federal-workforce/

[23] https://www.whitehouse.gov/briefing-room/presidential-actions/2021/06/25/executive-order-on-diversity-equity-inclusion-and-accessibility-in-the-federal-workforce/

[24] https://www.whitehouse.gov/omb/management/ofcio/m-24-08-strengthening-digital-accessibility-and-the-management-of-section-508-of-the-rehabilitation-act/

[25] https://www.ada.gov/assets/pdfs/web-accessibility-NPRM.pdf

[26] https://www.whitehouse.gov/briefing-room/statements-releases/2021/12/17/fact-sheet-the-biden-%E2%81%A0harris-administrations-historic-investments-and-support-for-historically-black-colleges-and-universities/

[27] https://www.whitehouse.gov/briefing-room/presidential-actions/2021/05/28/executive-order-on-advancing-equity-justice-and-opportunity-for-asian-americans-native-hawaiians-and-pacific-islanders/

[28] https://www.whitehouse.gov/briefing-room/presidential-actions/2021/09/13/executive-order-on-white-house-initiative-on-advancing-educational-equity-excellence-and-economic-opportunity-for-hispanics/

[29] https://www.whitehouse.gov/briefing-room/presidential-actions/2021/10/19/executive-order-on-white-house-initiative-on-advancing-educational-equity-excellence-and-economic-opportunity-for-black-americans

[30] https://www.whitehouse.gov/briefing-room/presidential-actions/2021/10/11/executive-order-on-the-white-house-initiative-on-advancing-educational-equity-excellence-and-economic-opportunity-for-native-americans-and-strengthening-tribal-colleges-and-universities/

- Establishing the White House Initiative on Advancing Educational Equity, Excellence, and Economic Opportunity Through Hispanic-serving institutions (HSIs), with the goal of strengthening the capacity of HSIs to provide a high-quality education to their students and increasing opportunities for these institutions to participate in federal programs.[31]
- Launching the American Climate Corps to support skills-based training and career development in the growing STEM fields of clean energy, conservation, and climate resilience.[32]
- Establishing new Workforce Hubs to stimulate workforce development in semiconductor manufacturing and other areas,[33] investing in STEM workforce development at community colleges via programs like the Department of Labor's Strengthening Community Colleges Training Grants[34] and the Department of Commerce's Tech Hubs,[35] and establishing Regional Innovation Engines to grow the workforce in fields like clean energy and climate-resilient agriculture.[36]
- Strengthening the nation's commitment to welcoming and retaining global talent that has long provided America with a global competitive advantage.[37]
- Creating a coordinated national approach to international education, including study in the United States by international students, researchers, and scholars; study abroad for Americans; international research collaboration; and the internationalization of U.S. campuses and classrooms.[38]
- Convening government and academic leaders to share strategies for preventing and reducing harassment, including in isolated scientific research environments.[39]

These actions reflect the Biden-Harris Administration's multifaceted commitment to advancing education and cultivating the nation's talent.

[31] https://www.whitehouse.gov/briefing-room/presidential-actions/2024/07/17/executive-order-on-white-house-initiative-on-advancing-educational-equity-excellence-and-economic-opportunity-through-hispanic-serving-institutions/

[32] https://www.whitehouse.gov/briefing-room/statements-releases/2023/09/20/fact-sheet-biden-harris-administration-launches-american-climate-corps-to-train-young-people-in-clean-energy-conservation-and-climate-resilience-skills-create-good-paying-jobs-and-tackle-the-clima/

[33] https://www.whitehouse.gov/briefing-room/statements-releases/2024/04/25/fact-sheet-president-biden-announces-new-workforce-hubs-to-train-and-connect-american-workers-to-good-jobs-created-by-the-presidents-investing-in-america-agenda

[34] https://www.dol.gov/agencies/eta/skills-training-grants/scc

[35] https://www.whitehouse.gov/briefing-room/statements-releases/2024/02/06/readout-of-white-house-convening-with-community-college-presidents-and-provosts/

[36] https://www.whitehouse.gov/briefing-room/statements-releases/2024/01/29/fact-sheet-biden-harris-administration-announces-innovation-engines-awards-catalyzing-more-than-530-million-to-boost-economic-growth-and-innovation-in-communities-across-america/

[37] https://www.whitehouse.gov/briefing-room/statements-releases/2022/01/21/fact-sheet-biden-harris-administration-actions-to-attract-stem-talent-and-strengthen-our-economy-and-competitiveness/

[38] https://educationusa.state.gov/sites/default/files/intl_ed_joint_statement.pdf

[39] https://www.whitehouse.gov/ostp/news-updates/2022/11/18/readout-of-the-national-science-and-technology-council-roundtable-on-preventing-harassment-in-isolated-scientific-research-environments/

A Federal Strategy for the Next Five Years

To strengthen and advance the nation's ability to harness the power of science, technology, and innovation, and to increase public literacy in STEM topics, CoSTEM has developed this new federal five-year strategic plan for advancing STEM education and cultivating STEM talent.

Underpinning this plan are **three cross-cutting principles** essential for advancing STEM education and cultivating STEM talent:

- **Access and opportunity** for all can only be achieved if the country acknowledges and takes action in ways that are consistent with the values of serving each and every individual, from every community, all across the nation.[40]
- The federal government alone cannot produce the STEM talent needed for the entire country. Multi-agency and multi-sector **partnerships**[41] **and ecosystem development**, including international counterparts, are necessary for achieving the national vision.
- Collaboration, coordination, and advancing federal efforts require **transparency and accountability**. Being transparent about federal actions and progress, promoting accountability within the federal government, and sharing the knowledge and the resources the government develops along the way helps the nation benefit and achieve more collectively than individually.

In tandem with these principles, this plan pursues progress on **five interdependent pillars** necessary to advance STEM education and cultivate STEM talent across the nation:

- STEM **Engagement**: Foster youth, community, and public engagement that supports inspiration and belonging, connects research and practice, and builds STEM literacy and lifelong learning.
- STEM **Teaching and Learning**: Improve the opportunities and outcomes for learners and educators in and across all STEM disciplines.
- STEM **Workforce**: Support the training and recruitment of the nation's federal and national STEM workforce while cultivating global talent mobility and opportunity.
- STEM **Research and Innovation Capacity**: Drive cutting-edge STEM education research and innovation, build and advance STEM research capacity, and cultivate innovation and entrepreneurial talent development.
- STEM **Environments**: Remove barriers to participation and retention in STEM learning, working, and research environments.

[40] https://www.whitehouse.gov/briefing-room/presidential-actions/2021/06/25/executive-order-on-diversity-equity-inclusion-and-accessibility-in-the-federal-workforce/

[41] Multi-Sector Partnerships: Collaboration among partners with different roles in the STEM ecosystem (e.g., pre-K–12 schools, educational institutions, museums, libraries, etc.), including stakeholder groups from government, civil society, and the private sector, to jointly achieve a policy outcome.

Figure 1: The five major pillars of the strategic plan are connected by the foundational principles of access and opportunity, partnerships and ecosystem development, and transparency and accountability.

As reflected in the five pillars, this plan recognizes that STEM talent development includes programming for learners of all ages—including pre-K to postsecondary school students and workers at all career stages—in both formal and informal STEM learning environments. As such, several communities (including pre-K–12 teachers, community college students, and early career researchers) are referenced in the plan more than once.

This plan reflects a re-envisioned scope of CoSTEM that aims to ensure that federal STEM programming and activities work for and serve everyone across the nation. Each pillar that follows includes three objectives. Each objective, in turn, includes: a national aspiration for the objective; a description of the challenges and opportunities for reaching the objective; a description of how the federal government might aim to address the objective; approaches CoSTEM and/or agencies could use to achieve the objective; and possible metrics or measures that CoSTEM and/or agencies could use to assess progress on the objective over the next five years.

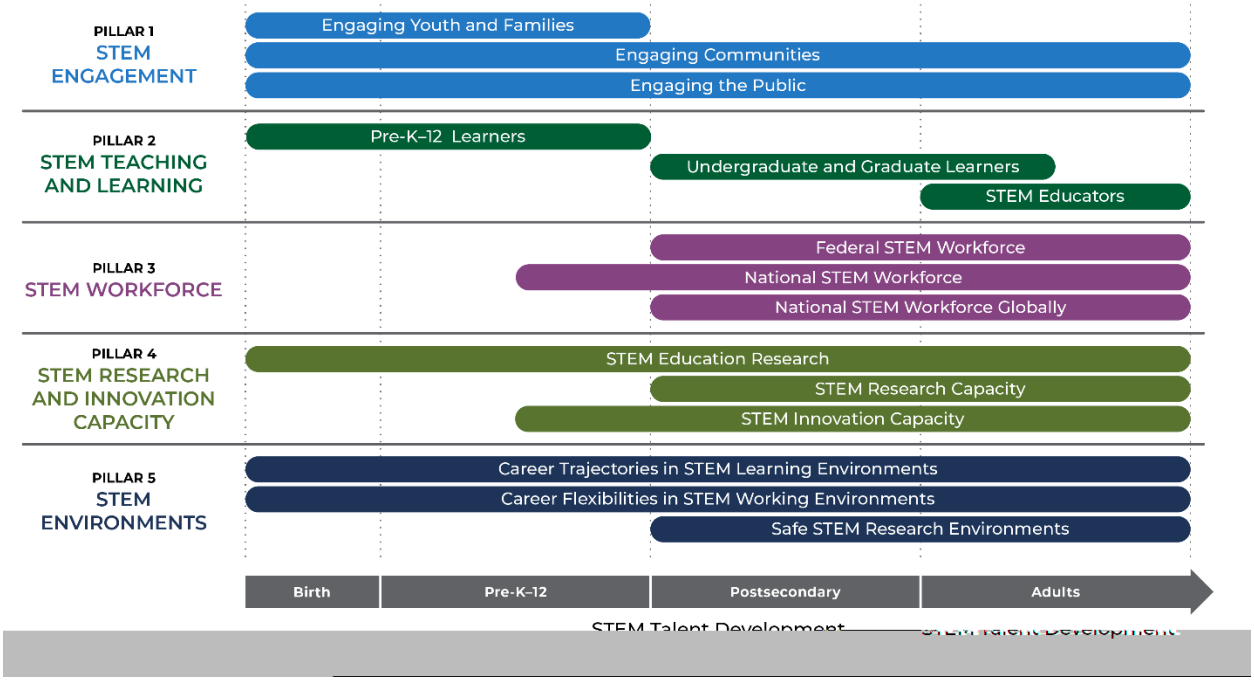

Figure 2: Each pillar of the strategic plan advances three objectives that address challenges and opportunities across the continuum of STEM Talent Development, from birth, K–12 education, postsecondary education, through adulthood.

Beyond guiding and coordinating the efforts of federal departments and agencies, this plan calls on all sectors of the STEM education, workforce, and research ecosystems to create bold visions; unify strategies; develop action plans; establish evidence-based policies; and direct effective, equitable programs for STEM. This plan aims to function as a nationwide blueprint for all sectors to work together to guide a nation full of talent toward STEM fields and STEM careers.

Principles Necessary for Carrying Out National Imperative

The plan's three cross-cutting principles provide overarching guidance for federal agencies in prioritizing their investments to spur interagency coordination and collaboration activities and can serve as a framework for the national STEM community to contribute to this strategy's success.

Principle: Access and Opportunity

Achieving the objectives outlined in this plan will require the STEM community—including federal agencies, educational institutions, and other partners—to make significant gains in providing equitable access to high quality STEM experiences for everyone, especially those historically underrepresented and underserved in STEM fields and careers. The benefits of a STEM-engaged society cannot be fully realized until disparities in educational achievement standards are eliminated, and all members of society have access to STEM opportunities.

The competitiveness of the nation depends on inspiring, educating, and retaining STEM learners and workers from all across the nation. Unequal distribution of and access to resources across the country, historical and ongoing discrimination, and implicit biases mean that high-quality STEM opportunities are not currently available to all Americans.[42] These barriers can be based on differences in geography, socioeconomic status, race, ethnicity, and gender/gender identity. Though the STEM workforce[43] is gradually becoming more diverse, multiple groups remain underrepresented relative to their share of the national adult population.[44] These groups also face pay disparities in STEM jobs, a problem compounded by patterns of underrepresentation across postsecondary STEM education and degree attainment. The COVID-19 pandemic exacerbated these inequities, contributing to unemployment and underemployment among many STEM workers and shining light on barriers faced by underrepresented groups and underserved communities across STEM career pathways.[45, 46]

In accordance with civil rights laws (Title VI of the Civil Rights Act of 1964, Title IX of the Education Amendments of 1972, Section 504 of the Rehabilitation Act of 1973, and the Age Discrimination Act of 1975), recipients of federal funding are obligated to remove barriers to participation.[47] Additionally, the importance of digital accessibility in ensuring equity in pre-K–12 and higher education has been underscored by issuance of regulations outlining web and mobile accessibility obligations under Title II of the Americans with Disabilities Act. These regulations ensure that educational opportunities,

[42] https://www.whitehouse.gov/ostp/news-updates/2022/12/12/equity-and-excellence-a-vision-to-transform-and-enhance-the-u-s-stemm-ecosystem

[43] STEM Workforce: This subset of the U.S. workforce is comprised of workers in science and engineering (S&E) and S&E-related occupations. The Skilled Technical Workforce is a sub-set of the STEM Workforce, and is comprised of occupations that use significant levels of S&E expertise and technical knowledge but do not necessarily require a bachelor's degree for entry. https://www.nsf.gov/statistics/stw/skilled-technical-workforce.cfm#define-stw-a-working-definition

[44] Per the 2023 National Center for Science and Engineering Statistics (NCSES) Diversity and STEM: Women, Minorities, and Persons with Disabilities report, the STEM workforce in the United States gradually diversified between 2011 and 2021. However, women, people with disabilities, Hispanic or Latino individuals, Black or African American individuals, and American Indian or Alaska Native individuals are underrepresented in the STEM workforce relative to their share of the national adult population. https://ncses.nsf.gov/pubs/nsf23315

[45] U.S. National Science Foundation. Online Education in STEM and Impact of COVID-19, Elementary and Secondary STEM Education. https://ncses.nsf.gov/pubs/nsb20211/online-education-in-stem-and-impact-of-covid-19;

[46] U.S. National Science Foundation. Effects of the COVID-19 Pandemic on Employment, Earnings, and Professional Engagement: New Insights from the 2021 National Survey of College Graduates. https://ncses.nsf.gov/pubs/nsf23307

[47] NSTC. 2024. Best Practices for Reducing Organizational, Cultural, and Institutional Barriers in STEM Research. https://www.whitehouse.gov/wp-content/uploads/2024/05/CoSTEM-IWGIS-Barriers-Report.pdf

including STEM learning opportunities, do not create barriers for learners with disabilities.[48] This plan aims to leverage existing agency efforts that support equity in federal programming and support the development, implementation, and dissemination of evidence-based policies and practices for improving equity and inclusion in STEM within the federal government and across the STEM ecosystem.[49]

By leveraging the best practices and identifying previously unaddressed areas of opportunity, this plan illuminates new avenues for advancing education and cultivating talent across the federal STEM ecosystem. Through cross-agency collaboration, CoSTEM will work to ensure that people across the country have the opportunity to contribute to the STEM enterprise—regardless of geography, race, gender, ethnicity, age, socioeconomic status, veteran status, parental education attainment, disability, learning challenges, caregiving responsibilities, and other social identities—so that they can reach their full potential and achieve their personal and professional goals.

Principle: Partnerships and Ecosystem Development

Public participation and community engagement are a government priority.[50] Partnership and ecosystem development should continue to be a CoSTEM priority in order to strengthen and leverage the nation's complex and interconnected public and private STEM innovation and talent development systems.

Strategic partnerships can help ensure that what is taught and learned is relevant to the needs and realities of the communities that students come from, work in, or want to learn more from. Partnerships can also connect STEM activities to the needs and realities of communities, nonprofit organizations, the private sector, and academia, all of which use STEM information on a daily basis. Strategic, mutually beneficial partnerships with local organizations also enhance the long-term viability of STEM ecosystems. It is critical that these partnerships span both the domestic and international landscape to advance American competitiveness globally.

Partnerships are essential to the goals of creating inclusive environments that bring diverse voices, expertise, and experiences that enrich and strengthen an ecosystem. This is particularly true as the federal government aims to include communities that have been historically underrepresented in academic and political decision-making spheres, such as low-income communities, rural communities, racial and ethnic groups underrepresented in STEM, and people with disabilities. A lack of strategic partnerships with these communities is particularly problematic because limited representation reduces opportunities for additional voices and experiences to be part of STEM learning. Furthermore, a lack of partnerships can result in decisions being made, or solutions proposed, using scientific or policy narratives that might not reflect the knowledge and interests of these people and their lived experiences.

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[48] U.S. Department of Justice. Civil Rights Division. Fact Sheet: New Rule on the Accessibility of Web Content and Mobile Apps Provided by State and Local Governments. https://www.ada.gov/resources/2024-03-08-web-rule/

[49] NSTC. 2021. Best Practices for Diversity and Inclusion in STEM Education and Research: A Guide by and for Federal Agencies. https://www.whitehouse.gov/wp-content/uploads/2021/09/091621-Best-Practices-for-Diversity-Inclusion-in-STEM.pdf

[50] https://www.whitehouse.gov/omb/information-regulatory-affairs/broadening-public-engagement-in-the-federal-regulatory-process

[53] https://www.whitehouse.gov/wp-content/uploads/2023/07/Broadening-Public-Participation-and-Community-Engagement-in-the-Regulatory-Process.pdf

Co-created, bi-directional partnerships that center on the needs and perspectives of all invested parties are needed among educational institutions, academic and community scientists, nonprofit organizations, out-of-school programs, government, diaspora communities, international entities, philanthropies, learners of all ages, families and caregivers, and industry.[51] The most productive partnerships are bi-directional. While not necessarily equal, co-created and bi-directional partnerships aim to be mutually beneficial and equitable. As part of this federal strategic plan, agencies should nurture, prioritize, and institutionalize these partnerships and engagements across the STEM ecosystem.

Principle: Transparency and Accountability

Promoting transparency and accountability across federal agencies ensures that the federal government works for people all across the country.[52] Use of evidence-based practices is crucial to maximizing the impact of federal STEM investments. Evidence-based practices may originate from the federal government or from other components of the STEM ecosystem, including nonprofit organizations, the private sector, and academia, underscoring the need for open communication among all those who participate in the nation's STEM talent development and innovation systems.

Evaluating and assessing program performance and outcomes, through both quantitative and qualitative methods, is key to identifying which practices and strategies are effective (or ineffective) in which settings and for which group of individuals. Evaluating and assessing programs also enables the development of evidence-based practices.

In support of transparency, agencies should work openly and collaboratively with one another and with the public. Sharing evaluations, assessments, and outcomes across federal agencies fosters collaboration and coordinated policymaking and increases awareness and use of evidence-based practices and assessment techniques. It has the potential to illuminate common gaps and/or needs across programs and supports the potential development of coordinated responses to address those gaps and/or needs. Disseminating federal and federally funded resources as well as program evaluations, assessments, and outcomes to the public is key to enhancing public and Tribal awareness and collaboration to improve federal STEM programming and advance the national STEM enterprise.[53] Here, too, bi-directional relationships are important. Transparency and accountability are furthered when the federal government shares program results and thoughtfully considers feedback from external parties.

Both transparency and accountability are critical to understanding the impact of each agency's activities. This sharing of information facilitates cross-agency collaboration and coordination of STEM opportunities, maximizing the impact of the federal government's STEM programming as a whole.

[51] https://www.whitehouse.gov/ostp/news-updates/2023/03/31/readout-from-ostps-public-listening-sessions-in-support-of-the-next-federal-stem-strategic-plan/

[52] https://www.whitehouse.gov/briefing-room/statements-releases/2021/12/08/fact-sheet-the-biden-harris-administration-is-taking-action-to-restore-and-strengthen-american-democracy/

[53] https://www.evaluation.gov/assets/resources/Program-Evaluation-Standards.pdf

Pillars Necessary for Carrying Out National Imperative

As outlined earlier, each pillar that follows includes three objectives. Each objective, in turn, includes: a national aspiration for the objective; a description of the challenges and opportunities for reaching the objective; a description of how the federal government might aim to address the objective; approaches CoSTEM and/or agencies could use to achieve the objective; and possible metrics or measures that CoSTEM and/or agencies could use to assess progress on the objective over the next five years.

Strategic Plan Atlas

(Reflecting Pillars and Objective Foci)

STEM Engagement	STEM Learning and Teaching	STEM Workforce	STEM Research and Innovation Capacity	STEM Environments
Engaging **Youth and Families** and Increasing Inspiration in STEM *(with a focus on informal STEM)*	Educating **Pre-K–12 Learners** *(with a focus on formal STEM)*	Training and Recruiting a **Federal STEM Workforce** *(with a focus on work-based learning)*	Advancing **STEM Education Research**	Removing Barriers and Supporting **Career Trajectories in STEM Learning Environments** *(with a focus on research careers)*
Engaging **Communities** and Increasing Participation in STEM	Educating **Undergraduate and Graduate Learners**	Training and Recruiting a **National STEM Workforce** *(with a focus on career and technical education and the skilled technical workforce)*	Advancing **STEM Research Capacity** *(with a focus on HBCUs, TCUs, other MSIs, and ERIs)*	Removing Barriers and Supporting **Career Flexibilities in STEM Working Environments**
Engaging **the Public** and Building STEM Literacy	Training **STEM Educators** *(with a focus on pre-K–12)*	Cultivating a **Global Workforce Nationally** and a **National Workforce Globally**	Building **STEM Innovation Capacity**	Removing Barriers and Promoting **Safe STEM Research Environments**

1. Pillar: STEM Engagement

The pillar on STEM Engagement addresses the federal need to engage learners, beginning with the youngest and their families, so they may explore the world with wonder and excitement and see themselves as a part of the STEM ecosystem. This pillar also focuses on the need to view communities as active contributors in solving community challenges as they work with and alongside institutions of learning and research to co-develop local solutions to those challenges. This pillar also highlights the importance of STEM engagement as a lifelong process. Every person, regardless of age or career, should have access to the knowledge and skills needed to apply science, engineering, and mathematics and to use technology and data in their personal and professional lives.

1.1 Objective: Engaging Youth and Families and Increasing Inspiration in STEM

1.1.1 CoSTEM's National Aspirations for Engaging Youth and Families and Increasing Inspiration in STEM

CoSTEM would like to see a day when all individuals, but particularly the nation's youngest learners, have access to interesting and engaging STEM opportunities that spark their curiosities and drive them to question, explore, and learn all about the world around them. Driven by their natural curiosity, youth will remain lifelong learners who have ongoing access to authentic STEM engagement experiences embedded in place, culture, and societal relevance.

1.1.2 Challenges and Opportunities for Engaging Youth and Families and Increasing Inspiration in STEM

Informal STEM engagement provides an avenue for STEM educators and professionals to reach a broad and diverse audience with meaningful, authentic, and interest-sparking activities that will help grow the next generation of problem solvers, innovators, decision makers, and informed community members. Direct participation and exploration of the natural and human-made world increases understanding of fundamental STEM principles and encourages the development of a STEM mindset, which is important for people of all ages.[54,55]

Informal STEM engagement settings provide opportunities to reinforce classroom instruction, build practical STEM skills, provide insight into local and global issues, cultivate awareness and understanding of complex topics, and encourage the next generation of problem solvers to get involved in creating solutions. As such, successful STEM engagement programs will help young minds develop core math and science knowledge and skills in team building, problem solving, analytic reasoning, and risk taking that may be necessary for future success in STEM fields. Such a broader and participatory approach can also include invention understanding.[56] These considerations are discussed in more detail under Objective 4.3.

Effective informal STEM programs engage learners intellectually, academically, and emotionally. Effective programs are culturally and socially relevant, curiosity-driven, and help to develop STEM identity.[57] Meaningful informal STEM engagement with learners and their families allows learners to find the researcher or innovator within themselves, opening the gateway to STEM for everyone. The impact of federal agencies' investments in informal STEM engagement ranges in timescale from immediate to generational. These investments build a creative and informed population and a well-trained future workforce, which is essential for improving the nation's living standards, supporting economic prosperity at both the individual and national level, and maintaining global competitiveness in STEM.

[54] Hussim, H., Rosli, R., Mohd Nor, N. A. Z., Maat, S. M., Mahmud, M. S., Iksan, Z., Rambely, A. S., Mahmud, S. N., Halim, L., Osman, K. and Lay, A. N. 2024. A Systematic Literature Review of Informal STEM Learning. European Journal of STEM Education, 9(1), 07. https://doi.org/10.20897/ejsteme/14609

[55] Afterschool Alliance. Evaluating Afterschool: The Latest Research on the Impact of Afterschool and Summer Programs. https://afterschoolalliance.org/documents/The-Latest-Research-on-the-Impact-of-Afterschool-and-Summer-Programs-2024.pdf

[56] U.S. Patent and Trademark Office. 2024. National Strategy for Inclusive Innovation. https://www.uspto.gov/sites/default/files/documents/NationalStrategy.pdf

[57] National Research Council. 2015. Identifying and Supporting Productive STEM Programs in Out-of-School Settings. Washington, DC: The National Academies Press. https://doi.org/10.17226/21740

1.1.3 CoSTEM's Federal Objective for Engaging Youth and Families and Increasing Inspiration in STEM

To contribute to the national aspiration, CoSTEM aims to improve the opportunities that young learners and their families have to participate in authentic STEM engagement and learning experiences within informal STEM settings.

1.1.4 Approaches CoSTEM and/or Agencies Could Take toward the Federal Objective of Engaging Youth and Families and Increasing Inspiration in STEM

- Partner with local, Tribal, territorial, state, and national events to increase awareness of and access to more federal and federally funded STEM engagement activities.
- Work in partnership with organizations and entities that provide informal STEM engagement (such as museums, science centers, libraries, afterschool programs, summer camps, and community organizations) to create or share federal STEM resources that promote authentic STEM engagement.
- Offer direct programming that allows for intergenerational engagement, learning, and career awareness.
- Build bridges between informal STEM learning experiences and formal classroom instruction by connecting classroom teachers and out-of-school-time educators in collaborative professional development.

1.1.5 Potential Objective Metrics/Measures for Engaging Youth and Families and Increasing Inspiration in STEM

- The number of federal and/or federally funded informal engagement opportunities in which youth and families engage in authentic STEM experiences.[58]

1.2 Objective: Engaging Communities and Increasing Participation in STEM

1.2.1 CoSTEM's National Aspirations for Engaging Communities and Increasing Participation in STEM

CoSTEM would like to see a day when STEM engagement and education are seamlessly integrated into the fabric of communities and all individuals are seen as essential partners in participatory and community research. Communities should always be a part of the STEM ecosystem that helps to connect advances in STEM to societal impacts, ensure relevance for individuals of all ages and backgrounds, and inform decision making for community health and well-being.

1.2.2 Challenges and Opportunities for Engaging Communities and Increasing Participation in STEM

Access to scientific and technological knowledge enables people to make informed choices on matters such as personal health, environmental consciousness, and cybersecurity.[59] America's economic growth and national defense depend on urgent improvements in the access to STEM knowledge and the opportunities for communities historically underserved and underrepresented in STEM.

[58] Authentic STEM Experience: An experience inside or outside of school designed to engage learners directly or indirectly with practitioners and in developmentally-appropriate practices from the STEM disciplines that promote real-world understanding. An "Authentic STEM Experience" is as an active-doing, collaborative, meet learners where they are, appropriate learning approach/practice, leading to real-world understanding. National Academies of Sciences, Engineering, and Medicine. 2017. Undergraduate Research Experiences for STEM Students: Successes, Challenges, and Opportunities. Washington, DC: The National Academies Press. https://doi.org/10.17226/24622.

[59] Jackson, C., Mohr-Schroeder, M.J., Bush, S.B. *et al.* 2021. Equity-Oriented Conceptual Framework for K–12 STEM literacy. *IJ STEM Ed* 8, 38. https://doi.org/10.1186/s40594-021-00294-z

Challenges in weaving STEM into non-classroom settings, including community-focused settings, are multi-faceted and complex. The challenges include socioeconomic disparities; cultural biases and misunderstandings; lack of exposure to STEM; inadequate resources; inaccessibility of facilities and materials, particularly for people with disabilities; and STEM professionals not being viewed as authentic partners committed to the community.[60,61,62] Investing in relationship building with communities to support STEM engagement takes time and resources, and investments need to be intentionally designed and sustained. Building trust and ensuring attention to long-lasting relationships can positively influence a wide variety of interactions moving forward, including those that may not be STEM-related.[63]

Participatory STEM opportunities can positively impact STEM learning and problem solving when co-designed with a community focus.[64,65,66] Such opportunities can also provide individuals with tools to leverage their lived experiences to investigate and address inequities they face, including challenges affecting their community. These opportunities need to be co-created with communities for them to realize these benefits. Ensuring this impactful work occurs at a meaningful scale across the nation will require agencies to support the federal workforce in developing the skills and cultural competencies needed to effectively approach the co-creation of participatory STEM efforts.

1.2.3 CoSTEM's Federal Objective for Engaging Communities and Increasing Participation in STEM

To contribute to this aspiration, CoSTEM aims to improve the access that communities have to engage in federally funded learning opportunities and increase community awareness of opportunities to engage in participatory research.

1.2.4 Approaches CoSTEM and/or Agencies Could Take toward the Federal Objective of Engaging Communities and Increasing Participation in STEM

- Curate federal engagement activities and resources that center STEM opportunities and experiences in culture and place, and make STEM more participatory.
- Engage and develop local, Tribal, territorial, state, or regional STEM ecosystems that work with learners, families, and communities to build gradual and scalable on-ramps into higher education and STEM careers.

[60] Abbas, J. and Koh, K. 2015. Future of Library and Museum Services Supporting Teen Learning: Perceptions of Professionals in Learning Labs and Makerspace. The Journal of Research on Libraries and Young Adults, 6. https://www.yalsa.ala.org/jrlya/wp-content/uploads/2015/11/Abbas_Koh_FutureofLibraryMuseumServices.pdf

[61] Hinojosa, L., Swisher, E., and Garneau, N. 2021. The Organization of Informal Pathways into STEM: Designing towards Equity. International Journal of Science Education 43, 5. https://doi.org/10.1080/09500693.2021.1882010

[62] Hartman, S.L., Hines-Bergmeier, J., and Klein, R. 2017. Informal STEM Learning: The State of Research, Access and Equity in Rural Early Childhood Settings. Science Education and Civic Engagement 9, 2. https://seceij.net/wp-content/uploads/2017/07/Hartman.pdf

[63] National Girls Collaborative Project. 2024. Guidelines for Equitably Scaling Informal STEM Programs. https://ngcproject.org/ScalingInformalSTEMPrograms

[64] STEM Next Opportunity Fund. 2019. Changing the Game in STEM with Family Engagement: A White Paper for Practitioners and Field Leaders to Empower Families in STEM. https://stemnext.org/wp-content/uploads/2023/04/Changing-the-Game-in-STEM-with-Family-Engagement_Final_.pdf

[65] Nation, J.M. and Hansen, A.K. 2021. Perspectives on Community STEM: Learning from Partnerships between Scientists, Researchers, and Youth. Integrative and Comparative Biology 61, 3. https://doi.org/10.1093/icb/icab092

[66] Association of Science and Technology Centers. Dialogue & Deliberation Toolkit. Community Science Initiative. https://communityscience.astc.org/dialogue-deliberation-toolkit/

- Develop and expand community-centered opportunities that leverage and build on Community School models.[67]
- Build capacity within federal agency staff to appropriately and respectfully engage with communities in co-created participatory STEM undertakings.

1.2.5 Potential Objective Metrics/Measures for Engaging Communities and Increasing Participation in STEM

- The number of opportunities that allow for community engagement in federal and/or federally funded STEM opportunities, particularly opportunities engaging communities historically underrepresented in federal engagement.
- The number of opportunities that allow community members to engage in federal and/or federally funded participatory research opportunities.

1.3 Objective: Engaging the Public and Building STEM Literacy

1.3.1 CoSTEM's National Aspirations for Engaging the Public and Building STEM Literacy

CoSTEM would like to see a day when the general public has comprehensive scientific reasoning skills and is able to interpret and assess evidence for application to their everyday lives. All individuals should be able to see themselves capable of using STEM knowledge and skills to support decision making for individual well-being.

1.3.2 Challenges and Opportunities for Engaging the Public and Building STEM Literacy

Fostering comprehensive scientific reasoning skills in all individuals is vital to ensuring that the nation is equipped to engage with and solve pressing societal challenges today and in the future. All members of the public require scientific reasoning skills to process information and to use that information when making judgments and decisions.[68] The public is exposed to an enormous amount of information on a daily basis and needs scientific reasoning skills—including the ability to identify problems, ask questions, collect and analyze information, and draw reasoned conclusions—to evaluate the accuracy of the information.

Educational systems are required to rapidly evolve to keep pace with technological changes, but teachers may not be prepared to teach the scientific reasoning and/or digital skills their students need to safely navigate these changes.[69] This issue is increasingly apparent with the rapid developments in AI. Without explicit efforts to develop and refine the foundational skills around data and computational

[67] National Education Association. What Are Community Schools? https://www.nea.org/student-success/great-public-schools/community-schools/what-are-they; Full-Service Community Schools Program. U.S. Department of Education. https://www.ed.gov/grants-and-programs/grants-birth-grade-12/school-community-improvement/full-service-community-schools-program-fscs#number2

[68] Kelp, N. C., McCartney, M., Sarvary, M. A., Shaffer, J. F., Wolyniak, M. J. 2023. Developing Science Literacy in Students and Society: Theory, Research, and Practice. J Microbiol Biol Educ 24, 2. https://doi.org/10.1128/jmbe.00058-23

[69] NSTC. 2023. Building Computational Literacy through STEM Education: A Guide for Federal Agencies and Stakeholders. https://www.whitehouse.gov/wp-content/uploads/2023/11/Building-Computational-Literacy-Through-STEM-Ed-Guide-for-Federal-Agencies-FINAL-PUBLIC.pdf

literacy[70] that ultimately undergird cyber and AI literacy[71], educators and learners will continue to be underprepared to navigate the ways AI and other emerging technologies will change the landscape across all sectors of society.[72]

Effective science communication on emerging topics is a necessary part of STEM literacy. Providing evidence and context allows members of the public to make informed choices. The social and behavioral sciences provide useful insights into how cultural, socioeconomic, and other differences influence how people understand and interpret information. Effective communication—that presents cultural, socioeconomic, and other differences to conveying and understanding topics in science and technology—is important to reaching all members of our society. Leveraging STEM knowledge and skills is key to supporting the development of innovative thinkers and propelling socioeconomic advancement on a global scale.

1.3.3 CoSTEM's Federal Objective for Engaging the Public and Building STEM Literacy

To contribute to this national aspiration, CoSTEM aims to increase access to technology, data, and skills development opportunities, so that people in all communities across the nation can engage in STEM learning and STEM careers as well as benefit from new advancements and discoveries in science and technology.

1.3.4 Approaches CoSTEM and/or Agencies Could Take toward the Federal Objective of Engaging the Public and Building STEM Literacy

- Support equitable access to robust programming and technology focused on developing STEM learners, STEM workers, and the public's interest and skills in digital, computational, AI, data, and cyber literacy.[73,74]
- Use or provide technology, including assistive technologies and reasonable accommodation for individuals with disabilities, to expand the reach of STEM literacy and STEM skills to underserved communities, isolated geographic regions, and under-resourced institutions.

[70] Computational Literacy: The ability to use information, information processing agents, digital assets, networking components, and applications and systems that, combined, allow people and organizations to interact in a digital world to solve problems, either individually or with a team; to draw meaning and reasonable conclusions from digital information in both personal and professional contexts; to safely, ethically, and securely use networks (wired and wireless) and data; and to understand how computing, data, and connectivity affects society. Computational literacy helps an individual - (A) ethically, securely, safely, and efficiently use information processing agents, digital tools, and digital platforms to teach, learn, and solve problems, including problems with sensitive information; (B) problem-solve (e.g., decomposing problems into manageable pieces; heuristic reasoning; algorithmic thinking computational thinking); (C) think recursively; (D) navigate multiple levels of abstraction; (E) recognize patterns; (F) collect, analyze, manage, visualize, and communicate data; (G) translate domain knowledge into mathematical and visual models; (H) understand the social, technical, and cultural dynamics of computational technology, including equity, inclusion, and accessibility; and (I) critically evaluate related technologies. https://www.whitehouse.gov/ostp/news-updates/2023/11/27/nstc-building-computational-literacy-through-stem-education-a-guide-for-federal-agencies-and-stakeholders/

[71] AI Literacy: AI literacy as a set of competencies that enables individuals to critically evaluate AI, communicate and collaborate effectively with AI, and use AI as a tool online, at home, school, and in the workplace. https://doi.org/10.1145/3313831.3376727

[72] U.S. Department of Education. 2023. Artificial Intelligence and the Future of Teaching and Learning. https://tech.ed.gov/files/2023/05/ai-future-of-teaching-and-learning-report.pdf

[73] National Cyber Workforce & Education Strategy. https://www.whitehouse.gov/wp-content/uploads/2023/07/NCWES-2023.07.31.pdf

[74] U.S. Department of Education. 2022. Advancing Digital Equity for All. https://tech.ed.gov/advancing-digital-equity-for-all

- Develop new or enhance existing communication and outreach strategies to facilitate improved connections with communities.
- Develop engaging digital, computational, data-rich, place-based, and culturally relevant programming for communities.

1.3.5 Potential Objective Metrics/Measures for Engaging the Public and Building STEM Literacy

- The number of opportunities that support efforts and have outcomes that address current and sustainable critical technology needs, broadband needs, and/or digital infrastructure needs for STEM learners, communities, K–12 schools, or institutions of higher education.
- The number of opportunities with outputs and outcomes that build and broaden access to STEM literacy and skills.

2. Pillar: STEM Teaching and Learning

The pillar on STEM Teaching and Learning addresses the need to prepare learners with the STEM skills to both contribute to the well-being of their communities and secure desired STEM career opportunities. It aims to ensure students have exploratory experiences within their classrooms and the necessary structures to support individualized and personalized learning. This pillar aims to increase awareness of and exposure to the multiple pathways to a STEM career, including community colleges and career and technical education programs, as well as the many tutors, mentors, and evidence-based resources that support all STEM learners regardless of racial, ethnic, geographic and socioeconomic backgrounds, sexual orientations, gender/gender identities, and disability status. It also speaks to ways in which the federal government can contribute to the preparation and development of the STEM teacher workforce.

2.1 Objective: Educating Pre-K–12 Learners

2.1.1 CoSTEM's National Aspirations for Educating Pre-K–12 Learners

CoSTEM would like to see a day when all students in formal pre-K–12 educational settings[75] achieve or exceed grade level outcome standards and have early and consistent exposure to evidence-based STEM learning experiences. Pre-K students should have access to a diverse and inclusive population of trained and supported educators. These students should be afforded the ability to build the 21st century skills—including collaboration, communication, creativity, and analytical and critical thinking—needed to function in an increasingly technological and innovation-driven society.

2.1.2 Challenges and Opportunities for Educating Pre-K–12 Learners

Research shows that early and consistent exposure to STEM can support and, in many cases, enhance students' interests, skills, and career choices.[76,77] Many students across the United States lack access to STEM opportunities at a young age and are not achieving grade-level standards in mathematics and science.[78,79,80] Students from underrepresented groups, including students with disabilities, face additional challenges in accessing STEM resources and support.[81] Federal agencies should continue to support programs that assist in the translation of STEM research into equitable, research-based

[75] Formal Education: Learning or delivery of learning within a structured education system that requires students to demonstrate proficiency. Formal learning environments include publicly and privately funded organizations that (1) serve students in pre-K through graduate school and (2) provide learners with degrees, certifications, transcripts, or other evidence of participation.

[76] Van Tuijl, C., and van der Molen, J. H. W. 2016. Study choice and career development in STEM fields: An overview and integration of the research. International Journal of Technology and Design Education 26, 2. https://doi.org/10.1007/s10798-015-9308-1

[77] Rocker Yoel, S., and Dori, Y. J. 2021. FIRST high-school students and FIRST graduates: STEM exposure and career choices. IEEE Transactions on Education 65, 2. https://doi.org/10.1109/TE.2021.3104268

[78] Nores, M., and Barnett, W. S. 2014. Access to high quality early care and education: Readiness and opportunity gaps in America (Center on Enhancing Early Learning and National Institute for Early Education Policy Report). Center on Enhancing Early Learning Outcomes. https://nieer.org/wp-content/uploads/2014/05/ceelo_policy_report_access_quality_ece.pdf

[79] National Academies of Sciences, Engineering, and Medicine. 2024. A New Vision for High-Quality Preschool Curriculum. Washington, DC: National Academies Press. https://doi.org/10.17226/27429

[80] U.S. Department of Education, Office for Civil Rights, 2020-21 Civil Rights Data Collection. Students' Access to Educational Opportunities in U.S. Public Schools. https://www.ed.gov/sites/ed/files/about/offices/list/ocr/docs/crdc-educational-opportunities-report.pdf

[81] U.S. Department of Education, Office for Civil Rights, 2020-21 Civil Rights Data Collection. Student Access to and Enrollment in Mathematics, Science, and Computer Science Courses and Academic Programs in U.S. Public Schools. https://www.ed.gov/sites/ed/files/about/offices/list/ocr/docs/crdc-student-access-enrollment.pdf

instructional resources, authentic learning experiences, and educator preparation and development opportunities that support the needs of pre-K–12 learners. A goal of such programs should be to create a new generation of resilient problem solvers and innovators who will be prepared to tackle global challenges.[82]

Many agencies have developed resources to increase and improve the quality of STEM educational opportunities. Additionally, many agencies offer grants, cooperative agreements, and strategic partnerships with universities, nonprofits, businesses, and other organizations to create impactful, relevant learning materials for students and teachers. Learning and curricular decisions are made at the state or local level to best meet the needs of students in those areas. Federal resources may need to be adapted to support the needs of students across this diverse nation.[83] Currently, federally supported resources may be difficult to find. To address this issue, ongoing outreach efforts by federal agencies to educational organizations continues to be refined to increase accessibility and use. Further, research indicates that the onset of the COVID-19 pandemic severely disrupted student learning, both in formal in-person and in online learning settings.[84] In particular, there was a strong, negative impact on student math achievement, which is critical to success in many STEM fields.[85,86] For middle schoolers, for example, confidence in math skills at school promotes confidence in other STEM topics for a lifetime.[87]

While the shortage of math and science teachers has been reported for decades, the COVID-19 pandemic exacerbated the difficulty in hiring qualified STEM teachers.[88,89,90] Qualified, highly trained STEM teachers can provide students with the skills to succeed as STEM-literate community members and members of the STEM workforce. These shortages fall disproportionately on schools that serve a large percentage of students of color and students from low-income backgrounds. While there are many places across the United States in which teachers receive STEM professional development, there

[82] U.S. Patent and Trademark Office. 2024. National Strategy for Inclusive Innovation. https://www.uspto.gov/sites/default/files/documents/NationalStrategy.pdf

[83] U.S. Department of Education. Letter About How Federal Funds Can Support Science, Technology, Engineering, and Mathematics (STEM) Education. https://www.ed.gov/laws-and-policy/education-policy/key-policy-letters-signed-by-the-education-secretary-or-deputy-secretary/december-6-2022--letter-about-how-federal-funds-can-support-science-technology-engineering-and-mathematics-stem-education

[84] U.S. National Science Foundation. National Center for Science and Engineering Statistics. 2021. Online Education in STEM and Impact of COVID-19. https://ncses.nsf.gov/pubs/nsb20211/online-education-in-stem-and-impact-of-covid-19

[85] The Nation's Report Card. 2023. Scores Decline Again for 13-Year-Old Students in Reading and Mathematics. https://www.nationsreportcard.gov/highlights/ltt/2023/

[86] U.S. National Science Foundation. National Center for Science and Engineering Statistics. 2023. Student Learning in Mathematics and Science. https://ncses.nsf.gov/pubs/nsb202331/student-learning-in-mathematics-and-science

[87] U.S. Department of Education. Institute of Education Sciences. Middle School Math Is an Important Bridge to Lifelong STEM Learning and Success. https://ies.ed.gov/ncee/rel/regions/midwest/pdf/RELMW-ENACT-Infographic-508.pdf

[88] Feder, T. 2022. The US is in Dire Need of STEM Teachers. Physics Today 75, 3. https://pubs.aip.org/physicstoday/article/75/3/25/2842714

[89] U.S. Department of Education. Brief: Eliminating Educator Shortages through Increasing Educator Diversity and Addressing High-need Shortage Areas. https://www.ed.gov/about/ed-initiatives/raise-the-bar/raise-the-bar-policy-brief-2

[90] U.S. Department of Education. Institute of Education Sciences. Report on the Condition of Education 2023. https://nces.ed.gov/pubs2023/2023144.pdf

is wide variety in the rigor and types of opportunities offered, and challenges remain in ensuring educators have equitable access to these resources.[91,92]

Convergence education[93] and transdisciplinary learning approaches support students and communities historically underserved and underrepresented in STEM, such as rural, Title I, non-male students in STEM, and persons from underrepresented racial/ethnic groups.[94,95] The recent emphasis on grounding AI literacy in perspectives from multiple disciplines is one area that is ripe with opportunities to apply convergence education approaches. There is also substantial evidence for the positive value and impact of mentorship and career exposure for pre-K–12 students in developing their STEM identity and career interest.[96,97,98] Given the substantial federal STEM workforce,[99] there is opportunity for federal agencies to strengthen the engagement of federal STEM professionals in formal educational spaces. With proper orientation, federal STEM professionals can be effective role models via classroom visits, research project mentorship, STEM competition coaching and judging, and more.

2.1.3 CoSTEM's Federal Objective for Educating Pre-K–12 Learners

To contribute to this national aspiration, CoSTEM aims to improve the opportunities and increase the access that pre-K–12 students in formal education settings have to evidence-based instructional STEM materials, authentic STEM learning experiences, transdisciplinary or convergent learning resources, accessible educational technology, and well-prepared and adequately supported instructional staff.

2.1.4 Approaches CoSTEM and/or Agencies Could Take toward the Federal Objective of Educating Pre-K–12 Learners

- Leverage transdisciplinary and convergent education approaches, including access to and the use of technology.
- Leverage and scale effective approaches to science and mathematics instruction, and improve access to high-quality and high-level coursework necessary for learners to advance in STEM fields and careers.

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[91] Winberg, C., Adendorff, H., Bozalek, V., Conana, H., Pallitt, N., Wolff, K., Olsson, T., and Roxå, T 2019. Learning To Teach STEM Disciplines in Higher Education: A Critical Review of The Literature. Teaching in Higher Education 24, 8. https://doi.org/10.1080/13562517.2018.1517735

[92] Huang, Biyun, Morris Siu-Yung Jong, Yun-Fang Tu, Gwo-Jen Hwang, Ching Sing Chai, and Michael Yi-Chao Jiang. 2022. Trends and exemplary practices of STEM teacher professional development programs in K–12 contexts: A systematic review of empirical studies. Computers & Education: 104577. https://doi.org/10.1016/j.compedu.2022.104577

[93] Convergence education is driven by compelling or complex societal problems or topics, where learners apply knowledge and skills using a blended approach across multiple disciplines (i.e., transdisciplinary) to create and innovate new solutions. https://www.whitehouse.gov/ostp/news-updates/2022/11/30/nstc-convergence-education-a-guide-to-transdisciplinary-stem-learning-and-teaching/

[94] Filipović, Jelena. 2019. Transdisciplinary qualitative paradigm in applied linguistics: autoethnography, participatory action research and minority language teaching and learning. International journal of qualitative studies in education 32, no. 5: 493-509. https://doi.org/10.1080/09518398.2019.1597209

[95] https://stemteachingtools.org/assets/landscapes/STEM-Teaching-Tool-11-Meaningful-Indigenous-STEM-Education.pdf

[96] Gallagher Dunn, Sarah Louise, Heidi Fuqua Haviland, and Dennis Lee Gallagher. 2023. The importance of local long-duration STEM mentorship as a global mechanism for increasing diversity at all levels of education. *Frontiers in Astronomy and Space Sciences* 10: 1134836. https://doi.org/10.3389/fspas.2023.1134836

[97] Atkins, K., Dougan, B.M., Dromgold-Sermen, M.S. *et al.* 2020. Looking At Myself in the Future: How Mentoring Shapes Scientific Identity for STEM Students from Underrepresented Groups. International Journal of STEM Education 7, 42. https://doi.org/10.1186/s40594-020-00242-3

[98] https://safesupportivelearning.ed.gov/voices-field/how-do-high-quality-mentoring-relationships-benefit-young-people

[99] U.S. Office of Personnel Management. 2023. Federal Workforce Data. https://www.fedscope.opm.gov/employment.aspx

- Promote student-centric approaches and strategies, such as personalized learning and tutoring, work-based learning, and dual enrollment to support current approaches to classroom learning.
- Engage federal STEM professionals in outreach and volunteer efforts.

2.1.5 Potential Objective Metrics/Measures for Educating Pre-K–12 Learners

- The number of federal STEM opportunities that support evidence-based and equitable improvements for learners, educators, and/or schools in achieving on-grade-levels for science or mathematics.
- The number of opportunities that support mechanisms that allow for the development or improvement of effective local, Tribal, territorial, state, and/or regional STEM education ecosystem models.

2.2 Objective: Educating Undergraduate and Graduate Learners

2.2.1 CoSTEM's National Aspirations for Educating Undergraduate and Graduate Learners

CoSTEM would like to see a day when undergraduate and graduate students at all levels have equitable access to both (1) affordable, evidence-based postsecondary educational opportunities in STEM fields, including coursework, credentials/degrees, access to educational technology and research facilities, transdisciplinary research, and professional experiences, and (2) faculty and mentors who are adequately prepared and resourced to support their learning.

2.2.2 Challenges and Opportunities for Educating Undergraduate and Graduate Learners

Varying access to quality K–12 education results in different levels of preparedness for college-level work. Challenges in post-secondary settings can be persistent, resulting in inequities in higher education. These issues include long-standing challenges for underrepresented racial, ethnic, geographic, economic, and gender communities in post-secondary STEM education.[100,101] Students face many challenges in the post-secondary context, including uneven access to opportunities and financial support, which contribute to the disproportionate rate of historically underrepresented students in STEM leaving rather than staying in pathways toward STEM employment.[102,103] Students with disabilities, including mental health challenges, can face further obstacles in accessing educational resources and support. The social connections that are critical for finding internships, research, mentorship, and faculty support also put historically underrepresented students at a disadvantage.[104] A lack of resources, access to advanced coursework, and STEM role models in elementary, secondary school, and out-of-school-time learning can undermine access in post-secondary education by leaving

[100] Catherine Hill, Christianne Corbett, and Andresse St. Rose. 2010. Why so Few? Women in Science, Technology, Engineering, and Mathematics. American Association of University Women. https://eric.ed.gov/?id=ED509653

[101] U.S. Department of Education. National Center for Education Statistics. Digest of Education Statistics: Table 303.70. https://nces.ed.gov/programs/digest/d20/tables/dt20_303.70.asp.

[102] Catherine Riegle-Crumb, Barbara King, and Yasmiyn Irizarry. 2019. Does STEM Stand Out? Examining Racial/Ethnic Gaps in Persistence Across Postsecondary Fields. Educational Researcher 48, 3. https://doi.org/10.3102/0013189X19831006

[103] Brecht Neyt et al. 2019. Does Student Work Really Affect Educational Outcomes? A Review of the Literature. Journal of Economic Surveys 33, 3. https://doi.org/10.1111/joes.12301

[104] Emilio J. Castilla, George J. Lan, and Ben A. Rissing. 2013. Social Networks and Employment: Mechanisms (Part 1). Sociology Compass 7, 12. https://doi.org/10.1111/soc4.12096

some students unaware of STEM opportunities and pathways after graduation.[105,106] Additionally, students who lack quality STEM education in the pre-K–12/out-of-school-time context will face additional barriers to success.[107]

Exacerbating these issues are the challenges educators at postsecondary institutions face. While some of these challenges are addressed elsewhere within this plan, problems such as inequitable access to educational resources[108] are addressed under this objective. In the context of interconnected environmental and societal problems, the demands on post-secondary STEM students will increase. Understanding these problems will require high-quality STEM education that includes support for real-world experiences. Exposing post-secondary students to innovation, both within and outside of STEM coursework, is valuable for cultivating skills that will be important to these students later in life as STEM professionals. For example, a single post-secondary course in entrepreneurship has been shown to have meaningful benefits to students later in life. Such a course can include business, design, communication, and IP creation and protection.[109]

Students must have equitable access to STEM opportunities after high school, particularly those who may not have had sufficient opportunities available to them at their high schools. Outreach efforts can help connect individuals to postsecondary STEM opportunities. For example, supporting programs that provide quality educational opportunities for college students while reducing educational inequities at the pre-K–12 level (i.e., near-peer mentor model)[110] can help local communities build STEM success.

Not all those interested in pursuing postsecondary-level learning in STEM are able to access the full range of learning opportunities and resources that prepare individuals to fully engage in and contribute to their communities and/or to succeed in STEM-related careers. By recognizing the large role financial disparities play in determining access to post-secondary opportunities and outcomes, federal agencies can continue to support those with academic ability, talent, or potential to pursue STEM programs of study. Such support can include federally funded scholarships, fellowships, and training programs that prepare students for future success in the nation's STEM workforce.

2.2.3 CoSTEM's Federal Objective for Educating Undergraduate and Graduate Learners

To contribute to this national aspiration, CoSTEM aims to increase availability and access to undergraduate and graduate learning experiences that include the use of evidence-based STEM instructional materials, opportunities for transdisciplinary research experiences, accessible

[105] Martha C. Bottia et al. 2015. The Relationships Among High School STEM Learning Experiences and Students' Intent to Declare and Declaration of a STEM Major in College. Teachers College Record: The Voice of Scholarship in Education 117, 3. https://doi.org/10.1177/016146811511700308

[106] Guan K. Saw and Charlotte A. Agger. 2021. STEM Pathways of Rural and Small-Town Students: Opportunities to Learn, Aspirations, Preparation, and College Enrollment. Educational Researcher 50, 9. https://doi.org/10.3102/0013189X211027528

[107] Martha C. Bottia et al. 2021. Factors Associated with College STEM Participation of Racially Minoritized Students: A Synthesis of Research. Review of Educational Research 91, 4. https://doi.org/10.3102/00346543211012751

[108] Marybeth Gasman et al. 2017. Minority Serving Institutions: A Data-Driven Student Landscape in the Outcomes-Based Funding Universe. Berkeley Review of Education 7, 1. https://eric.ed.gov/?id=EJ1169644

[109] U.S. Patent and Trademark Office. 2024. National Strategy for Inclusive Innovation. https://www.uspto.gov/sites/default/files/documents/NationalStrategy.pdf

[110] Trujillo G, Aguinaldo PG, Anderson C, Bustamante J, Gelsinger DR, Pastor MJ, Wright J, Márquez-Magaña L, Riggs B. 2015. Near-peer STEM Mentoring Offers Unexpected Benefits for Mentors from Traditionally Underrepresented Backgrounds. Perspect Undergrad Res Mentor. 4, 1. https://pubmed.ncbi.nlm.nih.gov/27668127/

educational technology and research facilities, and opportunities to gain knowledge and understanding of subjects vital to transform research into the creation of products, processes, and systems to advance innovation.

2.2.4 Approaches CoSTEM and/or Agencies Could Take toward the Federal Objective of Educating Undergraduate and Graduate Learners

- Leverage federal scholarship-for-service STEM programs and consider incorporating best, emerging, or new practices to develop transferable skills applicable to multiple critical and emerging technologies.
- Support experiences that allow learners to engage multi-disciplinary learning curricula, hands-on place-based and course-based research experiences, paid work-based learning opportunities, and mentorship opportunities with sector, government, and/or industry leaders.
- Promote the development and deployment of learning and training materials for entrepreneurship for post-secondary STEM learners.
- Explore the use of models and other mechanisms to support stackable credentialing[111] at or through federally funded institutions.
- Increase STEM education capacities, including at community colleges, MSIs, and ERIs, to provide authentic STEM experiences and training opportunities for students and faculty. Capacity building includes opportunities to address essential administrative, physical, and digital/technology infrastructure needs.
- Increasing access to educational opportunities that offer innovative, holistic, and comprehensive student programming that considers local, cultural, instructional, institutional, and/or systemic contexts.

2.2.5 Potential Objective Metrics/Measures for Educating Undergraduate and Graduate Learners

- The number of opportunities that provide access to need-based and student-centric STEM scholarships and produce desired educational outcomes.
- The number of opportunities that provide transdisciplinary or interdisciplinary fellowships, particularly those that allow students to participate in critical and emerging areas of STEM.
- The number of opportunities that support the use of effective, evidence-based best practices for student support systems at academic institutions, including those that support transitional programs (high school to college; two-year college to four-year college; four-year college to graduate school; in-person to online, and vice versa).

2.3 Objective: Training STEM Educators

2.3.1 CoSTEM's National Aspirations for Training STEM Educators

CoSTEM would like to see a day when STEM educators are from diverse populations that are reflective of their students and have the tools, knowledge, and opportunities to enter, persist, be effective, and be promoted in the STEM teacher workforce. A diverse STEM educator workforce empowers students from all backgrounds to see themselves in STEM.[112]

[111] U.S. Department of Labor defines a "stackable credential" as "part of a sequence of credentials that can be accumulated over time to build up an individual's qualifications and help them move along a career pathway or up a career ladder to different and potentially higher-paying jobs" (Training and Employment Guidance Letter 15-10, U.S. Department of Labor, Employment and Training Administration). https://cte.ed.gov/initiatives/community-college-stackable-credentials

[112] Smithsonian Institution. 2022. Building Networks & Enhancing Diversity in the K–12 STEM Teaching Workforce. https://ssec.si.edu/includes-sourcebook

2.3.2 Challenges and Opportunities for Training STEM Educators

Governmental and nongovernmental programs have helped attract, retain, and promote highly qualified STEM teachers, particularly those who teach students from underrepresented populations and in rural areas. All levels of government can develop policies to expand the representation of STEM teachers to address the needs of the student populations that they serve.[113,114] From the 2012–2013 to the 2019–2020 school year, the number of individuals who were enrolled in and completed teacher preparation programs declined, signaling a national decrease in individuals pursuing training for teaching careers.

There is a broad awareness that teaching as a profession is undervalued and underpaid despite its critical importance to training the future workforce across government, nongovernmental organizations, and the private sector.[115] Efforts are required to raise the profile and level of respect for the teaching profession nationally. The onset of the COVID-19 pandemic highlighted complex issues facing educators. The United States does not have enough STEM instructors[116] to train and nurture the anticipated increase in the STEM workforce,[117] and the instructional materials available are often insufficient in quantity and quality. STEM students need resources and laboratory time for experiential learning. Large class sizes combined with limited instructional time minimize the individual attention and feedback STEM teachers can provide. STEM teachers, who must balance numerous responsibilities, may not be aware of nor have the resources or incentives to implement the pedagogical best practices developed from evidence-based research, further impacting student enthusiasm in STEM and the likelihood of students aspiring to become STEM teachers.[118]

In addition, STEM teachers are not adequately compensated for their skills and time and are often drawn to other STEM professions or out of STEM altogether in order to achieve higher salaries.[119] Low salaries drive nearly 20% of public school teachers to work a second job.[120] Further, STEM teaching is not typically considered a "STEM profession."[121] STEM teachers require educational training and certifications and are often expected to teach many science classes, even those beyond their own expertise. Ongoing education is required for teachers to stay up-to-date in fields that are changing rapidly, such as computer science.

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[113] Schaeffer, Katherine. 2021. America's Public School Teachers Are Far Less Racially and Ethnically Diverse Than Their Students. https://www.pewresearch.org/short-reads/2021/12/10/americas-public-school-teachers-are-far-less-racially-and-ethnically-diverse-than-their-students/

[114] U.S. Department of Education. National Center for Education Statistics. 2020. Race and Ethnicity of Public-School Teachers and Their Students. https://nces.ed.gov/pubs2020/2020103/index.asp

[115] Mao, Angela, and Ariane Lee. 2021. The American Teacher's Plight: Underappreciated, Underpaid and Overworked. https://www.nytimes.com/2021/06/15/learning/the-american-teachers-plight-underappreciated-underpaid-and-overworked.html

[116] U.S. Department of Education. Teacher Shortage Areas. https://tsa.ed.gov/#/home/

[117] Krutsch, Emily, and Victoria Roderick. 2022. STEM Day: Explore Growing Careers. https://blog.dol.gov/2022/11/04/stem-day-explore-growing-careers

[118] Smithsonian Institution. 2022. Building Networks and Enhancing Diversity in the K–12 STEM Teaching Workforce. https://ssec.si.edu/includes-sourcebook

[119] Economic Policy Institute. Teacher pay penalty still looms large. Trends in teacher wages and compensation through 2022. https://www.epi.org/publication/teacher-pay-in-2022/

[120] Pew Research Center. 2018. About One-In-Six U.S. Teachers Work Second Jobs – And Not Just in The Summer. https://www.pewresearch.org/short-reads/2019/07/01/about-one-in-six-u-s-teachers-work-second-jobs-and-not-just-in-the-summer/

[121] U.S. Bureau of Labor Statistics. 2023. Occupational Employment and Wage Statistics. https://www.bls.gov/oes/current/oes_stru.htm#19-0000

2.3.3 CoSTEM's Federal Objective for Training STEM Educators

To contribute to this national aspiration, CoSTEM aims to provide federal opportunities that ensure STEM educators have the preparation, support, and continuous professional development required to provide quality STEM instruction to their learners.

2.3.4 Approaches CoSTEM and/or Agencies Could Take toward the Federal Objective of Training STEM Educators

- Identify and broaden opportunities that incentivize STEM majors to enter the teaching profession.
- Increase the use of evidence-based workforce development models such as Registered Apprenticeship Programs for teachers, teacher residency programs, and grow-your-own programs, including pre-service professional development opportunities.
- Promote the use of evidence-based pedagogy[122] in STEM education across pre-K–12 and post-secondary teaching.
- Raise awareness of the opportunities that study evidence-based pedagogies and disseminate findings from this research.
- Promote public-private partnerships that enable engagement with school administrators and teacher leaders to increase the access to and use of evidence-based STEM education resources and to improve the training of and support to STEM teaching professionals.
- Engage classroom pre-service teachers and out-of-school-time educators in collaborative professional development.

2.3.5 Potential Objective Metrics/Measures for Training STEM Educators

- The number of opportunities that expose and support STEM students and/or STEM professionals entering and advancing in the STEM teacher workforce.
- The number of opportunities that engage STEM teachers in research and/or evidence-based professional STEM learning.

[122] U.S. Department of Education. Institute of Education Sciences. What Works Clearinghouse. https://ies.ed.gov/ncee/wwc/FWW

3. Pillar: STEM Workforce

The pillar on STEM Workforce speaks to the opportunities the federal government has to build its federal STEM workforce while also building a national STEM workforce for the private and nongovernmental sectors. This pillar also aims to consider the contributions of international STEM talent who receive training in the U.S. private and nongovernmental sectors, the ways the federal government can support global-minded STEM workers across the nation, and the ways the federal government can support global experiences to diversify the STEM workforce perspective.

3.1 Objective: Training and Recruiting a Federal STEM Workforce

3.1.1 CoSTEM's National Aspirations for Training and Recruiting a Federal STEM Workforce

CoSTEM would like to see a day when the federal STEM workforce reflects the wide range of individuals from across the nation who have the knowledge and skills to further drive innovation in order to meet the nation's current and future challenges.

3.1.2 Challenges and Opportunities for Training and Recruiting a Federal STEM Workforce

It is important that training opportunities build STEM knowledge while also engaging learners and trainees in technical and professional experiences that prepare them to become versatile STEM professionals. Federal agencies can continue to support traineeships, including those that promote innovation, interdisciplinary and transdisciplinary learning, and engagement with a wide range of STEM career pathways. Understanding the important role that work-based learning opportunities[123] play in developing learners' professional skills and career awareness, federal agencies will continue to support programs and foster partnerships that make these work experiences available to postsecondary learners.

Among the greatest challenges toward ensuring a robust federal STEM workforce is the competition for qualified talent with the private sector. In general, industry can offer higher salaries[124] and additional incentives (e.g., signing bonuses). Additionally, the federal STEM workforce is facing a surge in retirements with insufficient replacements, a challenge exacerbated by a broad lack of awareness of the government as a career option, particularly among early career professionals. Furthermore, the need for STEM professionals within the federal workforce continues to grow as the complexity of societal challenges grows.

Another challenge for the federal STEM workforce is that it does not reflect the diversity of the working-age population of the United States. The federal government and educational institutions need to work together to ensure that all students gain access to training so they can develop STEM skills and competencies and ideally have experiences exposing them to the STEM work conducted by federal agencies. Making the federal STEM workforce more representative of the U.S. population will require

[123] Work-based learning means "sustained interactions with industry or community professionals in real workplace settings, to the extent practicable, or simulated environments at an educational institution that foster in-depth, firsthand engagement with the tasks required in a given career field, that are aligned to curriculum and instruction." Such opportunities include, for example, internships, co-ops, and Registered Apprenticeship programs. https://www.govinfo.gov/content/pkg/COMPS-3096/pdf/COMPS-3096.pdf

[124] Analytical Perspectives: Budget of the U.S. Government (Fiscal Year 2025). https://www.whitehouse.gov/wp-content/uploads/2024/03/spec_fy2025.pdf

engagement and recruitment efforts to be directed toward underrepresented communities, in alignment with federal Merit Systems Principles.[125]

In addition to diversifying the pool of STEM talent, the federal government must ensure that hiring processes and retention measures of STEM workers are accessible, transparent, fair, and effective.[126] Agencies must proactively identify and mitigate practices that lead to inequities in hiring, professional development, and promotions. The areas for improvement include ensuring hiring panels have members with diverse perspectives[127] and providing workers with equitable opportunities for skills training to meet rapidly evolving STEM needs and to support career advancement. To be a competitive employer for skilled STEM talent, the federal government needs to ensure that workers have the opportunity to manage their well-being (e.g., by offering telework flexibilities) and also develop a sense of individual purpose in contributing to the mission of the agency.

3.1.3 CoSTEM's Federal Objective for Training and Recruiting a Federal STEM Workforce

To contribute to this national aspiration, CoSTEM aims to improve the training opportunities that are available for STEM learners and workers in preparation for them to enter (or re-enter) federal service and improve the recruitment and hiring practices leading to federal employment.

3.1.4 Approaches CoSTEM and/or Agencies Could Take toward the Federal Objective of Training and Recruiting a Federal STEM Workforce

- Strengthen federal agency recruiting and hiring practices for STEM positions with an emphasis on inclusive hiring practices, including the use of flexible hiring authorities.
- Provide outreach training to federal employees, support social media outreach, and engage employees as outreach ambassadors for federal STEM recruitment.
- Evaluate federal STEM job descriptions, education requirements, and promotion criteria and update as necessary.
- Identify and disseminate evidence-based strategies that are effective for promoting diversity and inclusion in federal STEM careers.
- Expose early career workers from communities underrepresented in STEM to federal career opportunities and request feedback to continuously improve and increase access and opportunities to STEM fields and careers.
- Review and assess research, best practices, and policies across government related to the inclusion of individuals in STEM careers.
- Examine whether barriers exist to promoting diversity and inclusion within federal agencies employing scientists and engineers.
- Leverage federal initiatives and resources (i.e., https://stem.usajobs.gov) to reach skilled and diverse talent aligned with government-wide mission critical occupations and STEM occupations.

[125] U.S. Merit Systems Protection Board. Merit System Principles. https://www.mspb.gov/msp/meritsystemsprinciples.htm

[126] NSTC. 2021. Best Practices for Diversity and Inclusion in Stem Education and Research: A Guide by and for Federal Agencies. https://www.whitehouse.gov/wp-content/uploads/2021/09/091621-Best-Practices-for-Diversity-Inclusion-in-STEM.pdf

[127] U.S. Patent and Trademark Office. 2024. National Strategy for Inclusive Innovation. https://www.uspto.gov/sites/default/files/documents/NationalStrategy.pdf

- Expand the implementation of policies and practices that remove barriers to participation in STEM careers. [128]

3.1.5 Potential Objective Metrics/Measures for Training and Recruiting a Federal STEM Workforce

- The number of paid work-based STEM learning opportunities, which support entry and/or retention in STEM careers.
- The number of STEM opportunities that leverage STEM-focused hiring authorities.
- The transition rate of work-based learning participants to federal employees.

3.2 Objective: Training and Recruiting a National STEM Workforce

3.2.1 CoSTEM's National Aspirations for Training and Recruiting a National STEM Workforce

CoSTEM would like to see a day when the nation's STEM employment needs are assessed rigorously and met equitably and efficiently with stable, quality jobs that provide essential skill-building opportunities for all STEM workers.

3.2.2 Challenges and Opportunities for Training and Recruiting a National STEM Workforce

A robust STEM workforce requires a pool of talent with the education and training to meet the immediate and long-term needs of the U.S. economy. STEM jobs at all levels often provide well-paid, stable work that allow individuals, families, and communities to build a prosperous future in alignment with the Good Jobs Principles articulated by the Departments of Labor and Commerce.[129]

A critical challenge with training and recruiting a national STEM workforce is the need to further develop the current workforce data infrastructure to better identify STEM workforce and training needs and to develop effective policy responses.[130] Supplementing currently available federal data sources (e.g., National Center for Science and Engineering Statistics, Census Bureau, and Bureau of Labor Statistics) with additional reliable and timely information that is demographically and geographically representative will facilitate identification and analysis of labor and training gaps. Greater availability of data also helps ensure equitable participation in the STEM workforce, including by people from underrepresented and underserved communities. A robust workforce data infrastructure is required for (1) employers to understand and articulate the skills that employees need to be successful; (2) education and training providers to create curriculum and prepare workers; and (3) workers to have the STEM knowledge for the jobs they seek.

Developing a robust STEM workforce requires diversifying the pool of individuals with the skills and competencies needed to meet the immediate and long-term needs of the U.S. economy. STEM workers, both domestic and international, can be recruited and trained using multiple pathways—including through targeted partnerships with institutions serving significant percentages of students from communities historically underrepresented in the STEM workforce, career and technical education programs, community colleges, Registered Apprenticeship Programs, and other credentialing

[128] NSTC. 2021. Best Practices for Diversity and Inclusion in STEM Education and Research: A Guide by and for Federal Agencies. https://www.whitehouse.gov/wp-content/uploads/2021/09/091621-Best-Practices-for-Diversity-Inclusion-in-STEM.pdf

[129] U.S. Department of Commerce and U.S. Department of Labor, Good Jobs Principles, 2022. https://www.dol.gov/general/good-jobs/principles

[130] U.S. Government Accountability Office. Science, Technology, Engineering, and Mathematics Education: Assessing the Relationship between Education and the Workforce. https://www.gao.gov/products/gao-14-374

opportunities—to enter the national STEM workforce in areas that align with critical and emerging workforce needs. A healthy STEM labor market also requires employers to clearly articulate the necessary qualifications for jobs in order to communicate their needs to potential employees and to institutions providing training and education at all levels, including in pre-K–12 settings, community colleges, career and technical education programs, and other college and university settings. For example, employers nationwide have found it useful to reassess their skill requirements and at times replace degree requirements with specific skills, competencies, or demonstrated experience—federal agencies should continue to prioritize this practice.[131]

Obtaining the STEM education and training that is necessary for both STEM and STEM-adjacent jobs is a critical challenge. Many of the barriers to accessing education are not STEM-specific: they include a lack of awareness of career opportunities, the high cost of education, the difficulty of balancing education with work, and family responsibilities. In addition, multiple intersecting barriers stemming from socioeconomic, physical, and institutional factors—and, in many instances, a legacy of explicit and implicit bias and discrimination—impede availability of and access to quality, affordable educational and training opportunities. Pervasive bias and discrimination experienced by people from underrepresented and underserved communities when seeking employment exacerbate the barriers they face in entering occupations requiring STEM knowledge and skills. Despite efforts to address these and other barriers to participation in STEM, barriers persist.[132] Ensuring access to STEM education and training and eliminating barriers to the participation of people from underrepresented and underserved communities is critical to meeting the current and future growing demand for labor.

All STEM learners and workers can benefit from work-based learning opportunities to complement academic studies. Work-based learning opportunities can include internships, co-ops, and Registered Apprenticeship Programs, which are considered the gold standard in work-based learning and can be utilized at all levels, including high school, career and technical education, community colleges, and four-year colleges. Finally, hiring a national STEM workforce will require improved recruitment and retention policies.[133] As discussed, recruitment of individuals from groups historically underrepresented in STEM is key to diversifying the STEM workforce, which, in turn, is critical to building the robust STEM workforce that the nation needs. Improving retention will require employers to provide incentives, such as competitive benefits and opportunities for professional development and career advancement, and to ensure safe and supportive STEM environments.

3.2.3 CoSTEM's Federal Objective for Training and Recruiting a National STEM Workforce

To contribute to this national aspiration, CoSTEM aims to recruit and train learners and workers equitably through multiple pathways—including through career and technical education programs at the secondary and postsecondary level and other community college programs—to enter the national STEM workforce in areas that align with critical and emerging workforce needs.

[131] Guidance Release - E.O. 13932; Modernizing and Reforming the Assessment and Hiring of Federal Job Candidates. https://chcoc.gov/content/guidance-release-eo-13932-modernizing-and-reforming-assessment-and-hiring-federal-job

[132] NSTC. 2024. Best Practices for Reducing Organizational, Cultural, and Institutional Barriers in STEM Research. https://www.whitehouse.gov/wp-content/uploads/2024/05/CoSTEM-IWGIS-Barriers-Report.pdf

[133] Consistent with Good Jobs Principles articulated by the U.S. Department of Labor. https://www.dol.gov/general/good-jobs/principles

3.2.4 Approaches CoSTEM and/or Agencies Could Take toward the Federal Objective of Training and Recruiting a National STEM Workforce

- Increase awareness of successful on-ramps to quality Registered Apprenticeships and support retention and completion efforts in Registered Apprenticeships.
- Improve the integration of apprenticeship retention services such as apprenticeship mentor programs, flexible caregiving supports, and wrap-around services.
- Ensure federally funded STEM programming and training opportunities are informed by available workforce data related to needed STEM skills and competencies.
- Promote work-based learning opportunities, the uptake of competency- and skills-based hiring practices, and employability skills development in order to broaden the pool of potential national STEM workers, including STEM skilled technical workers.[134,135]
- Review and assess research, best practices, and policies to minimize the effects of implicit bias and other systemic factors in hiring, performance evaluation, and promotion in the STEM workforce.
- Expand the implementation of policies and practices that remove barriers to participation in STEM careers.[136]
- Foster multi-agency efforts and multi-sector partnerships between pre-K–12 schools; career and technical educational programs at the secondary and postsecondary level; other community college programs; industry; community-based and other non-national organizations; and local and/or state governments in support of equitable workforce outcomes for national STEM workers, including STEM skilled technical workers.[137,138139]

3.2.5 Potential Objective Metrics/Measures for Training and Recruiting a National STEM Workforce

- The number of opportunities focused on effective and equitable talent development outcomes toward building a national STEM workforce.
- The number of opportunities focused on effective and equitable talent development outcomes toward building a national STEM skilled technical workforce.

[134] Smaldone, F., Ippolito, A., Lagger, J., and Pellicano, M. 2022. Employability skills: Profiling data scientists in the digital labour market. European Management Journal 40. https://doi.org/10.1016/j.emj.2022.05.005

[135] van Laar, E., van Deursen, A.J.A.M., van Dijk, J.A.G.M., de Haan, J. 2020. Determinants of 21st-century skills and 21st-century digital skills for workers: A systematic literature review. SAGE Open. https://doi.org/10.1177/2158244019900176

[136] NSTC. 2021. Best Practices for Diversity and Inclusion in STEM Education and Research: A Guide by and for Federal Agencies. https://www.whitehouse.gov/wp-content/uploads/2021/09/091621-Best-Practices-for-Diversity-Inclusion-in-STEM.pdf

[137] Smaldone, F., Ippolito, A., Lagger, J., and Pellicano, M. 2022. Employability skills: Profiling data scientists in the digital labour market. European Management Journal 40. https://doi.org/10.1016/j.emj.2022.05.005

[138] van Laar, E., van Deursen, A.J.A.M., van Dijk, J.A.G.M., de Haan, J. 2020. Determinants of 21st-century skills and 21st-century digital skills for workers: A systematic literature review." SAGE Open. https://doi.org/10.1177/2158244019900176

[139] Examples of Industry-Led Workforce Training Partnerships. https://www.eda.gov/news/press-release/2022/08/03/us-department-commerce-announces-winners-american-rescue-plan-500

3.3 Objective: Cultivating a Global STEM Workforce Nationally and a National STEM Workforce Globally

3.3.1 CoSTEM's National Aspirations for Cultivating a Global Workforce Nationally and a National Workforce Globally

CoSTEM would like to see a day when the United States continues to be the destination of choice for top international STEM talent, while developing a globally engaged domestic workforce that advances U.S. leadership in discovery and innovation, economic prosperity, and national security.

3.3.2 Challenges and Opportunities for Cultivating a Global Workforce Nationally and a National Workforce Globally

International exchanges and collaborations play an essential role in sustaining a vibrant U.S. science and technology enterprise—they are critical to discovery, innovation, and maintaining a globally competitive U.S. STEM workforce. International exchanges and collaborations bolster the economic prosperity of the nation, advance collective problem-solving, and support national security and world peace.[140,141,142]

To maintain STEM leadership, the United States must successfully attract, recruit, retain, and integrate top STEM talent from all over the world. Although the benefits of welcoming foreign-born STEM professionals are widely recognized, these professionals often face substantial barriers to joining the U.S. STEM workforce due to limited immigration options. Barriers to entering the U.S. STEM workforce are faced by the hundreds of thousands of foreign-born STEM students who study and earn degrees at U.S. educational institutions each year.[143] Meanwhile, the nation's allies and competitors are changing their immigration policies to recruit more top talent.[144,145,146] Further, individuals who earn degrees and/or professional credentials in other countries may find it difficult to have their degrees and credentials recognized in the United States. Standards for verification and acceptance of degrees and credentials vary widely, often dependent on the discipline, the country where the degree or certificate was earned, and the location of the individual's work opportunity in the United States.

On an increasingly competitive global playing field, U.S. STEM workers need more than technical skills. It is essential to prepare and equip U.S. STEM learners and professionals with skills, knowledge, and experiences to support successful work with partners from around the world. These skills include teamwork skills, problem-solving skills, fluency in other languages, and cultural competencies.

[140] National Academies of Sciences, Engineering, and Medicine. International Talent Programs in the Changing Global Environment. https://www.nationalacademies.org/our-work/international-talent-programs-in-the-changing-global-environment

[141] U.S. National Science Foundation. 2022. National Science Board. International STEM Talent is Crucial for a Robust U.S. Economy. https://www.nsf.gov/nsb/sei/one-pagers/NSB-International-STEM-Talent-2022.pdf

[142] https://www.whitehouse.gov/briefing-room/statements-releases/2022/01/21/fact-sheet-biden-harris-administration-actions-to-attract-stem-talent-and-strengthen-our-economy-and-competitiveness/

[143] Burke, A., Okrent, A., and Hale, K. 2022. The State of U.S. Science and Engineering 2022. National Science Board Science and Engineering Indicators. https://ncses.nsf.gov/pubs/nsb20221/u-s-and-global-stem-education-and-labor-force

[144] National Foundation for American Policy. 2022. Analysis of U.S. and Canadian International Student Data. https://nfap.com/studies/analysis-of-u-s-and-canadian-international-student-data/

[145] IDA Science and Technology Policy Institute. 2024. Characterizing the Loss of Talent from the U.S. STEM Ecosystem. https://www.ida.org/-/media/feature/publications/c/ch/characterizing-the-loss-of-talent-from-the-us-stem-ecosystem/product-3001891.ashx

[146] Nuwer, Rachel. 2024. Why China has been a growing study destination for African students. Nature 630, S14-S16. https://doi.org/10.1038/d41586-024-01599-z

International exchanges significantly enhance STEM talent development. These programs expand worldviews; foster cultural understanding; facilitate relationship-building; stimulate new ideas; and promote the creation of products and solutions that are more universal. International exchange programs can also provide economic growth opportunities to individuals, as well as public and private sector organizations, and can inspire collaborations to address the world's greatest challenges.

3.3.3 CoSTEM's Federal Objective for Cultivating a Global Workforce Nationally and a National Workforce Globally

To contribute to this national aspiration, CoSTEM aims to maintain a globally engaged U.S. STEM workforce that includes international STEM talent.

3.3.4 Approaches CoSTEM and/or Agencies Could Take toward the Federal Objective of Cultivating a Global Workforce Nationally and a National Workforce Globally

- Expand opportunities for U.S. STEM learners and researchers to participate in international exchanges and collaborations consistent with strong research security practices.
- Develop uniform standards and mechanisms to regularly evaluate foreign degrees and professional certifications in STEM fields.
- Reduce barriers to bring foreign STEM talent into and retain foreign STEM talent in the United States.
- Leverage federal initiatives and resources that support students from low- and middle-income countries to engage with the U.S. STEM research enterprise
- Support visitor exchange programs with HBCUs, other MSIs, and institutions in Established Program to Stimulate Competitive Research (EPSCoR) jurisdictions, as well as training and career development programs at all educational levels that may increase the capacity of interested institutions to more readily engage with international partners.
- Provide opportunities for researchers in STEM fields at HBCUs, other MSIs, and institutions in EPSCoR jurisdictions to participate in international STEM collaborations and provide any additional mechanisms to positively impact U.S. representation in international STEM settings.[147]

3.3.5 Potential Objective Metrics/Measures for Cultivating a Global Workforce Nationally and a National Workforce Globally

- The number of opportunities that STEM students and researchers have to engage in international STEM learning and research exchanges, as well as the outputs and outcomes that demonstrate increased access and opportunity for participating learners and institutions.

[147] NSTC. 2024. Biennial Report to Congress on International Science and Technology Cooperation. https://www.whitehouse.gov/wp-content/uploads/2024/02/2024-Biennial-Report-to-Congress-on-International-Science-Technology-Cooperation.pdf

4. Pillar: STEM Research and Innovation Capacity

The pillar on STEM Research and Innovation Capacity addresses the continued need for the federal government to support the advancement of research related to learning and teaching in STEM fields to improve education and learning for people of all ages in all STEM environments. This pillar also aims to ensure that more individuals and institutions are engaged in the research enterprise, particularly at HBCUs, TCUs, and other MSIs; ERIs; and institutions located and/or serving those in rural communities. Given the interdependent nature of the pillars, this pillar additionally focuses on the need to build the capacity of learners, workers, and researchers in the innovation enterprise.

4.1 Objective: Advancing STEM Education Research

4.1.1 CoSTEM's National Aspirations for Advancing STEM Education Research

CoSTEM would like to see a day when the nation's STEM education researchers, including those at under-resourced institutions, are conducting research and generating widely used evidence-based tools to leverage and advance STEM learning, teaching, and equity in ways that center the voices of those most impacted by emerging and long-term societal challenges.

4.1.2 Challenges and Opportunities for Advancing STEM Education Research

In 2019, the National Assessment of Educational Progress (NAEP) assessment[148] of students' science knowledge revealed that over 25% of fourth graders scored below the NAEP basic achievement level—and by 12th grade, that percentage grew to over 40%. NAEP math scores show similar trends. Meanwhile, there is a nationwide call to grow the STEM workforce to address everything from maintaining national security to upholding global leadership in STEM innovation. Still, women, individuals from underrepresented racial and ethnic groups, individuals from rural areas, and people with disabilities continue to have fewer opportunities and face additional barriers to engaging in STEM throughout their education experiences. The lack of representation across the STEM workforce stifles innovation, limits the relevance of STEM outcomes to the everyday lives of the nation's diverse population, and reduces the creative capacity of the STEM workforce. Education R&D—along with sustained outreach and dissemination of existing research evidence—is needed to bring promising, evidence-based practices into the classroom and to broaden participation across STEM talent pathways.

While there is established research on developing STEM talent, there is a need to evaluate the efficacy of STEM education programs to determine if they are improving students' outcomes at all education levels, fostering persistence in STEM fields, and broadening participation in STEM talent pathways. It is imperative that federal investments support opportunities for STEM education researchers and communities to work together to translate research findings into effective and scalable practices, products, and tools.[149] Relatedly, despite efforts and policies to make the results of R&D investments available to the public, there remain barriers to finding the results of federally funded projects, including a lack of shared infrastructure to consolidate STEM education and STEM talent findings across the multiple federal agencies that support this work.

[148] 2019 National Assessment of Education Progress Science Assessment results available for grade 4 at https://www.nationsreportcard.gov/science/nation/scores/?grade=4 and for grade 12 at https://www.nationsreportcard.gov/science/nation/scores/?grade=12

[149] U.S. Patent and Trademark Office. 2024. National Strategy for Inclusive Innovation. https://www.uspto.gov/sites/default/files/documents/NationalStrategy.pdf

There is no universal set of standards across all federal agencies for evaluating the efficacy of STEM education programs[150] and the types of long-term data that would be useful to track progression through STEM education and talent pathways, as agency programming varies in meaningful ways.

4.1.3 CoSTEM's Federal Objective for Advancing STEM Education Research

To contribute to this national aspiration, CoSTEM aims to increase the body of knowledge and the applications of available knowledge in STEM education. This will increase the impacts of research findings and to scale further innovation based on evidence and emergent and long-term societal needs.

4.1.4 Approaches CoSTEM and/or Agencies Could Take toward the Federal Objective of Advancing STEM Education Research

- Expand capacity, data/data systems, and resources to support the development and equitable scaling of evidence-based products and tools that help drive more discovery and innovation.
- Increase the use of STEM education research findings and use-inspired research to improve STEM education at all levels.
- Develop or expand the available infrastructure to share information on funding opportunities for federal R&D on STEM education, including outputs[151] and outcomes[152] of these opportunities.
- Increase awareness of the opportunities that exist to build STEM education and education R&D talent.

4.1.5 Potential Objective Metrics/Measures for Advancing STEM Education Research

- The number of opportunities in which the public, the researcher/practitioner community, and/or other communities that are impacted by research results have ways to inform future STEM education research efforts.
- The number of opportunities offered, the resources disseminated, and feedback received from the STEM community on how they are utilizing federal STEM opportunities and resources.

4.2 Objective: Advancing STEM Research Capacity

4.2.1 CoSTEM's National Aspirations for Advancing STEM Research Capacity

CoSTEM would like to see a day when there is a diverse representation of institutions of all types and sizes in the STEM research enterprise.

4.2.2 Challenges and Opportunities for Advancing STEM Research Capacity

The scientific and technological progress of the nation should support an equitable distribution of STEM research opportunities and funding. Yet, only 3% of R&D institutions receive 40% of total R&D expenditures, with 24 institutions exceeding $1 billion each in FY21 out of a $96 billion overall funding

[150] U.S. Department of Education. Institute of Education Sciences. Common Guidelines for Education Research and Development. https://ies.ed.gov/pdf/CommonGuidelines.pdf

[151] Output: Direct products of education efforts, usually measured in terms of the volume of work accomplished or the number of classes taught, people served, or educational materials distributed. Outputs are not ends in themselves; rather, they are products that lead to a desired outcome. OMB M-20-12. https://www.whitehouse.gov/wp-content/uploads/2020/03/M-20-12.pdf

[152] Outcome: Desired affect that an education effort is designed to have (e.g., improved understanding of a STEM concept, changes in instructional practices, or an increased number of students pursuing STEM degrees or careers). OMB M-20-12. https://www.whitehouse.gov/wp-content/uploads/2020/03/M-20-12.pdf

pool.[153] This disparity widens the gap between well-resourced, usually majority-serving institutions[154] and less-resourced institutions, where most MSIs fall. This inequity prevents the nation from fully recognizing and utilizing the country's STEM potential.

In order for more institutions to participate in the STEM R&D enterprise, under-resourced institutions must build their capacities and capabilities to apply for, secure, and implement federal research awards. This requires investment in the personnel, physical space, instrumentation and equipment, technology and digital resources, and administrative supports that comprise a robust institutional research infrastructure. As one of the largest funders of basic research in the United States, the federal government has a stake in the research development successes of under-resourced institutions and ERIs, including institutions in rural areas or EPSCoR jurisdictions. Federal agencies have an important role to play in ensuring such institutions are aware of and can successfully secure federal research funding.

4.2.3 CoSTEM's Federal Objective for Advancing STEM Research Capacity

To contribute to the national aspiration, CoSTEM aims to increase the engagement and participation of learners and faculty in STEM education and research opportunities and build the institutional capacity at HBCUs, TCUs, MSIs, and ERIs to ensure a more equitable distribution of research opportunities and funding across the research enterprise.

4.2.4 Approaches CoSTEM and/or Agencies Could Take toward the Federal Objective of Advancing STEM Research Capacity

- Provide sustained outreach efforts that increase clarity, transparency, and accountability of agency investments in STEM education and research for HBCUs, TCUs, and MSIs, including such institutions in rural areas or EPSCoR jurisdictions.
- Improve the participation of HBCUs, TCUs, and MSIs in federal STEM programs, initiatives, and opportunities, particularly within critical and emerging research areas and within federal STEM opportunities in which HBCUs, TCUs, and MSIs are underrepresented or are not represented.
- Increase the capacity of HBCUs, TCUs, and MSIs to compete effectively for grants, contracts, and/or cooperative agreements.
- Expand federal implementation of the policies and practices that remove barriers to the participation of HBCUs, TCUs, MSIs, and ERIs.[155]
- Increase clarity and visibility of the federal opportunities that effectively support capacity building efforts in STEM education and research and the opportunities that exist for ERIs to implement and study innovative approaches for building capacity and sustainable competitiveness.

[153] U.S. National Science Foundation. 2021. Higher Education Research and Development (HERD) Survey. https://ncses.nsf.gov/surveys/higher-education-research-development/2021

[154] U.S. National Science Foundation. Degree-granting postsecondary institutions, by control and level of institution: Selected years, 1949-50 through 2019-20. https://nces.ed.gov/programs/digest/d20/tables/dt20_317.10.asp?current=yes

[155] NSTC. 2024. Advancing Research Capacity at High Research Activity Historically Black Colleges and Universities. https://www.whitehouse.gov/wp-content/uploads/2024/05/CoSTEM-HBCU-Report.pdf

4.2.5 Potential Objective Metrics/Measures for Advancing STEM Research Capacity

- The number of education and research proposals received from HBCUs, TCUs, other MSIs, and other ERIs.
- The number of HBCUs, TCUs, and MSIs as recipients of grants, contracts, or other awards (i.e., cooperative agreements or other transaction authorities).

4.3 Objective: Building STEM Innovation Capacity

4.3.1 CoSTEM's National Aspirations for Building STEM Innovation Capacity

CoSTEM would like to see a day when all Americans have equitable access to learning, participation, and training opportunities in STEM innovation that enable them to solve current and future societal challenges.

4.3.2 Challenges and Opportunities for Building STEM Innovation Capacity

Innovation and entrepreneurship are central to the nation's values.[156,157,158] While longstanding inequities in opportunities and access to education, innovation, and entrepreneurship have narrowed over the years, they are still pervasive. Providing equitable access to participation, learning, and training opportunities in STEM for all continues to be a national imperative to spur innovation and entrepreneurship and to ensure that the nation is prepared to tackle societal and technological challenges.

Existing policies to expand access to, opportunities in, and capacity for STEM innovation and entrepreneurship do not adequately take into consideration existing academic and technological disparities. For instance, students, schools, and small businesses from under-resourced communities (e.g., communities with limited internet access or low levels of technology ownership)[159,160,161] are less likely to be aware of, have access to, and participate in the available opportunities due to gaps in financial, human, and/or technological capital. Additionally, across all demographics, there is a fundamental lack of awareness and knowledge about IP (e.g., patents, trademarks, copyrights) and its impact on the ability of individuals to fully realize their entrepreneurship and innovation potential[162]—these gaps must be addressed.

As discussed in Objective 1.1: Engaging Youth and Families and Increasing Inspiration in STEM, additional collaboration across the STEM ecosystem is needed to provide equitable access to STEM

[156] U.S. Economic Development Administration. National Advisory Council on Innovation and Entrepreneurship (NACIE). https://www.eda.gov/strategic-initiatives/national-advisory-council-on-innovation-and-entrepreneurship

[157] U.S. Small Business Administration. Invention, Innovation, and Entrepreneurship Advisory Committee. https://www.sba.gov/about-sba/organization/sba-initiatives/invention-innovation-entrepreneurship-advisory-committee

[158] U.S. Patent and Trademark Office. Council for Inclusive Innovation (CI2). https://www.uspto.gov/initiatives/equity/ci2

[159] Miller, Michael. 2023. "Residents in 'digital deserts' have fewer health care options." UC News. https://www.uc.edu/news/articles/2023/06/patients-who-live-in-the-united-states-digital-deserts-have-less-access-to-health-care.html

[160] Pew Research Center. 2021. Some digital divides persist between rural, urban and suburban America. https://www.pewresearch.org/short-reads/2021/08/19/some-digital-divides-persist-between-rural-urban-and-suburban-america/

[161] U.S. Department of Education. 2022. Office of Educational Technology. Advancing Digital Equity for All. https://tech.ed.gov/files/2022/09/DEER-Resource-Guide_FINAL.pdf

[162] World Intellectual Property Organization. Global Intellectual Property Perception Survey 2023. https://tind.wipo.int/record/48527?v=pdf

learning and to ensure that the opportunities for STEM innovation and entrepreneurship are responsive to the needs of and have buy-in from the targeted communities. This will also require private sector buy-in and resources as well as partnerships across federal, academic, and community partners.

4.3.3 CoSTEM's Federal Objective for Building STEM Innovation Capacity

To contribute to the national aspiration, CoSTEM aims to increase opportunities to embed invention education and innovation and entrepreneurship training across the STEM ecosystem.

4.3.4 Approaches CoSTEM and/or Agencies Could Take toward the Federal Objective of Building STEM Innovation Capacity

- Increase access to learning and training opportunities that enable and build innovation capacity in all learners and workers.[163]
- Improve the awareness of invention, entrepreneurship, and IP literacy as integral components of the STEM ecosystems.[164]
- Increase the dissemination of invention- and IP- supportive curriculum, digital tools, and other educator resources as well as improve the awareness of inventor and entrepreneur career pathways.
- Increase access to opportunities that support development of technological and innovation infrastructure that can increase participation in the STEM innovation ecosystem.
- Improve exposure and participation of institutions (i.e., MSIs and ERIs) in research and commercialization programs that can provide innovation training and support STEM job creation through entrepreneurship/startups.

4.3.5 Potential Objective Metrics/Measures for Building STEM Innovation Capacity

- The number of federal opportunities that offer or provide access to invention education and/or innovation and entrepreneurship training experiences.

[163] Summary and Analysis of Request for Information to Make Access to the Innovation Ecosystem More Inclusive and Equitable. https://www.whitehouse.gov/wp-content/uploads/2022/09/09-2022-Equitable_Innovation_Ecosystem_RFI_Analysis_Public_Clean.pdf

[164] U.S. Patent and Trademark Office. Teachers and Classrooms Division. https://www.uspto.gov/about-us/organizational-offices/office-chief-communications-officer/office-education-and-outreach

5. Pillar: STEM Environments

Removing barriers to career advancement, supporting flexibilities important to career continuation, and promoting safe and inclusive workspaces have been recognized as priorities for the nation to remain globally competitive in science, technology, and innovation.[165] The pillar on STEM Environments addresses the need to remove the barriers that keep individuals from entering and persisting in STEM fields and careers. This pillar aims to promote STEM learning environments that retain and advance learners, workers, and researchers in particular. This pillar also aims to promote STEM working environments in which critical life events do not cause individuals to leave the workforce and that provide opportunities for them to continue in their careers. If individuals leave, they can re-enter, re-skill, or up-skill as needed. This pillar speaks to the conditions needed in STEM research environments to reduce bias, discrimination, and harassment.

5.1 Objective: Removing Barriers and Supporting Career Trajectories in STEM Learning Environments

5.1.1 CoSTEM's National Aspirations for Removing Barriers and Supporting Career Trajectories in STEM Learning Environments

CoSTEM would like to see a day when the individuals who have an interest in STEM or who work in academic STEM settings have the supportive role models and mentors they need in an inclusive environment that fosters career development and promotion.

5.1.2 Challenges and Opportunities for Removing Barriers and Supporting Career Trajectories in STEM Learning Environments

Incremental changes over the last few years have resulted in a more diverse and representative population across STEM learning and the STEM workforce. However, multiple groups remain underrepresented in STEM.[166] The diversity of those holding leadership positions is critical to achieving progress toward inspiring and mentoring the next generation of STEM talent, but women of color, for example, hold only 4% of STEM leadership roles.[167] The lack of representation in leadership positions across the country prevents the empowerment and future leadership potential of diverse and creative talent in STEM fields. Attrition across STEM education and workforce pathways contributes to individuals not seeing themselves within STEM occupations or positions of power, leading to further attrition, particularly among women and historically underrepresented populations.[168]

While effective mentors from diverse backgrounds are critical for nurturing and developing STEM learning and workforce pathways, mentors are often inadequately supported and compensated. STEM mentors and STEM professionals in leadership positions, especially those in positions of power, need to provide safe environments for students, trainees, and scientists at all career stages. Mentors may not

[165] Deliverable 5.1 - G20 Recommendations on Diversity, Equity, Inclusion, and Accessibility in Science, Technology, and Innovation. 2024. G20 Research and Innovation Working Group. https://www.whitehouse.gov/wp-content/uploads/2024/09/G20-RIWG-Deliverable-5.1.pdf

[166] Women, people with disabilities, Hispanic or Latino individuals, Black or African American individuals, and American Indian or Alaska Native individuals are underrepresented in the STEM workforce relative to their share of the national adult population. https://ncses.nsf.gov/pubs/nsf23315

[167] Association for Women in Science. 2019. Transforming STEM Leadership Culture. https://awis.org/leadership-report/

[168] Sithole, A. et al. 2017. Student Attraction, Persistence and Retention in STEM Programs: Successes and Continuing Challenges. Higher Education Studies. 7, 1. https://files.eric.ed.gov/fulltext/EJ1126801.pdf

be able to request and receive personalized, culturally relevant training on how to best support their mentees.[169,170,171]

Furthermore, mentors—particularly those who come from groups that are historically underrepresented or who are employed at historically underserved institutions—often shoulder a disproportionate burden of mentorship responsibilities for students and professionals from underrepresented populations. In many cases, faculty mentors must balance their mentoring responsibilities with course preparation, high teaching loads, and rigorous research programs, leaving little time for intentional career development. Unique barriers can also cause slower promotion paces for STEM professionals.[172,173]

Assessments of the culture of STEM environments, and intentional evidence-based efforts to shift these cultures, are required to remove barriers and support the recruitment, retention, and advancement of all individuals in STEM.

5.1.3 CoSTEM's Federal Objective for Removing Barriers and Supporting Career Trajectories in STEM Learning Environments

To contribute to this national aspiration, CoSTEM aims to increase access to high-quality STEM career training, mentorship, and professional development opportunities that support promotion, advancement, and leadership in STEM learning environments/academic STEM environments, and implement other practices that reduce the cultural and institutional barriers to STEM careers.

[169] OSTP and OPM. 2016. Reducing the Impact of Bias in the STEM Workforce: Strengthening Excellence and Innovation. https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/ostp-opm_bias_mitigation_report__20161129.pdf

[170] Center for the Improvement of Mentored Experiences in Research. Culturally Aware Mentoring. https://cimerproject.org/cam-nrmn/

[171] NSTC. 2021. Best Practices for Diversity and Inclusion in STEM Education and Research: A Guide by and for Federal Agencies. https://www.whitehouse.gov/wp-content/uploads/2021/09/091621-Best-Practices-for-Diversity-Inclusion-in-STEM.pdf

[172] Progress Toward Gender Equality in Research and Innovation. 2024. https://assets.ctfassets.net/o78em1y1w4i4/1yMfcH2t3uBjhsTeujhJbA/17174d4978b52fdd0a0f280c335993d4/R01428_ELS_Gender_Report_2024_Infographics_Longform_Global_v5.pdf

[173] National Academies of Sciences, Engineering, and Medicine. 2020. Promising Practices for Addressing the Underrepresentation of Women in Science, Engineering, and Medicine: Opening Doors. Washington, DC: The National Academies Press. https://doi.org/10.17226/25585

5.1.4 Approaches CoSTEM and/or Agencies could take toward the Federal Objective of Removing Barriers and Supporting Career Trajectories in STEM Learning Environments

- Promote equitable access to mentorship, sponsorship, career development, and recruitment and retention opportunities.
- Expand mentee-/trainee-centric mentorship, sponsorship, and career development/training opportunities for STEM learners, academic workers, and researchers.
- Identify and incentivize recruitment, retention, and promotion opportunities within federally funded academic STEM environments.
- Collect and disseminate evidence-based practices that remove or reduce cultural and institutional barriers that limit the recruitment, retention, and success of groups historically underrepresented in STEM, including individuals pursuing STEM research careers and participation in the federal research enterprise.
- Implement evidence-based policies and practices that support organizational change, including climate surveys and training opportunities.[174]

5.1.5 Potential Objective Metrics/Measures for Removing Barriers and Supporting Career Trajectories in STEM Learning Environments

- The number of federal and/or federally funded graduate students and/or postdoctoral fellows that utilize a mentorship plan or other career development safeguards.
- The number of policies, procedures, and/or resources developed or maintained and implemented to reduce barriers to participation and advancement in federal and/or federally funded STEM learning environments.

5.2 Objective: Removing Barriers and Supporting Career Flexibilities in STEM Working Environments

5.2.1 CoSTEM's National Aspirations for Removing Barriers and Supporting Career Flexibilities in STEM Working Environments

CoSTEM would like to see a day when STEM working environments intentionally facilitate the continuation of and re-entry into STEM learning or STEM careers during and after life events—such as childbirth, caregiving, illness, and disability—experienced by many individuals across the country.

5.2.2 Challenges and Opportunities for Removing Barriers and Supporting Career Flexibilities in STEM Working Environments

Recent demographic shifts in STEM learning and the STEM workforce indicate growing interest and commitment to STEM careers from historically underrepresented groups, such as women.[175,176] However, retention in STEM learning and working environments remains a challenge; several drivers contribute to individuals' decisions to exit the STEM ecosystem and create barriers to re-entry. Life events, such as illness and caregiving responsibilities, are examples of such drivers and can be

[174] NSTC. 2024. Best Practices for Reducing Organizational, Cultural, and Institutional Barriers in STEM Research. https://www.whitehouse.gov/wp-content/uploads/2024/05/CoSTEM-IWGIS-Barriers-Report.pdf

[175] NSTC. 2021. Best Practices for Diversity and Inclusion in STEM Education and Research: A Guide by and for Federal Agencies. https://www.whitehouse.gov/wp-content/uploads/2021/09/091621-Best-Practices-for-Diversity-Inclusion-in-STEM.pdf

[176] U.S. Census Bureau. Women Making Gains in STEM Occupations but Still Underrepresented. https://www.census.gov/library/stories/2021/01/women-making-gains-in-stem-occupations-but-still-underrepresented.html

particularly disruptive for groups already underrepresented in STEM. For example, the STEM careers of women and other persons from underrepresented groups (such as socioeconomically disadvantaged persons) are disproportionately affected by caregiving responsibilities.[177,178] Ensuring access to affordable on-site childcare is a particular challenge for families with young children. Currently, many STEM environments lack adequate policies and practices to support re-entry after a life event. Further, few STEM environments offer flexibilities that provide ongoing support to persons who may return but face ongoing responsibilities due to the life event (e.g., caregiving).

However, several recommendations and potential actions for changes to federal and non-federal policies and practices to support STEM researchers with caregiving responsibilities have been identified.[179] Major recommendations for federal action include incentivizing mentoring, allowing for caregiver cohort support, and providing allowances for flexibility in federal grant award timing and funding cycles. Other notable recommendations include conducting additional studies and needs assessments for STEM researchers with caregiving responsibilities and focusing on organizational and systems change to prevent caregiving responsibilities from being a barrier or challenge in STEM careers.

It is also important to note veterans and military spouses benefit from increased flexibilities in STEM careers. Veterans experience vastly different transitions from the military to civilian life based on their location, training, education level, timeframe for transition, and personal situations. The majority of military spouses experience at least three moves during the military careers of their spouses, and they are ten times more likely to relocate across state lines than their civilian counterparts.[180] Increased opportunities for these highly mobile military spouses could improve military readiness, retention, and recruitment, as the stress that unemployment creates in military families impacts a family's decision to leave or remain in the military.[181] Military spouses can experience barriers in their own employment due to frequent relocations during their spouse's military service, particularly when the active-duty member attends short-term military training (e.g., basic schools or career courses) which may prevent a spouse from securing and maintaining continuous local employment.

Innovative technical solutions, along with flexible workplace rules, have significantly enabled remote work for many Americans. This shift has the potential to reduce many of the traditional barriers experienced by veterans and military spouses pursuing STEM careers. In addition to traditional STEM pathways that yield four-year or advanced degrees, and in order to meet evolving workforce and industry needs, employment opportunities offered must include experiential training opportunities, short-term credentialing, and two-year degree options to further support re-skilling, re-entry, and

[177] National Academies of Sciences, Engineering, and Medicine. 2020. Promising Practices for Addressing the Underrepresentation of Women in Science, Engineering, and Medicine: Opening Doors. Washington, DC: The National Academies Press. https://doi.org/10.17226/25585

[178] E. Cech, M. Blair-Loy. 2019. The changing career trajectories of new parents in STEM. Proc. Natl. Acad. Sci. U.S.A. 116. https://doi.org/10.1073/pnas.1810862116

[179] NSTC. 2024. Federal Policies and Practices to Support STEM Researchers with Caregiving Responsibilities. https://www.whitehouse.gov/wp-content/uploads/2024/05/CoSTEM-IWGIS-Caregivers-Report.pdf

[180] Syracuse University. Institute for Veterans and Military Families. The Force Behind the Force: A Business Case for Leveraging Military Spouse Talent. https://ivmf.syracuse.edu/wp-content/uploads/2019/10/ForceBehindtheForce.BusinessCaseforLeveragingMilitarySpouseTalentACC_02.21.18.pdf

[181] NSTC. 2021. Strategic Plan to Improve Representation of Veterans and Military Spouses in STEM Careers. https://www.whitehouse.gov/ostp/news-updates/2021/12/31/nstc-strategic-plan-to-improve-representation-of-veterans-and-military-spouses-in-stem-careers/

upskilling needs. STEM career pathways with flexibility and portability are key to overcoming the barriers that veterans and military spouses face in pursuing STEM opportunities.

5.2.3 CoSTEM's Federal Objective for Removing Barriers and Supporting Career Flexibilities in STEM Working Environments

To contribute to this national aspiration, CoSTEM aims to increase access to and awareness of the resources available in STEM to accommodate career flexibilities.

5.2.4 Approaches CoSTEM and/or Agencies Could Take toward the Federal Objective of Removing Barriers and Supporting Career Flexibilities in STEM Working Environments

- Improve the use of federal policies and program opportunities that support re-skilling, re-entry, and up-skilling for individuals who have experienced a critical life event.
- Improve the use of federal policies and program opportunities that support re-skilling, re-entry, and up-skilling for individuals from underrepresented and underserved communities where career transitions, mobility, locality, etc., may limit their access to STEM training and employment opportunities.[182]
- Raise awareness and improve the use of universal design and reasonable accommodations for supporting STEM learners, workers, and researchers.
- Implement policies and practices as described in the reports, Federal Policies and Practices to Support STEM Researchers with Caregiving Responsibilities[183] and Strategic Plan to Improve Representation of Veterans and Military Spouses in STEM Careers.[184]

5.2.5 Potential Objective Metrics/Measures for Removing Barriers and Supporting Career Flexibilities in STEM Working Environments

- The number of opportunities that include policies and practices that foster STEM career continuation and/or support STEM career re-entry.
- The number of policies, procedures, and/or resources developed or maintained and implemented to reduce barriers and increase STEM career continuation and/or support STEM career re-entry.

5.3 Objective: Removing Barriers and Promoting Safe STEM Research Environments

5.3.1 CoSTEM's National Aspirations for Removing Barriers and Promoting Safe STEM Research Environments

CoSTEM would like to see a day when everyone has equal opportunity to pursue careers in STEM research and can learn and work in STEM research environments that are both psychologically and physiologically safe.

[182]Such examples may include: individuals who live in improvised households/communities; aging individuals; incarcerated individuals; veterans and military spouses; individuals with caregiving roles; individuals with disabilities; individuals with a language barrier; including English learners and those with low levels of literacy; individuals who are members of a racial or ethnic minority group; and individuals who primarily reside in a rural area.

[183]NSTC. 2024. Federal Policies and Practices to Support STEM Researchers with Caregiving Responsibilities. The White House. https://www.whitehouse.gov/ostp/news-updates/2024/05/15/nstc-federal-policies-and-practices-to-support-stem-researchers-with-caregiving-responsibilities/

[184]NSTC. 2021. Strategic Plan to Improve Representation of Veterans and Military Spouses in STEM Careers. The White House. https://www.whitehouse.gov/ostp/news-updates/2021/12/31/nstc-strategic-plan-to-improve-representation-of-veterans-and-military-spouses-in-stem-careers/

5.3.2 Challenges and Opportunities for Removing Barriers and Promoting Safe STEM Research Environments

Bias, discrimination, and harassment present significant challenges in ensuring safe and inclusive STEM environments.[185,186] Differences in STEM education degree attainment, compounded with differences in employment rates and comparative wage earnings, result in a workforce that does not represent all of the potential talent within the United States.[187] Despite greater acknowledgement of the risks that systemic barriers—such as bias, racism, sexism, ableism, exclusion, discrimination, and cultural disincentives—generate across the STEM ecosystem, evidence-based approaches to mitigate these barriers remain underutilized.[188,189] Issues with both recruitment and retention among diverse populations in STEM fields are further exacerbated by a lack of institutional commitments to maintain workplaces that are free from discrimination and harassment and are actively welcoming to and supportive of all employees.[190]

Inclusive STEM environments require a culture of respect in which discrimination and harassment are not tolerated and learners and workers feel willing and empowered to access all protections available to them. The lack of consistent policies and procedures to address inappropriate behaviors that do not rise to the threshold of illegal harassment creates additional complexities in how STEM learners and workers are forced to address and navigate potentially toxic environments.[191] Furthermore, underreporting—by both institutions reporting on compliance and victims reporting on harassment and discrimination—results in a lack of data that can limit abilities to identify problematic learning and working environments and determine if institutional changes have addressed core issues.[192]

5.3.3 CoSTEM's Federal Objective for Removing Barriers and Promoting Safe STEM Research Environments

To contribute to this national aspiration, CoSTEM aims to support the development and improvement of policies and practices in federally supported research environments that facilitate the physiologically and psychologically safety of researchers, trainees, and support staff.

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[185] U.S. Equal Employment Opportunity Commission. 2022. "Sexual Harassment in Our Nation's Workplaces." https://www.eeoc.gov/data/sexual-harassment-our-nations-workplaces

[186] Referencing Subtitle D - Combating Sexual Harassment in Science. https://www.congress.gov/117/plaws/publ167/PLAW-117publ167.pdf

[187] U.S. National Science Foundation. 2023. National Center for Science and Engineering Statistics. Diversity and STEM: Women, Minorities, and Persons with Disabilities. https://ncses.nsf.gov/pubs/nsf23315

[188] National Academies of Sciences, Engineering, and Medicine. 2018. Sexual Harassment of Women: Climate, Culture, and Consequences in Academic Sciences, Engineering, and Medicine. Washington, DC: The National Academies Press. https://nap.nationalacademies.org/catalog/24994/sexual-harassment-of-women-climate-culture-and-consequences-in-academic

[189] NSTC. 2024. Best Practices for Reducing Organizational, Cultural, and Institutional Barriers in STEM Research. https://www.whitehouse.gov/wp-content/uploads/2024/05/CoSTEM-IWGIS-Barriers-Report.pdf

[190] Pew Research Center. 2018. Women and Men in STEM Often at Odds Over Workplace Equity. https://www.pewresearch.org/social-trends/2018/01/09/women-and-men-in-stem-often-at-odds-over-workplace-equity/

[191] U.S. Equal Employment Opportunity Commission. Harassment. https://www.eeoc.gov/harassment

[192] U.S. Equal Employment Opportunity Commission. Special Topics Annual Report: Women in STEM: Supplement to the US Equal Employment Opportunity's Annual Report on the Federal Workforce Fiscal Year 2019. https://www.eeoc.gov/special-topics-annual-report-women-stem

5.3.4 Approaches CoSTEM and/or Agencies could take toward the Federal Objective of Removing Barriers and Promoting Safe STEM Research Environments

- Ensure implementation of federal civil rights laws that impact individual learners and workers participating in research experiences and/or conducting research and take all appropriate steps to eliminate barriers to their participation in STEM.[193,194, 195,196]
- Establish appropriate and consistent definitions, policies,[197] consequences, record keeping, and reporting within and between federal agencies to address harassment experienced and perpetuated in federally supported research environments.
- Encourage and incentivize the implementation of evidence-based practices for improving institutional culture and climate.

5.3.5 Potential Objective Metrics/Measures for Removing Barriers and Promoting Safe STEM Research Environments

- The number of policies, procedures, and/or resources developed or maintained and implemented to reduce the prevalence of sex-based harassment and sexual harassment involving award personnel.
- The number of policies developed or maintained for federal funding recipients to report sex-based harassment and sexual harassment involving federally funded award personnel.

[193] Section 601 of Title VI of the Civil Rights Act of 1964 (codified at 42 U.S.C. 2000d) Statutory provision: No person in the United States shall, on the ground of race, color, or national origin, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance. Section 504 of the Rehabilitation Act of 1973 (codified at 29 U.S.C. 794) Statutory provision: No otherwise qualified individual with a disability in the United States, as defined in [29 U.S.C. 705(20)], shall, solely by reason of her or his disability, be excluded from the participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance[.] Title IX (prohibits discrimination on the basis of sex) Title II and Title III of the Americans with Disabilities Act of 1990 (codified at 42 U.S.C. 12132 and 12182) Title II Statutory provision: Subject to the provisions of this subchapter, no qualified individual with a disability shall, by reason of such disability, be excluded from participation in or be denied the benefits of the services, programs, or activities of a public entity, or be subjected to discrimination by any such entity. Title III Statutory provision: No individual shall be discriminated against on the basis of disability in the full and equal enjoyment of the goods, services, facilities, privileges, advantages, or accommodations of any place of public accommodation by any person who owns, leases (or leases to), or operates a place of public accommodation. Section 901 of Title IX of the Education Amendments of 1972 (codified at 20 U.S.C. 1681) Statutory provision: No person in the United States shall, on the basis of sex, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any education program or activity receiving Federal financial assistance[.] Section 303 of the Age Discrimination Act of 1975 (codified at 42 U.S.C. 6102) Statutory provision: [N]o person in the United States shall, on the basis of age, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under, any program or activity receiving Federal financial assistance.

[194] U.S. Equal Employment Opportunity Commission. Diversity in High Tech. https://www.eeoc.gov/special-report/diversity-high-tech; Meeting of January 2023 - Navigating Employment Discrimination in AI and Automated Systems: A New Civil Rights Frontier. https://www.eeoc.gov/meetings/meeting-january-31-2023-navigating-employment-discrimination-ai-and-automated-systems-new

[195] U.S. Department of Justice. Federal Coordination and Compliance Section. https://www.justice.gov/crt/federal-coordination-and-compliance-section.

[196] https://www.usccr.gov/files/pubs/archives/10yr02/vol1/main.htm

[197] NSTC. 2024. Interagency Working Group on Safe and Inclusive STEM Environments Inventory. https://www.whitehouse.gov/wp-content/uploads/2024/02/Interagency-Working-Group-on-Safe-and-Inclusive-STEM-Environments-Inventory-2024.pdf

A Coordinated Federal Approach to Implementation

The vision, principles, pillars, and objectives outlined in this federal strategic plan will benefit from participation by the entire STEM community. The federal government has endeavored to align this plan with the broader goals of the national community through outreach to representatives from across the STEM enterprise with the hope that this plan will serve as a nationwide call to action.

Federal Implementation Plan

Interagency collaboration will be a critical factor in successfully implementing the strategic plan. Agencies are committed to working together to advance STEM education and cultivate STEM talent by sharing best practices, leveraging the expertise and resources of federal partners, and coordinating activities in support of common objectives. The coordination of federal STEM[198] education and talent development are overseen by CoSTEM. CoSTEM convenes and coordinates federal agencies and the broader STEM community through community engagements and STEM events to gain valuable input to guide its work. A subcommittee of CoSTEM, the Subcommittee on Federal Coordination on STEM, was charged with facilitating the development of this strategic plan. More subcommittees may be created under CoSTEM as needed to ensure the objectives of this plan are met and implemented accordingly. Interagency working groups, which support subcommittee coordinating activities, lay the fundamental groundwork for interagency efforts to strategically and collectively implement the plan. The identification of agency alignment with this new strategic plan will serve as the starting point from which CoSTEM will build its implementation structure.

Coordinated Federal Approaches around Principles

CoSTEM Approaches to Ensuring Access and Opportunity

To facilitate improvements in access and opportunity, agencies will seek to broaden STEM education, workforce, and research opportunities available to those from underrepresented communities, underserved geographic areas, and/or under-resourced academic institutions. Agencies, in doing so, may provide details on their anticipated outreach and engagement approaches, new and/or expanded funding opportunities that increase the capacity and capability of under-resourced institutions and/or ERIs, and new and/or expanded programming that incentivizes effective partnerships with under-resourced institutions and/or ERIs. Agencies may also develop planning grants to equip institutional grant offices with the requisite knowledge to submit competitive proposals and manage awards or may offer training opportunities for staff, students, and faculty. Agencies may also implement other approaches for making current competitive funding models more accessible to underrepresented communities, underserved geographic areas, and under-resourced institutions and/or ERIs. CoSTEM will aim to:

[198] For the purposes of CoSTEM, STEM is defined broadly as the individual or transdisciplinary areas of science (agricultural science; biological science; chemical science; environmental science; earth, atmospheric, and ocean science; materials science; medicine/health science; physical science) and social sciences (e.g. psychology, sociology, anthropology, cognitive science, economics, behavioral sciences), technology, engineering, mathematics, and computer science disciplines, topics or issues, which include but are not limited to other areas of science and technology, such as biotechnology, climate science, data science, cybersecurity, quantum, space/aeronautics, artificial intelligence, etc. Invention education, innovation and entrepreneurship topics and skills should also be included, as related to the above STEM topics.

- Support and report[199] agency and cross-agency coordination of activities that aim to increase STEM education, workforce, and research capacity of underrepresented communities, underserved geographic areas, and under-resourced ERIs.
- Track and report progress on agency investments, relevant engagement activities, rates of participation, and federal funds awarded through grants, contracts, or cooperative agreements.

CoSTEM Approaches to Ensuring Partnership and Ecosystem Development

To facilitate improvements in partnerships and ecosystem development, CoSTEM will aim to prioritize and incentivize multi-agency collaborations and partnerships within and outside of the federal government. CoSTEM will aim to:

- Prioritize strategic plan approaches that are multi-agency and multi-programmatic.
- Foster agency collaborations by co-developing government-wide STEM recruitment and outreach resources, such as shared online resources and partnership playbooks that help facilitate multi-agency collaborations and partnerships outside of the government.
- Convene and collect feedback from local, Tribal, territorial, and state governments to ensure federal programs and resources are responsive to local, Tribal, territorial, and state level needs.
- Collaborate within the Executive Office of the President and partner on government-wide efforts to uplift whole-of-government initiatives, reduce agency burdens, and leverage common data sources and resources.
- Work with local, Tribal, territorial, and state governments as well as multi-sector organizations and collaboratives to amplify shared interests and activities around STEM engagement, teaching and learning, workforce, research and innovation capacity, and retention in STEM environments.
- Foster federal grant and contract programs that support collaborative partnerships and networks across federally funded institutions.

CoSTEM Approaches to Ensuring Transparency and Accountability

To build community around shared plan and/or program objectives and to facilitate improvements in program effectiveness, CoSTEM will develop a maturity model to support evidence building across CoSTEM investments.[200] Informed and guided by the maturity model, CoSTEM agencies will work together as a federal community to increase their program effectiveness around and through shared plan and/or program objectives. Progress reports issued under this strategic plan will focus on supporting the use of evidence-based practices and on synthesizing program evaluations and assessments in alignment with the pillars and objectives of the plan. CoSTEM will aim to:

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[199] Collection and reporting with consideration of current and future executive orders and federal data collection mechanisms, such as those collected by the National Science Foundation's National Center for Science and Engineering Statistics and the Office of Management and Budget (OMB) surveys of Federal agencies, as required by OMB Circular A-11.

[200] CoSTEM Investment: A funded federal program or formalized set of agency activities with a dedicated fiscal year allocation, authorization, or appropriation, federal staff to manage its budget, and has at least one of the following primary objectives: STEM engagement, STEM education and teaching, STEM training and workforce development, STEM research training and career development, STEM education research and development, STEM institutional capacity, STEM environment/ ecosystem reform, and or Innovation and entrepreneurship learning and training. Investments with a primary focus of increasing access and opportunity and/or building and advancing capacity in STEM education, STEM research, or in the STEM workforce, particularly those from underrepresented/underserved communities, geographic areas and jurisdictions, and/or emerging research institutions, should be included. CoSTEM investments that have annual obligations of more than $0.5 million must be reported in response to annual data call requests. CoSTEM investments may be part of a larger federal investment. Federal salaries and expenses as well as activities that are one-time or irregular expenditure of overhead funds are excluded. See Appendix A.

- Review how agencies are evaluating and assessing programs.
- Review program evaluations, assessments, and outcomes.
- Explore pathways for improving program evaluation and assessment procedures and for improving outcomes.
- Support agencies and programs with shared plan and/or program objectives to come together as a federal community in implementing common models or methods for improving program evaluation, assessment, and/or outcomes.

CoSTEM plans to enhance dissemination of program evaluations, assessments, and outcomes, as well as program best practices and program materials and resources.

Coordinated Federal Approaches around Pillars

CoSTEM will work with agencies to increase agency participation in pillar and objective approaches. Examples of agency participation include membership on various CoSTEM subcomponents such as existing interagency working groups, any new interagency working groups that are formed, and short-term task teams. In support of accountability, CoSTEM and its member agencies will track progress toward achieving the objectives outlined in this plan. To facilitate this endeavor, CoSTEM will work to identify and confirm coordinated approaches and metrics to measure progress toward plan objectives. Throughout the plan's implementation period, CoSTEM will aim to provide progress on approaches, metrics, and any other supportive actions in its annual progress reports. To demonstrate how CoSTEM investments align and contribute to plan objectives,[201] CoSTEM will aim to include updates on agency programming that contributes to progress toward plan objectives.

[201] See additional details on CoSTEM Investment, Appendix A.

Conclusion

For over a decade, the Committee on STEM has leveraged expertise from federal agencies to develop and implement a coordinated strategy to advance STEM across the United States. Following the onset of the COVID-19 pandemic, and in the face of rapid advancements across critical and emerging technologies, this third federal STEM strategic plan comes at a crucial time for ensuring all Americans have access to the knowledge, skills, training, and opportunities necessary to thrive in the changing world. By organizing federal efforts around five major pillars and three cross-cutting principles, this strategic plan provides a framework for advancing STEM education and cultivating the full continuum of STEM talent.

This document outlines a plan for how the federal government, in coordination with partners throughout the STEM ecosystem, aims to prepare all people to be inspired and connected (STEM engagement); to learn and to teach (STEM teaching and learning); to be trained and recruited (STEM workforce); to discover and innovate (STEM research and innovation capacity); and to thrive in learning, working, and research settings (STEM environments) across the country.

Innovative agency programs and policies, multi-agency initiatives, and new partnerships will be required to make meaningful progress toward this plan's objectives. Through CoSTEM, federal agencies have the collaborative infrastructure necessary to ensure this strategy's success.

Appendix

Appendix A: Definition of a CoSTEM Investment

A funded federal program or formalized set of agency activities with a dedicated fiscal year allocation, authorization, or appropriation, federal staff to manage its budget, and has at least one of the following primary objectives:

- **STEM engagement**. Support afterschool/out-of-school STEM education experiences. Increases interest in and understanding of STEM and increases STEM literacy. Support the connection of STEM knowledge to real-world problems. increases individuals' ability to participate and belong in STEM. Support STEM career awareness.
- **STEM education and teaching**. Develop STEM skills, practices, or knowledge of learners. Increase the number of individuals who enroll in STEM majors, complete STEM degrees or credentials, or are prepared to enter advanced STEM education. Prepare, develop, train, and retain educators (preservice or in-service) to improve their STEM content knowledge and pedagogical skills.
- **STEM training and workforce development**. Increase the number of individuals who complete STEM career technical education, training, or certification; who are trained with STEM skill sets to enter into the STEM workforce (including the skilled technical workforce); or are prepared to enter or re-enter into STEM careers.
- **STEM research training and career development**. Increase the number of, retain, and advance individuals in STEM career pathways or STEM research careers. STEM fellowship, traineeship, and training grant programs, including programs with a primary goal of training graduate students and postdoctoral graduates, are included.
- **STEM education R&D**. Address persistent challenges in STEM interest, learning, teaching, and participation through research, development, and evaluation. Develop evidence-based models, methodologies, knowledge, and technologies for or from STEM education, education research, research synthesis (including meta-analysis and meta-synthesis), and evaluation.
- **STEM institutional capacity**. Support, advance, and develop STEM personnel, capabilities, capacities, and infrastructures in educational institutions such as colleges and universities, informal education institutions, state education agencies, and local education agencies.
- **STEM environment/ecosystem reform**. Improve and expand access to STEM opportunities; remove or reduce barriers in STEM through a focus on STEM environment reforms, which consider complex interplays of individual, contextual (e.g., classroom, research lab, or workplace office), institutional, and systemic factors.
- **Innovation and entrepreneurship learning and training**. Increase the number of individuals who are prepared to conceive, develop, deliver, and scale new products, services, processes, and models using STEM skills, practices, or knowledge in support of STEM talent, career, and/or innovation development pathways.

Investments with a primary focus of increasing access and opportunity and/or building and advancing capacity in STEM education, STEM research, or in the STEM workforce, particularly those from underrepresented/underserved communities, geographic areas and jurisdictions and/or emerging research institutions, should be included.

Program/activities that have the following objectives may not be considered a CoSTEM investment if:

- R&D programs (i.e., basic research awarded via competitive grants) where the education and training of STEM learners, workers, and researchers is not the program's primary objective.
- Programs designed to provide and retain current federal employees or military personnel in STEM fields through continuous education or training are excluded.
- Medical/health care-related programs that have a priority objective of clinical education (e.g., those for nurses, doctors, dentists, or veterinarians) are excluded.
- Programs focused on subjects other than STEM subjects or include STEM subjects as one of many possible focal subjects (more non-STEM areas than STEM) are excluded*.
- Programs focused on broad system reform that encompasses far more than STEM education, STEM training, or STEM talent development are excluded.
- Programs or activities that support one-time or ad hoc STEM education, STEM training, or STEM talent development are excluded.
- Programs or activities that support knowledge, interest, or skills not specific to STEM disciplines, research, careers, or workforce are excluded.

*The Department of Education, the Department of Labor, the Department of State, and the Department of Justice are excluded from this provision in order to include contributions to the CoSTEM portfolio that are funded via investments that may support education, training, and talent development in STEM subject areas.

CoSTEM investments that have annual obligations equal to or more than $0.5 million must be reported in response to annual data call requests. CoSTEM investments may be part of a larger federal investment. Federal salaries and expenses as well as activities that are one-time or irregular expenditures of overhead funds are excluded.

Appendix B: Federal Agency Alignment to Federal Strategic Plan

The following agencies intend to support the implementation of the *Federal Strategic Plan for Advancing STEM Education and Cultivating STEM Talent* through interagency, multi-agency, and/or individual agency investments, initiatives, activities, and/or actions. Representation below is based on current agency investments/programs or initiatives; anticipated agency initiatives, activities, or actions; and/or anticipated interagency participation.

	Pillar 1: STEM Engagement			**Pillar 2: STEM Teaching and Learning**			**Pillar 3: STEM Workforce**			**Pillar 4: STEM Research and Innovation Capacity**			**Pillar 5: STEM Environments**		
	Obj 1.1	**Obj 1.2**	**Obj 1.3**	**Obj 2.1**	**Obj 2.2**	**Obj 2.3**	**Obj 3.1**	**Obj 3.2**	**Obj 3.3**	**Obj 4.1**	**Obj 4.2**	**Obj 4.3**	**Obj 5.1**	**Obj 5.2**	**Obj 5.3**
AmeriCorps	■			■		■	■	■							
USDA	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
DOC	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
DOD	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
ED	■	■		■	■	■		■		■	■		■		
DOE	■	■	■	■	■	■	■	■	■		■	■	■	■	■
HHS											■			■	■
DHS				■			■	■			■	■			
DOI	■		■	■			■								
DOJ	■				■		■				■	■	■	■	■
DOL					■	■		■							
DOS				■	■	■	■	■	■	■	■	■	■		
DOT			■		■		■	■				■		■	■
EPA	■	■	■	■	■	■	■	■	■		■	■	■	■	■
NASA	■			■		■		■			■				
NSF	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
NRC	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
ODNI					■		■	■							
OPM							■								
SI	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■