National Science Foundation
WHERE DISCOVERIES BEGIN

MAKING **VISIBLE** THE INVISIBLE

UNDERSTANDING INTERSECTIONALITY

Committee on Equal Opportunities in Science and Engineering

2021-2022 Biennial Report to Congress

CEOSE MISSION & BACKGROUND

The Committee on Equal Opportunities in Science and Engineering (CEOSE) advises the U.S. National Science Foundation on policies, programs, practices and activities to encourage full participation of women, underrepresented racial/ethnic populations and persons with disabilities within all levels of the nation's STEM enterprise.

The committee was established by the United States Congress through the "Science and Engineering Equal Opportunities Act" in 1980 to address the problems of growth and diversity in America's STEM workforce. The legislation states the following:

> *"There is established within the National Science Foundation a Committee on Equal Opportunities in Science and Engineering (hereinafter referred to as the "committee"). The committee shall provide advice to NSF concerning (1) the implementation of the provisions of sections 1885 and 1885d of this title and (2) other policies and activities of NSF to encourage full participation of women, minorities and persons with disabilities in scientific, engineering and professional fields [42 U.S.C.§1885(c)].*
>
> *Every two years, the committee shall prepare and transmit to the director (of NSF) a report on its activities during the previous two years and proposed activities for the next two years. The director shall transmit to Congress the report, unaltered, together with such comments as the director deems appropriate [42U.S.C. §1885(e)]."*

The committee is comprised of approximately 16-18 individuals from diverse STEM disciplines, drawn from diverse institutions in higher education, industry, government and nonprofit sectors. Its membership also reflects the racial, ethnic and gender diversity of the country's citizenry and includes persons with disabilities. Members of the committee typically serve a three-year term. A full committee meeting is held three times a year (usually winter, spring and fall) to review and evaluate policies and program opportunities focused on the state of participation and advancement of women, underrepresented racial and ethnic groups, and persons with disabilities in education, training and science and engineering research. Based on these findings, the committee makes recommendations to the foundation for improving the levels of their participation in STEM professions.

The committee members also interact with other federal agencies, such as the National Institutes of Health, the Smithsonian Institution and the White House initiative on Historically Black Colleges and Universities, in forging ongoing collaborative insights about efforts to broaden participation in the nation's STEM workforce.

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NSF SENIOR LEADERSHIP/Director's Office

DR. SETHURAMAN PANCHANATHAN
NSF Director

DR. KAREN MARRONGELLE
NSF Chief Operating Officer

DR. FLEMING F. CRIM
Former NSF Chief Operating Officer

DR. VERNON ROSS
Former Senior Advisor

OFFICE OF INTEGRATIVE ACTIVITIES (OIA)

DR. ALICIA J. KNOEDLER
CEOSE Executive Liaison and Office Head

DR. SUZANNE IACONO
Former CEOSE Executive Liaison and Office Head

DR. ERIKA J. RISSI
Chief Evaluation Officer and Acting Section Head, Evaluation and Assessment Capability

DR. CLEMENCIA COSENTINO
Former Section Head, EAC

DR. STEPHEN MEACHAM
Section Head, Integrative Activities

DR. SANDRA RICHARDSON
Section Head, Established Program to Stimulate Competitive Research (EPSCoR)

DR. LORETTA MOORE
Former Section Head, EPSCoR

DR. CHRISTINA FREYMAN
Evaluator

MR. THOMAS J. JONES
Staff Associate for Budget

DR. TIMOTHY M. VANREKEN
Program Director

OFFICE OF EQUITY AND CIVIL RIGHTS (OECR)

MS. RHONDA DAVIS
Office Head

MS. SARAH P. WILLIAMS
Acting Deputy Office Head

DIRECTORATE FOR BIOLOGICAL SCIENCES (BIO)

DR. JOANNE TORNOW
Former Assistant Director

DR. THERESA A. GOOD
Acting Deputy Assistant Director

DR. ALAN TESSIER
Former Deputy Assistant Director

DIRECTORATE FOR COMPUTER AND INFORMATION SCIENCE AND ENGINEERING (CISE)

DR. MARGARET MARTONOSI
Assistant Director

DR. JOYDIP KUNDU
Deputy Assistant Director

DIRECTORATE FOR STEM EDUCATION (EDU) Formerly the Directorate for Education and Human Resources (EHR)

DR. SYLVIA BUTTERFIELD
Former Deputy Assistant Director and Former Acting Assistant Director

DR. DIANA ELDER
Division Director

DR. JERMELINA TUPAS
Deputy Division Director

DR. TORI RHOULAC SMITH
Lead Program Director, NSF's Eddie Bernice Johnson INCLUDES Initiative

DR. MONYA A. RUFFIN-NASH
Program Director and
Former Acting Deputy Division Director

DR. LURA JODY CHASE
Lead Program Director, TCUP

TATIANA CAMACHO
Former Program Director

DR. CARLEITTA PAIGE-ANDERSON
Lead Program Director, HBCU-UP, HBCU-EiR

DR. MARK LEDDY
Lead Program Director, AGEP

DR. JESSIE DEARO
Lead Program Director, ADVANCE

DR. REGINA SIEVERT
Program Director, TCUP, CREST-PRP

DIRECTORATE FOR ENGINEERING (ENG)

DR. DON MILLARD
Deputy Assistant Director

DIRECTORATE FOR GEOSCIENCES (GEO)

DR. TIMOTHY E. PATTEN
Deputy Assistant Director

DIRECTORATE FOR MATHEMATICAL AND PHYSICAL SCIENCES (MPS)

DR. SEAN L. JONES
Assistant Director

DR. DEBASIS MAJUMDAR
Program Director

DR. KATHLEEN McCLOUD
Program Director

DIRECTORATE FOR SOCIAL, BEHAVIORAL AND ECONOMIC SCIENCES (SBE) – NATIONAL CENTER FOR SCIENCE AND ENGINEERING STATISTICS (NCSES)

DR. KELLINA CRAIG-HENDERSON
Former Assistant Director

DR. MAY AYDIN
Senior Advisor

DR. JOHN M. FINAMORE
Chief Statistician

DR. KAREN HAMRICK
Former Senior Analyst

DR. AMY BURKE
Supervisory Program Director

DR. TIFFANY ANN JULIAN
Statistical Data Scientist and Acting Program Director

OFFICE OF INTERNATIONAL SCIENCE AND ENGINEERING (OISE)

DR. ANNE L. EMIG
Cluster Lead

DIRECTORATE FOR TECHNOLOGY, INNOVATION AND PARTNERSHIP (TIP)

DR. ERWIN GIANCHANDANI
Assistant Director

DR. GRACIELA L. NARCHO
Deputy Assistant Director

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ACRONYMS

ADVANCE . . . . Organizational Change for Gender Equity in STEM Academic Professions

AIHEC . . . . . American Indian Higher Education Consortium

AIAN . . . . . American Indian and Alaskan Native

AIICE . . . . . Alliance for Identity-Inclusive Computing Education

B2-Program . . Build and Broaden Program

BP . . . . . Broadening participation

CEOSE. . . . . Committee on Equal Opportunities in Science and Engineering

CISE. . . . . Directorate for Computer and Information Science and Engineering

COVID-19 . . . . Coronavirus Disease of 2019

CREST . . . . . Centers of Research Excellence in Science and Technology

DEIA . . . . . Diversity, equity, inclusion and access

EES . . . . . Division of Equity for Excellence in STEM

EDU. . . . . Directorate for STEM Education

LEAPS-MPS. . . Launching Early-Career Academic Pathways

H-1B . . . . . A temporary work visa that allows U.S. employers to hire highly-qualified workers for specialty jobs

HBCU . . . . . Historically Black colleges and universities

HBCU-UP . . . . Historically Black Colleges and Universities - Undergraduate Program

HRD. . . . . Divsion of Human Resource Development

HSI. . . . . Hispanic-serving institution

IHE. . . . . Institutions of higher education

INCLUDES . . . Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science

MPS-ASCEND. MPS Ascending Postdoctoral Research Fellowships

MREFC . . . . . Major research equipment and facilities construction

MRSEC . . . . . Materials Research Science and Engineering Centers

MSI . . . . . Minority-serving institution

NASEM . . . . . National Academies of Sciences, Engineering and Medicine

NCSES. . . . . National Center for Science and Engineering Statistics

NCWIT . . . . . National Center for Women & Information Technology

NIH . . . . . National Institutes of Health

NSB. . . . . National Science Board

NSF . . . . . National Science Foundation

OECR. . . . . Office of Equity and Civil Rights

OIA . . . . . Office of Integrative Activities

OSTP. . . . . [White House] Office of Science and Technology Policy

PI. . . . . Principal investigator

PFI. . . . . Partnerships for Innovation

PLUS . . . . . Partnerships Launching Underrepresented Students

PREM . . . . . Partnerships for Research and Education in Materials

PUSH. . . . . Pathways for Underrepresented Students to Higher Education

R&D. . . . . Research and development

R&RA. . . . . Research and related activities

RETF . . . . . Racial Equity Task Force

REU . . . . . Research Experiences for Undergraduates

RISE-UPP . . . . Re-Imagining STEM Equity Utilizing Postdoc Pathways

S&E . . . . . Science and engineering

SAHPR. . . . . Sexual Assault/Harassment Prevention Response Program Office

SBE . . . . . Directorate for Social, Behavioral and Economic Sciences

SEAS . . . . . Supporting Emerging Aquatic Scientists

STEM. . . . . Science, Technology, Engineering, and Mathematics

STEMM . . . . . Science, Technology, Engineering, Mathematics, and Medicine

STW. . . . . Skilled technical workforce

TCUs . . . . . Tribal colleges and universities

TCUP. . . . . Tribal Colleges and Universities Program

TIP. . . . . Directorate for Technology, Innovation and Partnerships

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

It is increasingly recognized that diverse and inclusive scientific teams can lead to amplified innovation, productivity and impact (National Academies of Sciences, Engineering and Medicine 2023[1]). Recognizing and trusting the abilities, perspectives and expertise of our fellow humans is essential for effective collaborations in science, technology, education and mathematics fields. Most scientists and engineers work with others in teams to solve problems facing our nation and conduct research to find revolutionary discoveries. STEM professors and teachers work with students from all backgrounds to help create the next generation of leaders. However, decades of research have illustrated the many barriers to enter into STEM education pipelines and the STEM workforce, particularly for women, minoritized racial and ethnic populations, and those with disabilities. The most significant and harmful barrier to participation in STEM is discrimination, which is the unjust or prejudicial treatment of another human's social identity, such as race, age, ability, gender, sexual orientation and other attributes, including intersections thereof.

What happens when a person experiences discrimination based on multiple "intersectional" social identities (Crenshaw 1991[2])? Bias and discrimination towards interconnected and overlapping social categorizations create compounded complexities and challenges for those with intersectional identities. This intersecting of social identities can result in multiplied oppression, which can cause adverse psychological and physical problems for individuals and communities. These barriers and denied opportunities prevent full participation in STEM and block unique contributions to the creation of new knowledge. Consequently, this severely hampers the nation's research enterprise and impedes the U.S. National Science Foundation from catalyzing scientific discovery and its benefits at speed and scale.

This report illuminates the dynamics of intersectionality in the STEM enterprise and how more information about intersectional identities is needed to remove barriers to participation in STEM. The Committee on Equal Opportunities in Science and Engineering (CEOSE) hopes this report will encourage others to participate in conversations about their differences in experiences with people who have different overlapping identities and start to analyze ways to make improved opportunities for students, personnel and fellow colleagues in safe and inclusive environments where diverse STEM talent is an asset. Additionally, it is important to address intersectional identity not as discrete characteristics that are occupied in different contexts and situations, but rather as dynamic and integrated identities that are constantly interacting, contradicting and reinforcing everyday lived experiences (Crenshaw, 1991).

1 National Academies of Sciences, Engineering, and Medicine. 2023. Advancing Antiracism, Diversity, Equity, and Inclusion in STEMM Organizations: Beyond Broadening Participation. Washington, DC: The National Academies Press. https://doi.org/10.17226/26803

2 Crenshaw, K. (1991). Mapping the margins: Intersectionality, identity politics, and violence against women of color. Stan. L. Rev., 43, 1241.

NSF efforts

Recent years have seen much activity by NSF in terms of policies, priorities and other initiatives including responsiveness to several federal executive orders and designing initiatives informed by advice from CEOSE. Current and future efforts by NSF to broaden participation of persons[3] from populations minoritized and underrepresented in the scientific enterprise must pay closer attention to intersectional populations of race and ethnicity, gender, disability and other identities. Whether the populations that constitute these intersectional identities are large or small, they contribute to the "missing millions" described by the National Science Board (NSB), in its Vision 2030 report and bring diverse perspectives that improve the scientific enterprise. NSF's new strategic plan for Fiscal Years 2022-2026, *Leading the World in Discovery and Innovation, STEM Talent Development and the Delivery of Benefits from Research*, includes a core value related to diversity and inclusion that informs decision-making and setting priorities, such as maintaining a staff that is representative of the broader national community and supporting outstanding researchers and innovative thinkers from across our nation's diversity of regions, institutions, organizations and demographic populations.

Recent NSF efforts have included the reorganization of the Office of Diversity and Inclusion, which is now the Office of Equity and Civil Rights (OECR). The office has developed and integrated a new diversity, equity, inclusion and accessibility plan into NSF's policies, practices and culture to recruit, retain and develop a diverse, high-performing workforce that draws from all segments of society. OECR has also established a Sexual Assault/Harassment Prevention and Response (SAHPR) support office.

Additional NSF organizational changes include the renaming of the Directorate for Education and Human Resources (EHR) to the Directorate for STEM Education (EDU), as well as changing its Human Resource Development (HRD) Division's name to the Division of Equity for Excellence in STEM (EES). A new directorate—Technology, Innovation and Partnerships (TIP)—was recently established to create breakthrough technologies; meet societal and economic needs; lead to new, high-wage jobs; and empower all Americans to participate in the U.S. research and innovation enterprise. TIP is a unique opportunity that engages the nation's diverse talent in strengthening and scaling the use-inspired and translational research that will drive tomorrow's technologies and solutions.

Programmatic activities include the expansion of NSF's broadening participation (BP) portfolio with the new focused programs highlighted in this report. In particular, NSF's Eddie Bernice Johnson INCLUDES Initiative has established a collaborative change consortium opportunity, which addresses a critical BP challenge in science, technology, engineering and mathematics (STEM) at city, state and/or regional levels of impact, as well as expanding the number of alliances in its national network.

New programs have been designed to support minority-serving institutions (MSI), such as Build and Broaden: Enhancing Social, Behavioral and Economic Science Research and Capacity at Minority-Serving Institutions, Computer and Information Science and Engineering Minority-Serving Institutions Research Expansion Program, and Partnerships for Research and Education in Chemistry. Additionally, NSF now publishes an annual report to Congress on funding of MSIs on its newly developed BP in STEM webpages.

NSF continues to make progress toward BP for persons from populations marginalized and underrepresented in STEM in meaningful ways. However, missing data, limitations in the ways data are reported, and a lack of principal investigator (PI) self-reporting all complicate efforts to document and track progress toward BP and representation, especially for populations at the intersections of underrepresentation involving race, ethnicity, gender, disability and other identities. More complete data sets on PIs, program officers and others involved in NSF-related activities can improve future efforts to assess BP efforts for persons from populations underrepresented in science and engineering (S&E).

3 Throughout this report, we refer directly to the actual persons (i.e., individuals) and populations (i.e., larger demographic collectives within our U.S. citizenry) that are underrepresented in STEM, as a best practice, as opposed to referring indirectly to them as ""groups," such as by using off-putting terms like "underrepresented groups" or "underrepresented minorities," [Williams, 2020] which serve to distract focus away from the actual individuals and, even worse, are susceptible to "otherizing" individuals in negative ways, unintentionally or not.

CEOSE activities and recommendations

CEOSE activities in 2021-22 included six virtual committee meetings, dissemination of the 2019-2020 CEOSE report, and the preparation of this report. The current work of the committee aligns with the plans set forth in the 2019-2020 CEOSE report, *Making Visible the Invisible: Bold Leadership Actions*. The ongoing work of the committee to advance BP in STEM and S&E aligns with the themes articulated in the NSB's *Vision 2030* report and NSF's current strategic plan. An additional activity during this reporting period was the formation of a subcommittee to envision the future of NSF's Established Program to Stimulate Competitive Research (EPSCoR). The *Envisioning the Future of NSF EPSCoR* report from the subcommittee was submitted to NSF in August 2022.

CEOSE recognized NSF's critical leadership role in developing the STEM pathways and S&E ecosystems that undergird the discovery and innovation vital to our nation's competitiveness and security. However, the agency must strive to become more responsive and inclusive to the myriad intersecting identities that make up our society. Focusing on and emphasizing intersectionality provides a means for illuminating and making visible the barriers that must be addressed and removed. Therefore, CEOSE recommends that NSF should respond to the following two actions to advance intersectionality in STEM:

> *Utilize intersectional analysis to remove barriers to the participation of persons from various populations historically underrepresented in STEM fields, so as to meet more effectively the needs of society and maximize the nation's scientific investment. This requires that NSF invest in obtaining and analyzing higher resolution data about investigators' identities, demographic characteristics and institutions to develop strategies and programmatic interventions.*
>
> *Develop metrics and utilize an intersectional analytical framework in implementing and assessing the recommended actions for the NSF EPSCoR portfolio from the future of NSF EPSCoR report. Recommendations and suggestions in the report are exemplary strategies that can be undertaken nationally to promote broadening participation and institutional transformation in the STEM enterprise.*

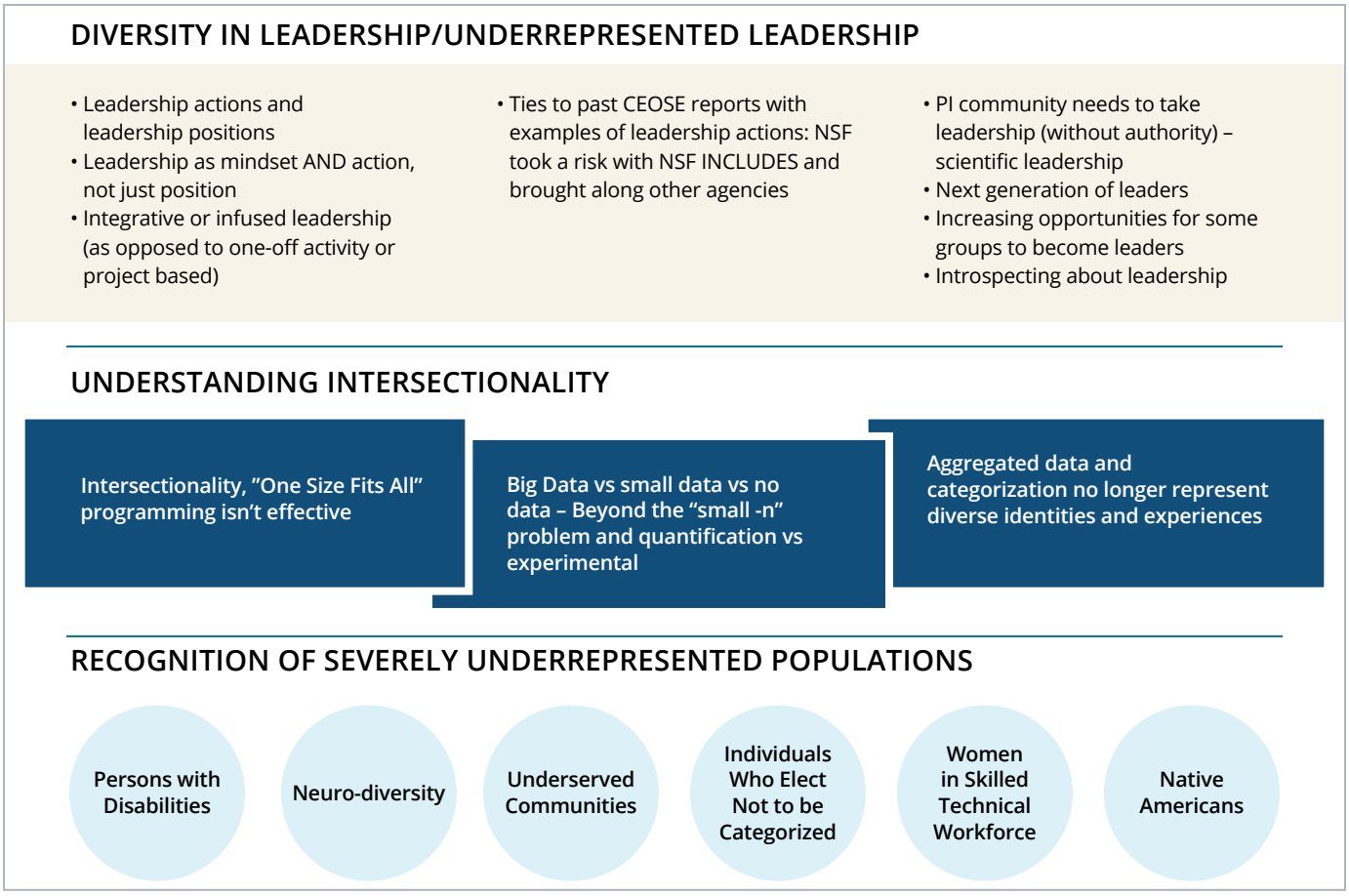
I: INTRODUCTION AND OVERVIEW OF MAKING VISIBLE THE INVISIBLE WITH AN EMPHASIS ON INTERSECTIONALITY

Introduction and overview

The Committee on Equal Opportunities in Science and Engineering (CEOSE) is a congressionally mandated committee charged to advise NSF on policies, programs and practices that will promote the full participation of women, persons from racial/ethnic populations and persons with disabilities within all levels of America's scientific and research enterprise. Biennially, CEOSE prepares a report of its activities for a two-year period and includes proposed activities for the next two years. This 2021-2022 CEOSE report to Congress fulfills the congressional mandate of the "Science and Engineering Equal Opportunities Act of 1980."

Near the end of 2018, members of CEOSE identified a set of critical topics focused on the theme "making visible the invisible" to address in a series of three consecutive reports. The first report covered inclusive excellence in leadership (2019-2020); the second report is about critical issues in defining and understanding intersectionality (2021-2022); and the third will address challenges and opportunities in acknowledging and valuing severely underrepresented populations, including Native Americans and individuals or representatives of lesbian, gay, bisexual, transgender and queer communities.

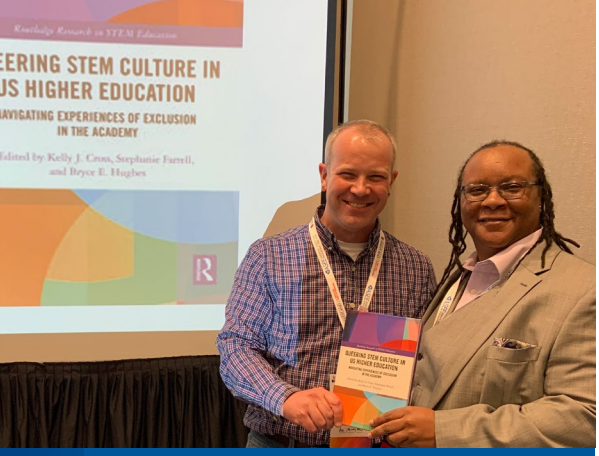
Figure 1: Diversity, equity and inclusion: Making visible the invisible



As stated in the previous report, the theme "making visible the invisible" is broad and serves to recognize that much of the work and understanding related to BP, diversity, equity, inclusion, access and belonging remains unacknowledged, misunderstood, undervalued and understudied. Therefore, CEOSE will continue to make recommendations to bring to the forefront the knowledge, experiences and perspectives critical to realizing measurable systemic change in BP in NSF-supported programs and activities.

In this report, CEOSE continues to send the message that BP is not a problem but a strategy to promote and advance scientific research. Diverse perspectives are necessary for solving critical scientific and societal challenges; however, data show relatively little diversity in the fields of science, technology, engineering and mathematics (STEM) necessary to solve scientific grand challenges and inclusion issues. CEOSE reiterates that as the number of persons in the U.S. from underrepresented and underserved groups grows in STEM, inclusion of those from diverse backgrounds is foundational to the success of the nation's science and engineering (S&E) enterprise. "The goal of broadening participation is not only an issue of fairness and equal opportunity but is the means of bringing diversity and intellectual breadth to the transformation of science itself" (NSF GRPA Report 2009; in CEOSE 2011-2012 and see box at the end of this section).

The previous report pointed out that categorizing people by demographic identity is a challenge that is multidimensional. Yet, it offers new opportunities to better understand multidimensional barriers to participation in STEM and how individualization and multi-cultural experiences can increase and enhance



A virtual community of practice to promote LGBTQ+ inclusion in engineering

This collaborative research award, *A Virtual Community of Practice to Promote LGBTQ Inclusion in Engineering*, aims to increase the inclusion of LGBTQ+ students and professionals in STEM. Comprising over 100 STEM faculty and administrators from institutions across the country, virtual communities of practice members have developed research-informed Safe Zone ally training workshops for STEM audiences and trained over 2,000 participants through conference workshops and webinars through the American Society of Engineering Education.

One outcome of this collaborative NSF-funded project is a groundbreaking volume entitled "Queering STEM Culture in US Higher Education: Navigating Experiences of Exclusion in the Academy" (Routledge, 2022). The book features the narratives of LGBTQ+ people in academic STEM departments ranging from students to administrators. These narratives reveal how LGBTQ+ people have navigated STEM culture, making meaning of their experiences with marginalization and exclusion on the basis of their complex, interrelated identities such as gender, sexual orientation, race and ethnicity, faith and disability. The book also sets an agenda for future scholarship and advocacy on LGBTQ+ equality and inclusion in STEM.

the STEM workforce for today and the future. Therefore, this second report in the three-part series aims to raise awareness for "focused attention" on issues of intersectionality.

This one-size-fits-all approach to BP is not a game-changer. It does not reveal complex systems of bias and discrimination that often prevent the participation of persons from minoritized populations in the STEM enterprise. **Instead, we bring the perspective that it is time to collect and analyze high-resolution intersectional data about STEM participants to better understand challenges to BP**. At the same time, a deeper understanding of intersectional identities in the STEM pathways and workforce will help NSF and the nation identify new opportunities to recognize and reward inclusive excellence by promoting a better understanding of intersectionality through individual, institutional and geographic lenses.

Intersectionality

The concept of self is an evolving theory an individual has of themselves and their functioning in the world that is both shaped by their experiences and shapes how they interact with the world (Epstein, 1973). It includes multiple identities that intersect to create the sense of self. Social identities are an important aspect of human life; however, as individuals increasingly identify with different social identities, they face conflicts that can be challenging to resolve (Hirsh, et al., 2016). The specific definition of intersectionality varies by research context, but a consistent thread across definitions is that social identities, which serve as organizing features of social relations, mutually constitute, reinforce and naturalize one another. Mutually constitute means that one category of identity, such as gender, can only derive true meaning when placed into context by one or more other categories (e.g., race, ability, age and sexuality) (Shields, 2008). It is important to address intersectional identities not as discrete characteristics that are occupied in different contexts and situations, but rather as dynamic and integrated identities that are constantly interacting, contradicting and reinforcing everyday lived experiences (Crenshaw, 1991).

Intersectionality in STEM —

Is a framework used to analyze how systems of power and oppression impact individual's lived experiences based on their various social group identities, diversity of thought, and diversity of field.

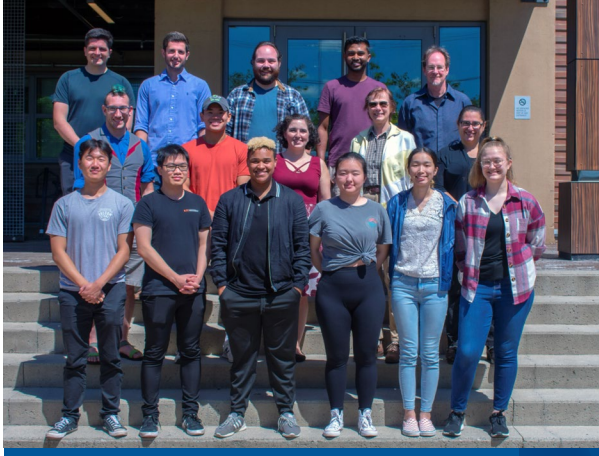
Understanding intersectionality

Intersectionality can be used as a framework to analyze how systems of power, oppression and privilege impact individuals' lived experiences based on their various social group identities. These identities may include age, race, class, ethnicity, ability, sexuality and/or others. Intersectionality can be used to uncover special challenges and areas for improvement, strengthen practice, and create opportunities where all identities can thrive (Crenshaw, 1991; Collins, 1990; Moore-Berg and Karpinski, 2018; Shields, 2008). It is also of note that an intersectional position may be disadvantaged relative to one social group, but advantaged relative to another (Shields, 2008; Misra 2020) and that intersectionality can change over time as people may acquire new characteristics or as a matter of circumstance.

A close examination of intersectionality begs the question: What counts as intersectional? Or more importantly, who counts as intersectional, and how do we highlight their stories and enable them to fulfill their greatest abilities for making achievements in STEM? It is important that we understand intersectionality in the context of the "missing millions," terminology introduced by the National Science Board (NSB) in the *Vision 2030* report, referring to the missing voices, perspectives and contributions of women, Hispanic or Latino, Black or African American, American Indian and Alaska Native populations that are needed for the 2030 scientific workforce to reflect the racial, ethic and gender representation of the nation.

More specifically, people with these identities are being excluded from STEM fields because of various structural barriers and therefore are vulnerable to an "accumulation of disadvantage" wherein multiple small biases in the same direction can compound to have large negative effects, particularly over time (Valian, 1998). At times, these barriers are physical (e.g., disabilities and accessibility issues) and sometimes social (e.g., policies, exclusive networks, racial attitudes and perceptions). Intersectional populations may face various and multiple combinations of these barriers and thus might be susceptible to an even greater accumulation of disadvantages relative to non-intersectional populations.

One example of an intersectional identity would be a 50-year-old African American woman with a disability. Persons who have intersectional characteristics can be subjected to multiple forms of discrimination based on some or all of their lived identities. Women of color experience more harassment in the workplace and often experience what is referred to as "double jeopardy" or a "tax" for being both a woman and a person of color (Berdahl and Moore, 2006; Williams, et al., 2014). Consequently, people of color, including those with intersectional characteristics, are leaving institutions of higher learning at a high rate, citing isolation, exclusion and a toxic work environment as the reasons (Dolezal, 2022). This has a negative impact on the STEM workforce.



Research internships for deaf and hard-of-hearing undergraduates

Peggy Cebe, a physics professor at Tufts University, has for close to two decades been supported by the Division of Materials Research for **her work on polymers**. During these years, she created a summer research internship program for deaf and hard-of-hearing (DHH) undergraduates, which she integrated into her NSF awards. This annual program, *Thermal and Structural Properties of Polyzwitterions, with Research Opportunities for Deaf and Hard of Hearing Interns*, has benefited many DHH undergraduates, a large fraction of them underrepresented minorities and women. Students are recruited primarily from Gallaudet University and the National Technical Institute for the Deaf at the Rochester Institute of Technology. For this initiative, Professor Cebe was honored by President Barack Obama as one of the recipients of the Presidential Award for Excellence in Science, Engineering, and Mathematics Mentoring.

AccessADVANCE

AccessADVANCE is an NSF ADVANCE partnership grant to develop training and tools using an intersectional perspective for institutions of higher education that want to recruit, retain and support STEM faculty with disabilities. AccessADVANCE aims to increase the understanding of equity issues for STEM faculty who identify as women with disabilities and develop and share promising practices to address the systemic issues impacting career advancement and success. The project has already had a national impact in the first two years. More than 730 individuals have participated in training, and a community of practice, tools and resources have been identified and curated to support efforts to make systemic changes. One example includes the University of Washington's online **Disabilities, Opportunities, Internetworking, and Technology Center's knowledge base**, which houses case studies, tools and promising institutional practices to increase the successful participation of women with disabilities in academic STEM careers.

Intersectionality in the STEM enterprise

Addressing intersectionality is a key factor in BP for persons from minoritized and underrepresented populations in STEM, which can be seen as a solution-oriented approach to advancing science. We are underutilizing the talent pool in the U.S., which stops us from being able to approach a myriad of problems from wide-ranging and useful perspectives. Thus, it is important to dispel the false narrative that excellence is somehow compromised or diminished by diversity. In actuality, it is just the opposite: Excellence is enabled and enhanced by diversity (Rock and Grant, 2016) (see also Appendix A).

Without the equitable engagement of diverse thinking and perspectives brought to bear on addressing pervasive and challenging S&E problems that affect many segments of society, how can creative solutions be discovered and applied for the benefit of all humanity? Likewise, if many segments of our society are not equitably included, engaged in opportunities, and given the means to make and benefit from technological and scientific contributions, how can our society as a whole make significant progress toward reaching its full potential?

It is only through including and embracing widely diverse ideas and perspectives — including and especially those from persons of all gender, racial, ethnic, identity, physical ability, religious, cultural, geographic, socioeconomic, sexual orientation and intersectional populations — that the most innovative and comprehensive solutions to critical global challenges can be discovered, for the benefit of all.

In this framing, understanding intersectionality as part of BP becomes a critical strategy to promote and advance scientific research and learning that will facilitate the development of a STEM workforce representative and inclusive of all US citizens. It also will grow the STEM ecosystem and lead to interventions that address systemic issues. Our focus on equitable inclusiveness is not just about problem solving but also is about addressing systemic issues of biases and harmful "isms" to remove barriers to exclusion. Indeed, recognizing and accounting for intersectionality can help lower barriers, improve retention, and increase success rates in populations for which we seek to broaden participation and move us toward achieving parity objectives (Yortsos, et al., 2017). Hence, without a nuanced understanding of the impacts of intersectionality that includes recognition of persons with protected characteristics (e.g., gender, gender identity, disability, marginalized racial and ethnic populations, etc.) on the STEM ecosystem, we risk perpetuating and, even worse, erecting additional impediments keeping us from making much-needed progress. Similarly, equitable inclusion should be considered as fundamental to any effective BP strategy. Incorporating intersectional frameworks enhances our ability to identify and overcome systemic biases and discrimination (e.g., racism, heterosexism, genderism, ableism and other "isms") that reduce the diversity of perspectives and talents that can spur and lead to increased innovation and scientific advancement, for the benefit of all in our society.

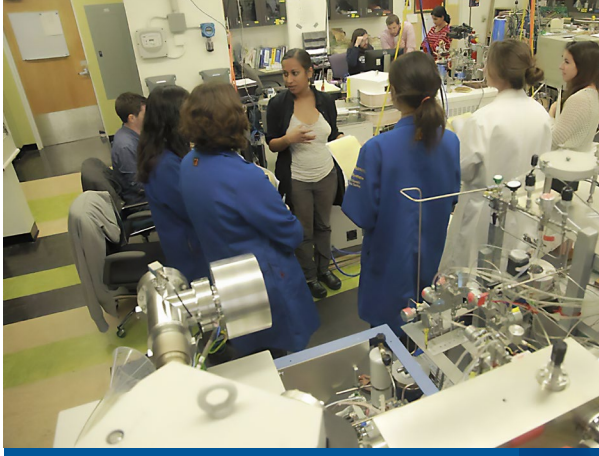
Furthermore, we need to prioritize providing equitable access to transformational leaders with intersectional identities. Such leaders bring their life experiences of stimulating attitudinal changes to positions of leadership. Lived experiences within the context of intersectionality sharpen their intellectual skills, perception and capacity to challenge theories and collaborate with others.

Measuring for inclusion of small numbers (small n)

The demographic landscape of higher education is constantly changing and increasingly becoming more diverse, but there is still much more work to be done. This has led to a greater number of individuals (e.g., students, staff and faculty) in the STEM community who are vulnerable to multiple intersectional threats, combined in various ways, arising from racism, homophobia, sexism, ableism, classism and religious discrimination on college and university campuses. However, it appears that the use of intersectionality as a framework to critically examine existing policies and practices within higher education settings has yet to become coherently supported by federal funding. As higher education becomes more culturally, racially and ethnically diverse, federal funding efforts within higher education contexts must be reimagined in ways in which programs and opportunities are provided that acknowledge and address those who inhabit these invisible (and hyper-visible) educational spaces.

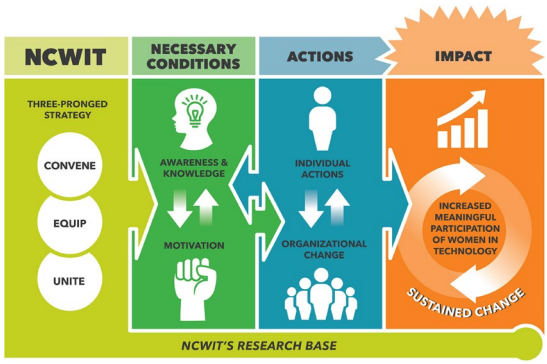
Mixed-methodological approaches and intersectionality frameworks offer the possibility of a science of BP that deeply understands, contextualizes and addresses complex barriers to STEM inclusion (Metcalf, et al., 2018). It can also inform new methods of analyzing data that have been referenced as small numbers (or "small n"), which have historically been removed from broader analysis that may influence STEM policies. As Wullert et al. states, "small numbers cannot be a rationale for stalled progress or for continuing to exclude persons from populations underrepresented in STEM" (2019). Oftentimes the terminology of "invisible" is inappropriately applied. Once again, we emphasize that people are not inherently or intrinsically invisible. They can be rendered invisible through a lack of physical presence (i.e., unseen or not represented), absence of voice (i.e., muted or silenced), diminished or absence of receptivity to contributions (i.e., not heard or not credited), and cut off from contributing intellectually (i.e., not included or inhibited). The barriers faced by those who are excluded may comprise multiple combinations. Intersectionality provides a means for illuminating and making visible the barriers that must be addressed and removed. Giving voice to those who are made invisible from (and lost to) conventional data-generation techniques necessitates innovative approaches for rigorous information collection and analysis.

Generating and analyzing data focused on persons from populations minoritized and underrepresented in STEM that are often neglected on the basis of statistical arguments is vital for supporting in-depth intersectional studies. These data should not only include demographic data but also data on experiences, networks and



The Center for Diverse Leadership in Science: Transforming the Geoscience Ecosystem

The Center for Diverse Leadership in Science at UCLA is addressing the diversity gap in in the geosciences. This effort includes partnering with MSIs and tribal and Hispanic communities to transform the geoscience culture. It includes leadership development and team-based science to break down traditional hierarchies. The center offers programs for early-career fellows that focus on educational and career trajectory, and it provides mentorships with peers, previous trailblazers and trained faculty for leadership, modeling and network development. There is a social component that involves community partnerships to ensure the science will be community driven. This project provides an opportunity to empower those who have been historically excluded in the geosciences and STEM fields. There is an intentionality to engage underserved communities and to lead in geoscience related research that impacts their communities.



Scaling and sustaining gender diversity in postsecondary computing using NCWIT's systemic change approach

The systemic social and structural disadvantages to women in computing at all identity intersections and levels of pathways to careers is deeply concerning from the viewpoint of equity and the nation's need for a highly-qualified scientific workforce and improved innovation. Women's low participation in computing is rooted in inequitable societal structures and everyday social interaction.

Since 2006, the National Center for Women & Information Technology's (NCWIT) Broadening Participation in Computing Alliance has aimed to stop the continuation of these longstanding inequities at the level of social systems, altering policy, everyday practices and decision-making, beliefs and norms to sustain change.

National conversations have heightened the urgency around intersectional equity and inclusion in the technology sector. Intersectionality theory informs the content of what NCWIT does – what kinds of awareness and knowledge must be addressed (e.g., knowledge about how individual bias and institutionalized systems of oppression impede diverse participation). Likewise, the goal of creating intersectional inclusive cultures also informs which individuals need to act as leaders in making changes (e.g., a variety of stakeholders; change agents diverse in race, class, etc.; those with power and those without) and what kinds of organizational systems need to be changed (e.g., unwelcoming workplace or educational cultures, biased business processes or educational systems). NCWIT will utilize funding to support postsecondary computing departments/schools, resources, research, evaluation and public education.

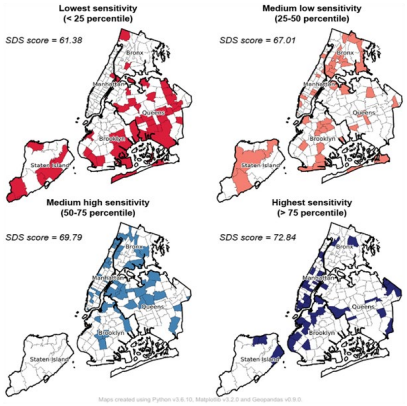
resources that may create or perpetuate social barriers to access and success. As highlighted in the previous CEOSE reports, we must continue to make innovations in measurement that allow for accountability and evidence-based decision-making.

We recognize that even within these efforts, access to disaggregated data at increasingly finer levels may be limited due to small n sample sizes for a variety of reasons (e.g., confidentiality, reporting limitations, sampling limitations). These limitations impede a greater understanding of the experiences of intersectional populations possessing combinations of protected characteristics. In certain cases, these data may be suppressed for reasons of confidentiality and statistical reliability. In a previous report, CEOSE encouraged the development of innovative strategies and approaches to define, monitor and report success in BP, thereby addressing the challenges related to the limits of analysis due to data quality and sample size of both large and small data sets (CEOSE 2019-2020). Despite this, acquiring and analyzing these data are critical for informing new program design. Perhaps there are some commonalities at the scale of "community" intersectionality that cut across various populations and can help with the small n problem in some cases. To this end, CEOSE has suggested that NSF invest more resources in innovative data collection strategies and programmatic interventions with the specific intent to highlight, and effectively address, the challenges and opportunities intersectionality presents in the STEM enterprise. CEOSE remains committed to promoting measurable systemic change in BP in NSF-supported programs and activities.

This section of the report (Part I) provides the contextual background for the theme "making visible the invisible" with a focus on the importance of leveraging intersectional analysis for the purpose of reducing barriers to equitable inclusion in STEM. Part II highlights recent NSF accomplishments and new efforts that are underway at the foundation. Part III summarizes CEOSE's activities in 2021 and 2022 and the committee's plans for 2023-2024. It also includes CEOSE's two recommendations to NSF on intersectionality in STEM, along with suggestions for advancing access to research support and geographic diversity via the EPSCoR investment and addressing equity and inclusion via innovative practices embracing intersectionality in STEM.

Diverse research teams

Inclusion of gender and racial/ethnic diversity on scientific teams has positive effects on creativity, innovation and productivity through knowledge enrichment. Scientific discovery is accelerated when informed by diverse viewpoints, approaches and research questions. Several studies have found that demographically diverse science teams yield research and publications that are more novel, receive more citations, and are published in higher impact journals (see Appendix A). However, simply including a diverse mix of individuals on a scientific team can be difficult and doesn't guarantee the expected benefits. In the absence of a social and institutional environment in which all team members and their perspectives and knowledge are included and valued, diversity on teams can lead to lower levels of cooperation, higher levels of conflict, low psychological safety among members, and biased perceptions and discrimination towards members of differing backgrounds. Despite decades of programs and interventions to improve these conditions, women and faculty of color have been persistently marginalized in and excluded from STEM and faculty careers. At the same time, faculty of color and women themselves may opt out of interdisciplinary collaboration or limit their collaborations to certain people because they are aware that white and/or male counterparts will receive more credit for shared ideas and publications. This may result in self-segregation, which decreases the potential for the positive effect of diversity among collaborative teams. Harnessing the beneficial effects of equitably inclusive research teams on scientific discovery and innovation depends on a) recruiting more persons from populations whose representation in STEM education pathways and workforce has been marginalized, and b) creating inclusive and welcoming environments in which an inclusive approach to knowledge, perspectives and standpoints is fully valued and integrated into research efforts and the STEM enterprise.



Bias and discrimination in city predictive analytics

This project focused on bias and discrimination in New York City's predictive analytics because of documented disparities in citizen-reported data and the potential impact of that data on the fairness of resource allocation decisions for cities. Data collected from citizen calls to 311 have been shown to have systematic biases because people from financially distressed communities report fewer concerns. Differences in reporting result from persistent spatial, racial and economic inequality and disparities in the condition of their particular neighborhood, trust in government, access to reporting e-systems, and other cultural and social factors. Consequently, predictive urban analytics based on citizen complaint data can unintentionally result in discriminatory outcomes and reinforce existing disparities.

Investigators developed a new methodological framework, integrating multiple data sources and incorporating approaches from machine learning and urban planning, that assesses, quantifies and corrects data bias in urban artificial intelligence models to address social equity and fairness in cities' decision-making. Specifically, this project addressed bias in citizen reports data to improve the fairness of data-driven decision-making in the urban context by: (1) building statistical machine learning models to estimate reporting rate biases, (2) providing tools to city decisionmakers, policymakers and planners to understand and visualize the spatial and socioeconomic dependence of reporting behaviors, and (3) developing methods to account for observed biases in responding to resident reports. In other words, this project developed methods to compensate for bias in reporting data to improve allocation of city services.

II: THE STATUS OF BROADENING PARTICIPATION OF WOMEN, RACIAL AND ETHNIC POPULATIONS, AND PERSONS WITH DISABILITIES IN SCIENCE AND ENGINEERING, 2021-2022, AND EFFORTS BY NSF

Overview[4]

The calendar years of 2021 and 2022 were dramatic and challenging in the U.S. and abroad. The coronavirus pandemic, movements for racial justice and gender and identity equity, and a myriad other events highlight the urgent need for innovative, inclusive and just solutions to critical challenges facing society. The broadening participation work of NSF, which involves promoting scientific progress through investments in research about science, engineering and education, remains essential to addressing these challenges. At the same time, NSF must continue to pay close attention to the talent gap in the science and engineering (S&E) workforce, an issue articulated by the National Science Board (NSB) in its recent vision statement, which articulated the need for BP efforts to address the challenge of the workforce's "missing millions."

Recent years have seen much activity by NSF in terms of policies, priorities and other initiatives including responsiveness to federal executive orders and designing initiatives informed by advice from CEOSE. Overall, NSF has demonstrated leadership in promoting the full participation and meaningful involvement of persons from populations minoritized and underrepresented in S&E. However, more work remains. Current and future efforts of NSF to broaden participation of persons from populations underrepresented in the scientific enterprise must pay closer attention to intersectional populations of race and ethnicity, gender, disability and other identities. Whether the populations that constitute these intersectional identities are large or small, they contribute to the "missing millions" described by the NSB and bring diverse perspectives that improve the scientific enterprise. NSF must strive to become responsive and inclusive to the myriad intersecting identities that make up our society.

4 See Appendix B for a more detailed discussion.

During these challenging times, the development and support of science, technology, engineering and mathematics (STEM) talent must remain a priority for creation of knowledge, discovery, innovation and national security. Recent data from NSF's National Center for Science and Education Statistics (NCSES) highlight the importance of prioritizing a diverse and inclusive STEM workforce and skilled technical workforce (STW)[5]:

- STEM workers make up 23% of the total U.S. workforce using the current expanded STW definition.
- Women make up 45% of the STW with a bachelor's degree or higher and 26% of the total STW.
- Black/African American workers made up nearly 10% of the STW in 2019, and the proportion of Hispanic workers in the STW grew from 15% to nearly 20% from 2010 to 2019 – comparable to their shares of the total U.S. working population in 2019 (approximately 12% and 18%, respectively).

Data from NCSES also highlight ongoing challenges associated with this national priority:

- Black/African American, Hispanic, American Indian and Alaska Native people are underrepresented among S&E degree recipients at the bachelor's degree level and above.
- The percentage of students scoring proficient or above in science of the National Assessment of Educational Progress is lower for students who qualify for free or reduced-price lunch.

Notably, NCSES data do not readily reveal details about the representation of intersectional identities, nor does it reveal perspectives in the STW or at any level of STEM education. Intersectionality is essentially invisible in performance and workforce production data. **Moving forward, intersectionality must become part of data collection and analysis efforts if the U.S. hopes to address the "missing millions" problem and to achieve a representative STEM workforce.**

5 NSB resources on a skilled technical workforce: https://www.nsf.gov/nsb/NSBActivities/skilled-technical-workforce.jsp.

The importance of MSIs

To better understand the educational pathways of Black, Hispanic, American Indian and Alaska Native (AIAN) students who obtained Ph.D.s and other types of research doctorates, NSF's National Center for Science and Engineering Statistics analyzed a decade of data from the "Survey of Earned Doctorates" (2010-2020). The August 2022 InfoBrief **Baccalaureate Origins of Underrepresented Minority Research Doctorate Recipients** looked at where these groups of doctorate recipients — that is, those who are collectively underrepresented in higher education compared to their share of the U.S. population — received their undergraduate degrees. Among U.S. citizens and permanent residents who received research doctorates between 2010 and 2020, 43% of Hispanics, 36% of Blacks and 26% of AIANs received their bachelor's degrees from MSIs. In addition, substantially greater percentages of Black, Hispanic and AIAN doctorate recipients earned their bachelor's degrees from public institutions, compared to the average for all U.S. citizens and permanent resident doctorate holders. The findings highlight the importance of public and MSIs in enhancing the diversity of the U.S. research enterprise and illustrate the role these institutions play as stepping stones on the path toward a research doctorate for underrepresented minority students.

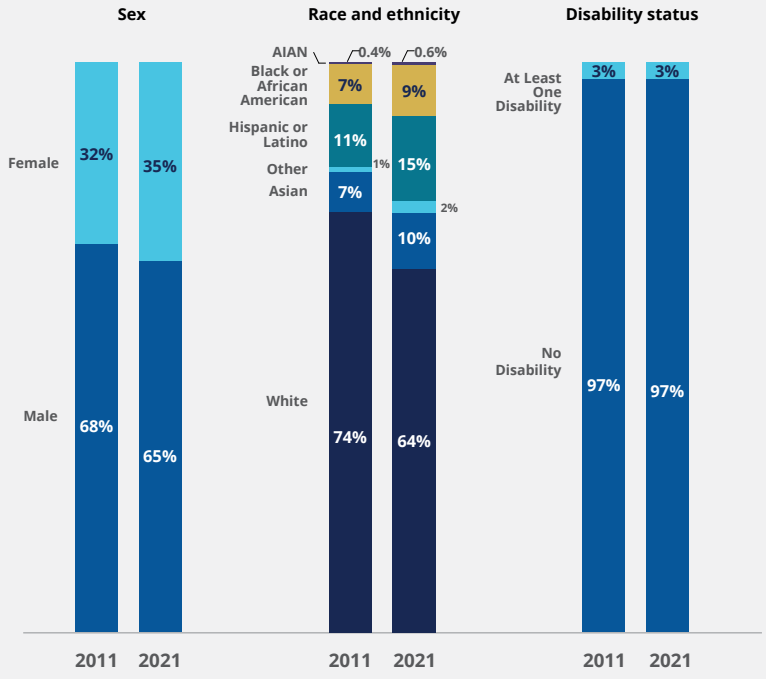
Intersectionality is essentially invisible in performance and workforce production, as evidenced in the following two NCSES presentation slides about the STEM workforce.

The share of women and underrepresented minorities in the STEM workforce increased between 2011 and 2021.

Characteristics of the STEM workforce ages 18-74: 2011 and 2021

Source(s): Census Bureau, Current Population Survey, Annual Social and Economic Supplement, 2021. *Diversity and STEM*, Figure 2-3.

AIAN = American Indian or Alaska Native

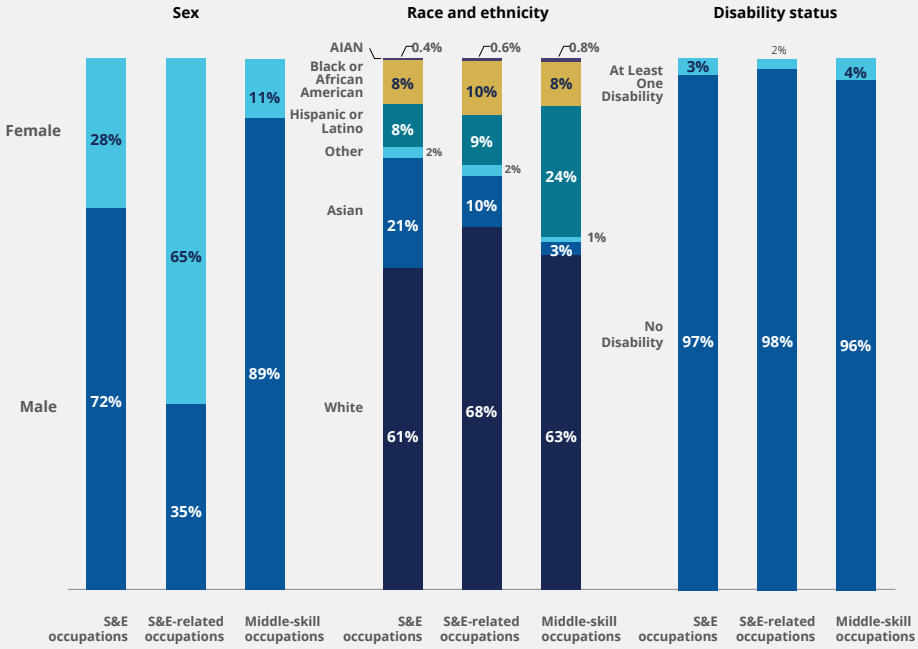


About two-thirds employed in S&E related occupations are women; about a quarter employed in middle-skill occupations are Hispanic.

Characteristics of the STEM workforce ages 18-74, by occupation: 2021

Source(s): Census Bureau, Current Population Survey, Annual Social and Economic Supplement, 2021. Diversity and STEM, Figure 3-2.

AIAN = American Indian or Alaska Native.



NSF policy and organizational updates and changes

In 2021, NSF reorganized the Office of Diversity and Inclusion into the Office of Equity and Civil Rights (OECR). In response to the Executive Order 13985, "Advancing Racial Equity and Support for Underserved Communities through the Federal Government" (Jan. 20, 2021), NSF established an equity action plan to improve racial equity and reduce harassment. The Racial Equity Task Force, charged with "examining the potential for racial barriers and making recommendations regarding how NSF can be a leader in meaningfully addressing them with the goal of extinguishing them," became the vehicle for policy review and development of sustainable initiatives with measurable outcomes. The equity action plan highlights several objectives (and actions) to advance equity, which include:

- Enhance NSF's harassment prevention efforts by extending them to research activities at field sites and on research vessels.
- Extend demographic data collection in support of equity assessments from a wider range of grantees, including undergraduate students, graduate students, postdoctoral fellows and research directors.
- Increase participation of disadvantaged institutions, including those from Minority Serving Institutions (MSIs), in solicitations and awards.
- Remove barriers to enhance participation of underserved Indigenous and Native American communities in the STEM enterprise.
- Invest in resources to help advance civil rights, including acting on findings of the Racial Equity Task Force report.
- Deliver land and rights acknowledgements to Native Hawaiian communities.
- Designate tribal organizations as eligible entities for funding submissions.
- Create a foundation to expand anti-harassment initiatives.

Within this context, the NSF Director has established a roadmap to embed and integrate diversity, equity, inclusion and access (DEIA) into NSF policies, practices and values. NSF has a new chief diversity and inclusion officer whose focus is to ensure that DEIA goals, metrics and advancements are tracked and met.

In February 2021, OECR issued an updated "frequently asked questions" sheet that explains how the "notification requirements regarding sexual harassment, other forms of harassment and sexual assault" terms and conditions would be applied. New to the FAQ update is the application of the term and condition to harassment other than or in addition to sexual harassment. An "Office of Polar Programs Affirmation of Non-Harassment Policy Statement" was also published to address measures to combat recently reported incidents of harassment, bullying, etc. at facilities of the U.S. Antarctic Program. Listening sessions were held and barriers to lines of reporting were removed with the establishment of the Sexual Assault/Harassment Prevention and Response (SAHPR) support office.

Partnerships for Innovation

The Partnerships for Innovation (PFI) program helps researchers develop and mature their technologies, demonstrating commercial potential. The program specifically invests in developing critical partnerships, educating and providing leadership development for students in innovation and entrepreneurship, and broadening participation in innovation, technology translation and entrepreneurial activities. In FY 2022, PFI sponsored two workshops to explore issues that inherently address intersectionality. The first workshop, "Supporting Undergraduate Institutions in Technology and Entrepreneurship Development," focuses on technology development, entrepreneurship and commercialization activities at primarily undergraduate institutions. This workshop provides participants with a forum to learn about opportunities, nurture supportive communities, address barriers and develop plans to improve infrastructure around technology development, entrepreneurship and commercialization activities. The second workshop, "Diversity in Innovation and Entrepreneurship," focuses on diversity in innovation and entrepreneurship with emphasis on community colleges. This workshop provides an opportunity for students at community colleges and those from backgrounds traditionally underrepresented to learn the concepts, processes and skills for business, innovation and entrepreneurship and inclusive practices.

Some of the objectives highlighted in Executive Order 13985 and the recommendations in the Racial Equity Task Force report are already being implemented across the agency. Two exemplar programs which are vital to meeting both the administration's goals and NSF's long-term objectives for growth in the geography of innovation and reaching the "missing millions" in the mathematical and physical sciences are Ascending Postdoctoral Research Fellowships (MPS-ASCEND) and Launching Early-Career Academic Pathways (LEAPS-MPS). MPS-ASCEND seeks to address the lack of role models in the professoriate by supporting postdoctoral fellows who broaden the participation of persons from populations historically excluded and currently underrepresented in MPS. LEAPS-MPS supports pre-tenured faculty at MSIs, primarily undergraduate institutions and R2 (doctoral universities - high research activity) institutions that traditionally do not receive significant NSF funding. Other noteworthy efforts are highlighted in the sidebars of this report, calling special attendance to support for tribal communities, the work of the Directorate for Computer and Information Science and Engineering (CISE), and the Directorate for Social, Behavioral and Economic Sciences (SBE) with MSIs.

Most recently, NSF established a new directorate. The Directorate for Technology, Innovation, and Partnership (TIP) aims to deliver benefits from supercharged research outcomes and to accelerate the cycles of discovery and innovation. The expectation is that innovative technologies will be more readily available to the end users. An emphasis is also placed on identifying metrics that demonstrate success, especially related to broader impacts of awards. For example, TIP will be proactive and intentional with industry partnerships/ collaborations.

Additional NSF organizational changes include the renaming of the Directorate for Education and Human Resources (EHR) to the Directorate for STEM Education (EDU), as well changing its Human Resource Development (HRD) Division's name to the Division of Equity for Excellence in STEM (EES).

Programmatic efforts[6]

Many of the design elements recommended in the 2013-2014 CEOSE report are incorporated in the foundation's newer programming to broaden participation in STEM. Another example is the increase in new funding opportunities that require the investment of diverse community voices, as recommended in the 2017-2018 CEOSE report. NSF's leadership has been bold in developing new programs focused on BP in all research directorates/offices to advance the agency's visionary pillar of accessibility and inclusivity. Again, these new BP investments represent meaningful actions that are responsive to CEOSE's suggestions and fill the opportunity gaps in the NSF BP portfolio.

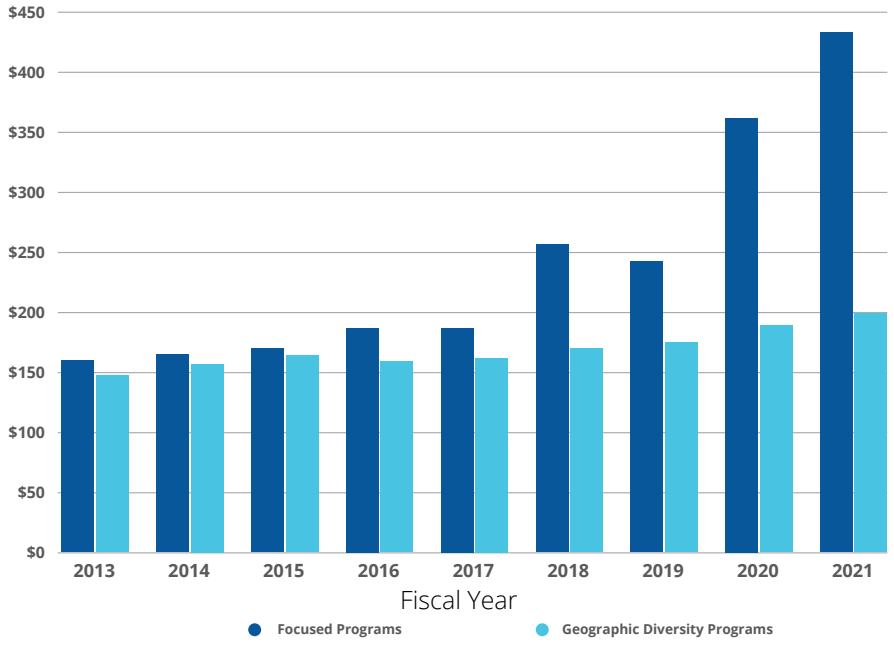
6 See Appendix C for NSF's Responses to CEOSE's Recommendations.

The following focused programs/programmatic tracks were initiated during the 2021-2022 reporting period:

- Build and Broaden.
- CISE Minority-Serving Institutions Research Expansion Program.
- Cultural Transformation in the Geoscience Community.
- EPSCoR Research Infrastructure Improvement Program: Bridging EPSCoR Communities.
- HSI Program Network Resource Centers and Hubs.
- Launching Early-Career Academic Pathways in the Mathematical and Physical Sciences (LEAPS-MPS).
- Leading Culture Change Through Professional Societies of Biology.
- LSAMP National Coordination Hub and Louis Stokes Community Resource Centers.
- MPS Ascending Postdoctoral Research Fellowships (MPS-ASCEND).
- Partnerships for Research and Education in Chemistry.
- Partnerships for Research and Education in Physics.
- Racial Equity in STEM Education.

Figure 2.1 shows gains in focused programmatic investments, while investment in geographic diversity programs (as evidenced by the EPSCoR portfolio) have remained relatively flat between FY 2012 and FY2021. Table 2.2 summarizes the investments from FY 2012 to FY 2021, which elucidates the growth of funding made in BP regarding programs that are fully focused on BP and those that have geographic diversity, as explicit in their program, such as the EPSCoR initiative.

Figure 2.1: Summary of broadening participation investments from FY 2012 to FY 2021.



MSI-CISE Research Expansion Program

The engagement of minority-serving institutions is critical in efforts designed to diversify STEM disciplines. With the aim of building research capacity to foster innovation and cultivate talent at MSIs, the NSF CISE Directorate established the MSI Research Expansion (CISE-MSI) program. The program was motivated by workshops that took place in 2019 and 2020 and led by HBCU, HSI and TCU faculty. The workshops focused on what is needed to strengthen institutional resources to conduct research; how to develop meaningful partnerships among MSIs, other postsecondary institutions, and industry; and how to advance opportunities for students from minoritized populations in STEM. Three key recommendations emerged from the workshops: (1) provide opportunities to develop research capacity, infrastructure, and proposal development support; (2) recognize that there is a wide range of MSIs requiring diverse types of support; and (3) improve NSF and the CISE Directorate's understanding of organizational context of MSIs from the perspective of the MSI community. With support from NSF's CISE to build research capacity at MSIs and with involvement of NSF program officers, the American Society for Engineering Education has provided extended workshops over the last three years focused on proposal development, NSF's review process, collaborative partnerships, and effective approaches for student involvement. Research mentors provide constructive feedback on proposals. In response to the other recommendations, the MSI-CISE program offers three threads: research capacity-building planning projects, demonstration projects, and research partnerships enhancement projects. The 2023 MSI-CISE program solicitation is the third offering of the program.

Table 2.2 presents a summary of current BP-focused programs (i.e., programs that have an explicit BP program goal). The table lists the programs by directorate.

Table 2.2: Summary of broadening participation focused programs by directorate/office.

Directorate	#	Title of Program
All	**5**	ADVANCE: Organizational Change for Gender Equity in STEM Academic Professions; EPSCoR Research Infrastructure Improvement Program Track-1. Established Program to Stimulate Competitive Research: Workshop Opportunities (EPS-WO); Historically Black Colleges and Universities-Excellence in Research; Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science (INCLUDES)
BIO	**2**	Leading Culture Change Through Professional Societies of Biology; Postdoctoral Research Fellowships in Biology
CISE	**2**	Broadening Participation in Computing; Computer and Information Science and Engineering Minority-Serving Institutions Research Expansion Program
EDU	**9**	Advancing Informal STEM Learning; Alliances for Graduate Education and the Professoriate; Historically Black Colleges and Universities Undergraduate Program; Improving Undergraduate STEM Education: Hispanic-Serving Institutions; Louis Stokes Alliances for Minority Participation; NSF Scholarships in Science, Technology, Engineering, and Mathematics; Racial Equity in STEM Education; Tribal Colleges and Universities Program; Center of Research Excellence in Science and Technology (CREST)/HBCU Research Infrastructure for Science and Engineering (RISE)
ENG	**2**	Broadening Participation in Engineering; Disability and Rehabilitation Engineering
GEO	**2**	Cultural Transformation in the Geoscience Community; Geoscience Opportunities for Leadership in Diversity
MPS	**6**	Mathematical and Physical Sciences Ascending Postdoctoral Research Fellowships; MPS-Ascend External Mentoring; Partnerships for Research and Education in Chemistry; MPS Launching Early-Career Academic Pathways (MPS-LEAPS) Partnerships for Research and Education in Materials; Partnerships for Research and Education in Physics; Partnerships in Astronomy & Astrophysics Research and Education
OIA	**1**	EPSCoR Research Infrastructure Improvement Program: Bridging EPSCoR Communities
SBE	**2**	Build and Broaden; SBE Postdoctoral Research Fellowships

Note: Much more work is underway in each of the units when you view the full BP portfolio on the NSF website. Approximately, 21 BP "Dear Colleagues Letters" were issued in 2021-2022. Additionally, the emphasis programs, which have additional review criteria on BP, grew substantially, including programs like LEAPS-MPS and Research and Mentoring for Post Baccalaureates in Biological Sciences.

NSF and the coronaviruses pandemic

The intervening years since the last CEOSE report was published have brought unprecedented societal changes, both in response to the coronavirus pandemic and in the strong resurgence of a call for social justice following the shooting of George Floyd. The pandemic caused the scientific workforce to go from working in laboratories, classrooms and offices to a remote work posture. This situation highlighted inequities known as the "digital divide" wherein internet access, computers and technology were simply unavailable in many marginalized and underrepresented, low-income communities. NSF responded with a "Dear Colleague Letter" which highlighted its Rapid Response Research funding mechanisms to enable researchers to respond to data collection needs specific to the coronavirus pandemic.

NSF also held the "COVID-19 Diversity, Equity, and Inclusion Challenge" where STEM faculty were able to showcase their institutional actions to mitigate negative impacts on the educational and career progress of STEM faculty, postdocs and students. Nine institutions were awarded and an additional 17 received honorable mentions (including four two-year institutions). With this robust start to programming, NSF is better equipped to address the "missing millions" problem raised in the NSB's Vision 2030 report.

The intersectionality of both socioeconomic and minoritized populations was highlighted by both the pandemic and social justice crisis and led to NSF convening numerous listening sessions to gather ideas on potential responses. Three listening sessions are notable: The NSB panel titled "Framing Black Experiences in Science and Engineering," the MPS Directorate panel titled "Blacks in Science," and the ENG Directorate's advisory committee panel titled "Black Lives in Engineering." All three were panels of distinguished Black scientists and engineers who shared interesting perspectives and gave very specific advice on useful program and policy recommendations for NSF. The longer-term implications of these panels were the creation of new programs such as MPS-LEAPS and MPS-ASCEND.

The Native FEWS Alliance

Native FEWS (Food, Energy, Water Systems) Alliance is a $10 million project that was funded by the INCLUDES initiative in 2021. The Alliance is a network of groups throughout the U.S. who share a common goal of addressing challenges faced by Indigenous communities around access to food, energy and water. The network aims to broaden the participation of Indigenous peoples in STEM fields in ways that ultimately build capacity within Indigenous communities and empower community-based solutions to food, energy and water challenges. Virtual and in-person activities bring together community members as well as students and faculty members from research institutions and Tribal Colleges and Universities (TCUs). Activities emphasize approaches to research, education and engagement that are based on reciprocity and respect for Indigenous and local knowledge systems. The American Indian Higher Education Consortium (AIHEC) serves as a central hub for the Native FEWS Alliance.

One of the signature NSF programs for DEIA is NSF's newly renamed Eddie Bernice Johnson Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science (INCLUDES) Initiative, which is building the infrastructure needed to foster collaboration and accelerate broadened participation in STEM (James, 2020). The vision of NSF's INCLUDES Initiative is to catalyze the STEM enterprise to work collaboratively for inclusive change, resulting in a STEM workforce that reflects the nation's population. The INCLUDES Initiative has supported design and development launch pilot projects, alliances, planning grants and other projects. Alliances (described in Table 2.3) are the largest INCLUDES investment and are positioned to build novel connections and intentional synergy across hundreds of individual DEIA reform efforts in STEM to develop and sustain the systemic change needed to accelerate inclusivity in STEM. Alliances work collectively toward solutions to specific DEIA issues and through a network of key stakeholders from different sectors.

Table 2.3 Summary of NSF's Eddie Bernice Johnson INCLUDES Initiative Alliances

Year	Alliance	Mission
2018	Alliance for Inclusive and Diverse STEM Faculty (Aspire)	Develop inclusive and diverse STEM faculty across the nation by aligning and reinforcing professional development, hiring and retention practices of STEM faculty at institutional, regional and national levels.
2018	Computing Alliance of Hispanic-Serving Institutions (CAHSI)	Grow and sustain a networked community committed to recruiting, retaining and accelerating the progress and success of Hispanics in computing.
2018	First2 Network Alliance	Improve STEM persistence among rural, first-generation and other underrepresented college students so that they in turn can contribute to an innovation economy in West Virginia.
2018	Inclusive Graduate Education Network (IGEN)	Increase the number of doctoral degrees earned by Black, Latinx and Indigenous students so that there is no difference in bachelor and doctoral degree attainment rates.
2018	STEM Core Alliance	Create a pathway bringing students to the foundational skill level required for associate and Bachelor of Science degrees and industry employment in STEM fields.
2019	STEM Pathways for Underrepresented Students to Higher Education (PUSH) Network	Create systemic change in the postsecondary admissions process by reinventing the relationship between pre-college STEM programs and higher education admissions offices.
2019	STEM Opportunities in Prison Settings (OPS) Alliance	Develop a national network to expand the number of culturally responsive STEM higher education programs and opportunities for people who are currently or recently incarcerated.
2019	Supporting Emerging Aquatic Scientists (SEAS) Islands Alliance	Promote and facilitate student engagement, sense of belonging, and achievement in the marine and environmental sciences.
2021	Accelerate Latinx Representation in STEM Education (ALRISE)	Develop a network of faculty, staff, and students in two-year and four-year Hispanic-Serving Institutions (HSIs) to accelerate Latinx representation in STEM education.
2021	The Alliance of Persons with Disabilities for Inclusion, Networking, and Transition Opportunities in STEM (TAPDINTO-STEM)	Increase the quantity of students with disabilities completing associate, undergraduate and graduate degrees in STEM, facilitate the transitions of students with disabilities from STEM degree completion into the STEM workforce, and enhance communication and collaboration among IHEs, government, national labs and local communities in addressing the education needs of students with disabilities in STEM disciplines.
2021	Alliance for Identity-Inclusive Computing Education (AIICE)	Create systems change in computer science to 1) increase computer science student and educator knowledge and use of identity and related topics; 2) support computer science educators and leaders in fostering academic cultures that are more inclusive of non-dominant identities; and 3) increase K-16 policy-driven changes to computer science education that infuse identity-inclusive strategies.
2021	Engineering PLUS (Partnerships Launching Underrepresented Students)	Achieve transformative, systemic and sustainable change that will dramatically increase the number of underrepresented students and women obtaining undergraduate and graduate engineering degrees.
2021	Native FEWS (Food, Energy, and Water Systems) Alliance	Focus on innovative research and community partnerships linking two interconnected challenges: a crisis in access to food, energy and water in Indigenous communities, and limited educational and career pathways available to Indigenous populations to address these needs.
2022	Alliance Supporting Pacific Impact through Computational Excellence (ALL-SPICE)	Create new pathways into data science careers to support sustainability, economic development and social justice in the Hawai'i-Pacific region.
2022	Cultivating Indigenous Research Communities for Leadership in Education and STEM (CIRCLES) Alliance	Build on the collaborative efforts of an existing partnership among six EPSCoR states — Idaho, Montana, New Mexico, North Dakota, South Dakota and Wyoming — to develop Native-based education activities for K-12 and higher education students in order to address the severe underrepresentation of American Indians and Alaska Natives in STEM.
2022	National Data Science Alliance (NDSA)	Increase the number of Black people who earn data science credentials, such as undergraduate, graduate and post-baccalaureate minors, certificates and degrees.
2022	Re-Imagining STEM Equity Utilizing Postdoc Pathways (RISE UPP)	Create systemic models for enhanced recruitment, engagement and transition to faculty roles for minoritized postdoctoral scholars.

BP by the numbers[7]

Minority serving institutions[8]

In FY 2021, NSF funded 10,438 new awards representing a total investment of $7.38 billion distributed to more than 1,100 institutions of higher education (IHEs) nationwide. That same year, 16.5% of new awards to IHEs went to MSIs, representing 13.4% of total new award funding that year, according to NSF's dashboard called "NSF by the Numbers." The 1,718 awards to MSIs represented a $988.8 million investment to 246 institutions nationwide.[9]

Between 2012 and 2021, annual new award funding increased by 20% for all IHEs and increased 57% for MSIs. The number of new awards made annually to all IHEs remained largely unchanged during the 10-year period, but the number of new awards made annually to MSIs increased by more than 30%, rising from 1,301 awards in 2012 to 1,718 awards in 2021.

NSF submits an annual report to Congress regarding its support for MSIs. Taken from the FY 2021 annual report submitted to Congress, the table below (Table 2.4) shows the annual funding to IHEs and MSIs from FY 2011-2021.[10]

Table 2.4 Share of Funding to IHEs that are Currently MSIs for the Last 10 years (FY 2011-2021) (Millions of Dollars)

Fiscal Year	Funding to All Categories of Minority-Serving Institutions (millions)					Funding to All IHEs (millions)	Funding to MSIs (millions)	Percentage of MSIs Funding in All IHEs
	EDU	MREFC	R&RA	H-1B	Total			
2011	$200.60	$0.00	$462.77	$18.43	$681.80	$5,094.73	$682.69	13.4%
2012	$179.38	$0.00	$428.36	$23.62	$631.36	$5,199.41	$629.13	12.1%
2013	$179.43	$0.00	$442.50	$28.78	$650.71	$5,083.53	$650.69	12.8%
2014	$175.49	$0.00	$481.13	$24.06	$680.68	$5,220.09	$678.61	13.0%
2015	$176.68	$0.00	$488.63	$34.68	$699.98	$5,525.05	$701.68	12.7%
2016	$186.21	$0.00	$548.69	$48.61	$783.52	$5,529.79	$785.23	14.2%
2017	$158.01	$0.00	$503.39	$22.92	$684.32	$5,595.80	$682.69	12.2%
2018	$214.88	$0.00	$542.27	$55.62	$812.77	$5,860.43	$814.60	13.9%
2019	$223.58	$0.00	$579.96	$40.41	$843.94	$6,129.53	$845.88	13.8%
2020	$255.13	$0.00	$602.38	$36.14	$893.65	$6,240.33	$892.37	14.3%
2021	$242.21	$0.00	$712.89	$33.66	$988.76	$6,529.18	$985.91	15.1%

7 Relevant tables are in Appendix D.

8 This section is informed by two information sources: "NSF by the Numbers" database using the recent update to MSI status data and the FY 2021 MSI Report to Congress (based on data before the recent update). The "NSF by the Numbers" database provided more detailed information about the award count and obligation amount.

9 Data from NSF by the Numbers, https://beta.nsf.gov/about/about-nsf-by-the-numbers

10 IBID and https://nsf-gov-resources.nsf.gov/2022-05/msi-report-2021-508.pdf

Among MSIs, relatively few institutions receive a large share of NSF awards, as manifested by the fact that 10 institutions received approximately 40% of all NSF awards to MSIs in FY 2021. In contrast, among all IHEs, the top 10 recipients accounted for approximately 12% of all NSF awards made during FY 2021.[11]

PI Data

In 2020, the last year for which demographic data are available for principal investigators, PIs from racial or ethnic populations underrepresented in STEM submitted 2,699 proposals to NSF and were funded at a rate of 29%. Female PIs submitted 9,511 proposals and were funded at a rate of 32%. PIs with disabilities submitted 384 proposals and were funded at a rate of 30%. For all PIs, the funding rate was 28%.[12]

PI demographic data are self-reported. About 24% of proposals came from PIs who indicated neither their race nor their ethnicity, and 26% of proposals came from PIs who did not indicate their gender.

The absence of a complete demographic dataset limits the ability of NSF to identify or monitor trends in potential funding rate disparities by race or ethnicity, gender, disability status or combinations thereof.

NSF Program Directors

The year 2020 is also the most recent one for which demographic data are available for program officers at NSF. Program officers make funding recommendations on proposals and include both permanent and non-permanent employees. In 2020, females made up nearly 45% of program officers, and approximately 30% of program officers were from racial/ethnic populations. Based on annual merit review reports issued by NSF in recent years, the percentage of female program officers fell slightly in 2020 from a high of 47% in 2018 and 2019 after growing from approximately 40% a decade ago, whereas the percentage of program officers from underrepresented racial/ethnic populations has risen steadily from 22% a decade ago.[13]

Missing/No Data

Missing data limit the ability of NSF to identify and address the underrepresentation of intersectional populations. More complete datasets on PIs, program officers, reviewers, and others involved in NSF-related activities can improve future efforts to broaden participation of persons from populations underrepresented in science and engineering. NSF should communicate the importance of collecting demographic data on PIs and others, and the agency should also study and implement strategies that may lead to more complete reporting in the future.

11 Data from *NSF by the Numbers*, https://beta.nsf.gov/about/about-nsf-by-the-numbers

12 Data from *NSF's Merit review Process: FY 2020 Digest*, https://www.nsf.gov/nsb/publications/2021/merit_review/FY-2020/nsb202145.pdf

13 Ibid

SBE's Build and Broaden Program

The Social, Behavioral and Economic Sciences Directorate launched the Build and Broaden program in 2020 with the goal of supporting research and capacity-building at minority-serving institutions. The program encompasses all disciplines funded by the directorate, from anthropology to sociology.

Since FY 2021, the Build and Broaden program has provided support to dozens of minority-serving institutions across the country and over a thousand personnel. In addition to conducting original research, many of the minority-serving institutions are collaborating with other institutions, including larger research-intensive universities. These collaborations are fostering enduring partnerships that will enrich human-focused research and expand the nation's STEM pipeline.

"Through the Build and Broaden program, NSF is demonstrating new ways to support research at minority-serving institutions while fostering equitable and rewarding partnerships for all institutions," said NSF Director Sethuraman Panchanathan.

In late 2022, the directorate held a two-day workshop on "diversifying diversity" that featured presentations from Build and Broaden awardees about their current research and discussions with program officers on how to prepare proposals and submissions.

NSF continues to make progress toward broadening participation of persons from populations underrepresented in STEM in meaningful ways. However, missing data, limitations in ways that data are reported, and lack of PI self-reporting all complicate efforts to track progress toward broader participation and representation, especially for populations at the intersections of underrepresentation involving race, ethnicity, gender, disability, and other identities. NSF needs to pay close attention to year-to-year trends in the participation among severely underrepresented populations, including intersecting populations. Other opportunities exist for NSF to track and report on the number and characteristics of outside entities (e.g., professional societies, foundations, corporations) who participate in NSF-supported work. These additional steps can contribute to NSF's efforts to make visible the invisible in terms of quantitative metrics used to track progress toward broadening participation. For implementation actions, NSF may consider some of the specific recommendations given in the 2020 and 2021 reports[14] by the National Academies of Sciences, Engineering, and Medicine (NASEM), which are summarized in the Appendix E.

See the example below from the report, National Academies of Sciences, Engineering, and Medicine. 2021. Transforming Trajectories for Women of Color in Tech. Washington, DC: The National Academies Press. https://doi.org/10.17226/26345

RECOMMENDATION 5-1. Government efforts aimed at addressing the underrepresentation of particular groups in tech should intentionally account for intersectionality.

- 5-1 A. Any legislation aimed at addressing issues of underrepresentation in STEM and in tech should take an intersectional approach that considers the unique experiences of women of multiple marginalized identities.
- 5-1 B. Government efforts calling for data collection related to groups underrepresented in STEM and in tech should clearly indicate that such data be disaggregated by race/ethnicity and gender (to the extent possible given the need to protect anonymity of individuals) and should require qualitative as well as quantitative data collection, especially when the numbers are small enough that qualitative data would provide more meaningful information.
- 5-1 C. Program solicitations and descriptions at federal agencies should be explicit in directing prospective grantees to take an intersectional approach. History demonstrates that unless policies, practices, programs, and individuals embrace an intersectional approach to promote diversity, equity, and inclusion in our institutions, women of color will not benefit from these efforts.

14 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 and National Academies of Sciences, Engineering, and Medicine. 2021. *Transforming Trajectories for Women of Color in Tech*. Washington, DC: The National Academies Press. https://doi.org/10.17226/26345.

III: CEOSE ACTIVITIES AND RECOMMENDATIONS

CEOSE activities in 2021-22 include virtual committee meetings, dissemination of the 2019-2020 CEOSE Biennial Report[15], and the preparation of this report. The ongoing work of the committee aligns with the plans set forth in the 2019-2020 CEOSE report. Additionally, the ongoing work of the committee to advance broadening participation in STEM and S&E aligns with the themes articulated in NSB's Vision 2030 and NSF's current strategic plan. The Committee was cognizant of NSF's critical leadership role in developing the STEM pathways and S&E ecosystems that undergird the discovery and innovation vital to our nation's competitiveness and security. This section provides a brief overview of the committee's work during the 2021-22 reporting period and plans for the upcoming year, as well as the recommendations to enhance NSF's effort for inclusive excellence in the scientific enterprise.

2021-2022 CEOSE Meetings

CEOSE convened six meetings between February 2021 and October 2022. Regular sessions at these meetings included the following: INCLUDES Initiative updates, reports by CEOSE liaisons to NSF directorate/office advisory committees, sessions with the leadership of the National Science Board (NSB), National Center for Science and Engineering Statistics (NCSES) briefings, and discussions with the NSF Director and Chief Operating Officer. In addition, a CEOSE subcommittee was empaneled to envision the future of the NSF Established Program to Stimulate Competitive Research (NSF EPSCoR). There was robust dialogue among NSF leadership, researchers, thought leaders, and the committee to develop insights and recommendations to assist NSF in ensuring that our national STEM and S&E ecosystem is preeminent, equitable and inclusive. Meeting minutes on the CEOSE webpage provide more information about each of the six meetings. Highlighted below are recurring topics and themes from the presentations and discussions.

The Time is Now – Meeting Today's Moment

Three overarching sentiments emerged from committee discussions. First, was the "Urgency of Now" and the call to action needed to respond to rapidly shifting global socioeconomic forces that threaten American innovation leadership and national security. There was a shared sense that we are approaching a "tipping point" in our nation's future, and we need to accelerate progress in broadening STEM and S&E participation.

Second, there was recognition that our innovation challenges have grown too complex for any one entity or sector—including government— to solve alone. Rather, solutions require an all-partners-on-deck approach to overcome long-standing demographic and geographic barriers to mobilize the collective potential of our nation at speed and scale.

Third, NSF has never been more critical for American innovation leadership. Investments, strategies, actions (and inactions) durring this decade will have significant implications for our near-term national security and economic prosperity, perhaps more than ever before.

Accordingly, in addition to discussion of NSF's ongoing BP efforts, a significant portion of CEOSE discussions related to NSF's increasing focus on innovation and partnerships, such as developing new crosscutting programs, building and catalyzing trans-sectoral partnerships, and fostering institutional transformation to better address the needs of underserved communities. In discussion with NCSES, the committee frequently highlighted the need for more robust datasets, such as intersectional and longitudinal data, to understand

15 See Appendix F

Bridging EPSCoR Communities

In FY22, funding from the American Rescue Plan provided a new pathway for EPSCoR jurisdictions to build the STEM career pipeline within their communities. The EPSCoR Research Infrastructure: Building EPSCoR Communities program provided funding for bridge programs to facilitate the transitions of Affected Groups (e.g., women, underrepresented groups, research trainees, and graduate fellows) from one stage of training to the next, with particular focus on providing support for individuals from groups underrepresented in STEM and those transitioning from or to minority-serving institutions within EPSCoR jurisdictions.

In Alabama, for example, the University of Alabama partnered with three historically Black colleges and universities to create their bridge program. Project goals include enhancing the competitiveness of HBCU student participants as applicants to graduate programs, preparing participants for the STEM workforce by reinforcing hands-on lab experiences that were lost during the coronavirus pandemic, and providing students with content knowledge, skills, experiences and confidence to engage in entrepreneurial pursuits in the STEM arena. Bridge program activities will take place through resident summer programs at the university as well as student exchanges between the university and HBCU students during the academic year.

and remove long-standing systemic barriers. The committee also discussed the importance of leveraging unique lessons learned from the coronavirus pandemic and social injustice that produced asymmetrical impacts across the S&E community. Collectively, the discussions and insights were used to shape our plans for the coming year and the recommendations in this report.

Innovation, partnerships and geography

CEOSE meetings included significant discussion on NSF's recent strategies to build partnerships and networks among and across government, academic, industrial and private sectors to accelerate BP and innovation. A particular focus was the geography of innovation, recognizing the urgent need to reach under-resourced communities and regions, such as rural America where the economic gap is widening. Several discussions related to the future of NSF's EPSCoR program and the new Technology, Innovation, and Partnership Directorate (TIP), are discussed in Section II.

EPSCoR was developed in 1980 with the goal of expanding support to jurisdictions that "historically have received relatively little Federal Research and Development funding" and have "demonstrated a commitment to develop their research bases and improve science and engineering research and education" (See Envisioning the Future of NSF EPSCoR). NSF EPSCoR is a critical asset for building national STEM research competitiveness by enhancing demographic and geographic diversity.

In May 2021, NSF issued a Dear Colleague Letter (DCL NSF 21-088) that called for "Envisioning the Future of NSF EPSCoR." In response, a subcommittee of CEOSE was formed and charged to address two questions:

1. What does the available evidence tell us about the effectiveness of NSF EPSCoR's current investment strategies, both individually and collectively, in advancing scalable, jurisdiction-wide solutions and best practices to achieve the program's goals?
2. Based on the answers to the above, are there novel strategies or changes to the current strategies that would enable NSF EPSCoR and its jurisdictional partners to achieve the mission more effectively?

Four working groups (education/ workforce, broadening participation research capacity/ infrastructure, and economic development) were formed to conduct a document review and to collect information from the community via six listening sessions and a survey (that received 49 responses).

The report on Envisioning the Future of NSF EPSCoR highlighted notable successes of NSF EPSCoR, including increased NSF funding to institutions within EPSCoR jurisdictions, retention of NSF EPSCoR-funded faculty within their original jurisdictions, new research centers, upgraded research facilities, and new degree programs within EPSCoR jurisdictions. However, it also recognized areas of

concern that prompted eight recommendations that are described in detail in the report. CEOSE members expressed enthusiasm for the recommendations and agreed that they were well-aligned with the plan, particularly with its goals to (a) "Empower STEM talent to fully participate in science and engineering"; (b) "Benefit society by translating knowledge into solutions"; and (c) "Create new knowledge about our universe, the work and ourselves."

The final report was released in August 2022 and has been disseminated through a variety of mechanisms, including a summary document and a series of report videos, which can be found on https://beta.nsf.gov/funding/initiatives/epscor/future-nsf-epscor. See callout box for a brief description of the recommendations.[16]

Recommendations in the report on envisioning the future of NSF EPSCoR

Recommendation 1

Ecosystem approach to investments

- Leverage partnerships with other federal agencies.
- Encourage collaboration between EPSCoR and non EPSCoR jurisdictions.

Recommendation 2

Increased integration of NSF EPSCoR

- Support greater integration of EPSCoR across NSF.
- Develop internal programs to leverage strengths and priorities of EPSCoR jurisdictions.

Recommendation 3

Diverse talent recruitment and retention

- Grow the critical mass of highly competitive and capable faculty, technical staff, and students.
- Develop new grant programs to encourage nationally competitive, sustainable research, and promote collaboration within NSF EPSCoR jurisdictions and beyond.

Recommendation 4

Physical and administrative infrastructure

- Invest in constructing and/or modernizing research infrastructure in NSF EPSCoR jurisdictions.
- Invest in staff to support intellectual property development, commercialization, and corporate engagement in NSF EPSCoR jurisdictions.

Recommendation 5

Programs to promote intra- and inter-jurisdictional research, education and workforce development

- Fund collaborative proposals across multiple jurisdictions that leverage existing expertise and resources, and promote synergistic research, workforce development and educational activities.

Recommendation 6

Support for workforce, including those with diverse career pathways

- Expand research and collaboration opportunities for individuals at different career stages, especially pre-tenure and pre-promotion mid-career faculty.

Recommendation 7

Proactive inclusion strategies

- Provide opportunities for EPSCoR researchers, particularly those from underrepresented populations, to participate and offer input on NSF panels and advisory committees.

Recommendation 8

Access and opportunity

- Provide greater support in research administration, funding of brick-and-mortar research facilities, research collaborations, and innovative mentoring partnerships at minority-serving institutions, primarily undergraduate institutions, and two-year colleges.

16 See Appendix G for Report Handout.

Intersectionality in Building STEM Entrepreneurship Capacity: Rurality, Indigeneity and Technology

The Social, Behavioral and Economic Sciences Directorate's Science of Science and Science of Broadening Participation Programs support research into the processes of scientific discovery and education, including the question of what strategies help to increase STEM participation by historically underrepresented groups. One example is the BPINNOVATE: Intersectionality in Building STEM Entrepreneurship Capacity: Rurality, Indigeneity and Technology award to researchers at the University of New Mexico. The project aims to create new STEM and technology career pathways for Native American, Hispanic, low-income and rural students in New Mexico. The researchers are investigating how young New Mexican's intersectional identities influence their attitudes towards and interest in STEM and technology careers. The research team is also conducting workshops with high school and college students to discuss intersectional perspectives on STEM-related topics. Their findings will be used to inform the design of training and internship opportunities at the University of New Mexico and nearby national laboratories to foster STEM entrepreneurship in rural, Indigenous and Hispanic students.

CEOSE received a presentation from members of the National Science Board (Dr. Ellen Ochoa, chair, NSB; Dr. Anneila Sargent, chair, NSB Committee on Oversight; and Dr. Roger Beachy, chair, Vision 2030 Task Force) on the current "geography of innovation" within the U.S.

The NSB presenters reiterated NSF's leadership role to determine how to create more science and engineering hubs and bring more states and regions and a wider variety of people into the fold. NSB's geography of the innovation roadmap elevates attention to the many interrelated elements that contribute to creating science and technology hubs and the geography of innovation.

In consideration of the future role of NSF in expanding the geography of innovation, NSB encouraged CEOSE to engage in the ongoing dialogue to answer and find innovative solutions to questions like: What can be done to get NSF-funded educational research off the shelf and into classrooms to strengthen K-12 STEM education nationwide? How can we build on the EPSCoR initiative as newly defined to further efforts in building research and educational capacity at all higher education institutions, as well as MSIs, urban vs rural, and EPSCoR vs non-EPSCoR states? What other NSF programs might more explicitly address geography? How might expanding the geography of innovation be more explicitly integrated in broader impacts, or into the NSF approach to broadening participation? The NSB chair emphasized that geography is an important dimension of diversity in the STEM enterprise.

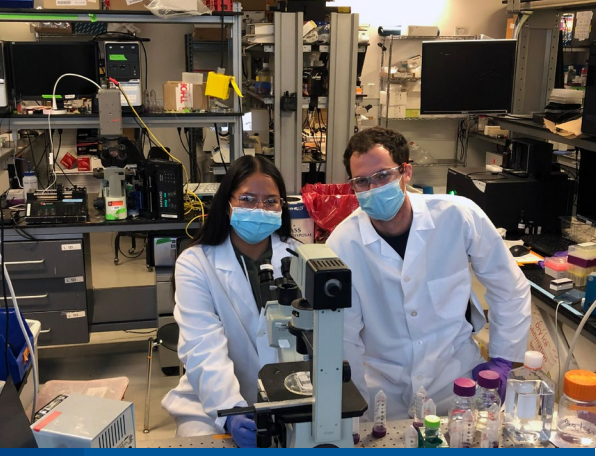
Data and metrics

A recurring theme among all CEOSE discussions was pervasive questioning about why more progress has not been made in broadening participation in science and engineering, especially for persons from populations underrepresented in STEM, despite several decades of investment. This led to frequent discussions highlighting the need for more robust datasets, especially intersectional and longitudinal data, to better understand and remove long-standing systemic and institutional barriers.

Several presentations featured NCSES's recently expanded datasets and online data visualization tools, along with plans for future advances. NCSES is reimagining the Women, Minorities, and People with Disabilities in Science and Engineering report to be more user friendly and modernized, which should increase its reach and impact and allow for more thematic reports. CEOSE members volunteered to be interviewed by NCSES and noted that the report needs to give increased attention to intersectionality, disaggregate the data along career paths, identify and address the gaps in disability data reporting, and share/show solutions for addressing the small n data problem.

Every CEOSE meeting is premised and rooted with data, data platforms, or data tools that lead to analyses and summations but also prompt more questions and inquiries. This is the essence of science. During the six CEOSE meetings in 2021 and 2022, data presentations were broad, diverse and evocative (see listing of presentations below).

February 2021 Open Science & NSF Broader Impacts – Tananbaum	Underscored that open science is better for philanthropy, science and society. Solving the world's most pressing problems requires a vast ecosystem of sources and knowledge, built on equal access to information that is vital to the public good. CEOSE members raised concerns such as what do the mutually reinforcing vectors look like at an under-resourced institution? How can more students be engaged in faculty research and be part of the research conversation before publication?
June 2021 STEM Technical Careers by NSB – McCrary	STW – skilled technical workforce – was the focus of the presentation as related to science and engineering but STEM in general. The presenter highlighted the need for 3.4 million more STW by next year (2022).
BP Accountability Data by NCSES – Hamrick	Black or African Americans receiving S&E bachelor's degrees at HBCUs declined while the share of other populations increased based on data from 2011 to 2018. CEOSE members requested similar information for Tribal colleges and universities. Together with NCSES, they planned a hackathon to leverage data in support of the theme "making visible the invisible," especially for tackling the intersectionality, the topic of this report.
NSF Learning Agenda – Cosentino	The learning agenda is designed to generate information useful for decisionmakers to enable data-driven planning and decision-making. They challenged CEOSE to think about the questions that NSF should be asking and focusing on for the next four years, for example "What are the barriers that have historically prevailed in specific fields or in S&E in general? CEOSE was pleased to learn that the Evaluation and Assessment Capacity (EAC) unit in the NSF Office of Integrative Activities is already helping NSF to address a culture of evidence in decision-making.
October 2021 Leadership Roles of MSIs in STEM Education & Workforce Development – Panel of program directors	Overviews with data were provided for Centers of Research Excellence in Science and Technology, the Tribal Colleges and Universities Program, the Improving Undergraduate STEM Education: Hispanic-Serving Institutions Program, and the Historically Black Colleges and Universities Undergraduate Program. Among the insights shared: The HSI program is supporting more than 90 institutions in 13 states and Puerto Rico and >15 of these awardees are new to the NSF funding portfolio.
February 2022 Demographic Data Collection – Cosentino, Ross, Finamore	NSF launched a new platform, Education and Training Application, for connecting applicants, students, post-docs, and teachers to opportunities in one location. Presenters stressed the importance of privacy and confidentiality in collecting NSF administrative data. One potential solution to reduce the burden of collecting/storing these data and improving data quality is the use of a unique identifier. The OMB Equity Data Working Group, created by Executive Order 1395, is involved in ongoing discussions along these lines.



Partnership for Research and Education in Materials

The Partnership for Research and Education in Materials (PREM): Vision for Excellence at Navajo Technical University in Research and Education in STEM (VENTURES) is a partnership between Navajo Technical University and the NSF Materials Research Science and Engineering Center at Harvard University. The PREM program is designed to foster long-term collaboration in materials research and education between minority-serving institutions and large-scale, NSF-supported research facilities in order to bring diversity, equity, inclusion and access in cutting-edge materials research, education and profession. In addition to supporting new discoveries, the PREM pathway provides institutional support to increase recruitment, retention, and degree-attainment by underrepresented groups, and provides underserved communities with access to state-of-the-art materials research and education. PREM awards are intended to pull together the resources of the partners and support a diverse cohort of students through graduation, ushering them in to higher education and/or rewarding careers in STEM. These students are part of the "missing millions" who, as a highly trained and diverse workforce, will drive future research and innovation, propelling U.S. leadership in STEM.

VENTURES is the first PREM based at a Tribal university. Ms. Breanna Thompson, a PREM undergraduate student from this Tribal university, is seen here in the microfluidics laboratory at Harvard University with her MRSEC mentor, Dr. Brendan Deveney. After earning her bachelor's degree from Navaho Technical University, Ms. Thompson enrolled at Arizona State University as a Ph.D. student in microbiology.

In February 2022, CEOSE continued to collaborate with NCSES to explore the types of data needed from NCSES to address the issues of intersectionality; going beyond gender, ethnicity and disability status; the need for a deeper examination of attrition rates across various demographic populations; and the use of time series disaggregated data analyses to assess the types of institutions students attend. During a presentation on demographic data collection, CEOSE members commented on the value of evidence-based policymaking, the need to track participants across multiple programs/activities, the need to link data systems across agencies to enable longitudinal studies, and the need to have data in a timely manner.

The June 2022 data briefing by NCSES covered demographic trends using the new definition of the STEM workforce: workers at all education levels working in occupations that use significant levels of S&E expertise and skills. At the last meeting of this reporting period (October 2022), CEOSE acknowledged some improvements in providing disaggregated data by NCSES; however, members continued to discuss the small n problem.

Lessons from pandemics

During the current reporting period (2021-2022), we experienced several pandemics that will have lasting effects on our nation, its STEM research enterprise, and the STEM workforce. For many people, the coronavirus pandemic stands out as the game-changer that will impact the ways in which we conduct and manage research and innovation in the future. Indeed, the coronavirus pandemic spurred innovation (e.g., mRNA vaccines) and illustrated the importance of reducing barriers to collaboration across disciplines and sectors. However, we were also gripped by another pandemic that highlighted issues of injustice and inequality that have long been visible to some, but not to everyone in our nation. CEOSE participated in a variety of discussions that impinge on both the coronavirus and racial injustice pandemics and lessons learned from those conversations are captured below.

Like other employers across sectors, NSF had to modify its expectations and provide opportunities for virtual work during the coronavirus pandemic. CEOSE members viewed this as an important experiment that opens up the possibility of continuing to allow flexibility, thereby broadening participation on NSF panels and even within NSF rotator and permanent workforces. In the February 2021 meeting, NSB chair Dr. Ellen Ochoa reported that the NSB had hosted discussions about the impact of the pandemic, especially on women in STEM. Importantly, the 2023 "Women, Minorities, and Persons with Disabilities in Science and Engineering" report addresses the impact of the coronavirus pandemic on the broader swath of underrepresented scientists and engineers. In response to these and other pressures, NSF has broadened access to remote and hybrid work schedules for its employees.

In response to the pandemic of racial injustice, the NSF Office of Diversity and Inclusion has been re-envisioned as the Office of Civil Rights and Equity. Led by Ms. Rhonda Davis, who reported to CEOSE during its June 2021 meeting, the office has launched a Racial Equity Task Force (RETF) that will identify barriers to achieving racial equity

both within (internal working group) and outside (external working group) of NSF and recommend strategies to address them. CEOSE members were pleased to learn that the RETF will address barriers to participation both within and outside NSF and that it will recommend sustainable strategies to achieve racial equity. During the February 2022 meeting, Dr. Alicia Knoedler, head of NSF's Office of Integrative Activities, raised the concept of an "equity ecosystem" at NSF, a concept that was well-received by CEOSE.

In short, CEOSE members agreed there is much to learn from the multiple pandemics that have affected the country and the world at large. Many of the levers discussed in this report (institutional transformation, robust data, committed and empowered leadership, and others) were viewed as key to sustaining and growing this essential ecosystem.

Leveraging the influence of NSF to broaden participation through institutional transformation

Many of CEOSE's conversations were centered on the need for institutional transformation, within both NSF and its grantees, as a mechanism for broadening participation and enhancing innovation in STEM because "... broadening participation is not a problem, but a strategy to promote scientific research, learning and innovation" (2019-2020 CEOSE report). For example, when members of the National Science Board met with CEOSE and in several sessions with NSF leadership, CEOSE discussed NSF's ADVANCE program as a lever to achieve institutional transformation. While CEOSE members appreciated the impact of ADVANCE on women in academic science and engineering, they noted a need to expand the program to address the needs of persons from other demographic populations underrepresented in STEM, particularly scientists and engineers of color. CEOSE also implored the Directorate for STEM Education (EDU, formerly EHR) to carefully inspect data generated by ADVANCE programs to identify best practices, gaps and the potential for expanding its focus. During the meetings with the NSF Director, CEOSE members suggested development of ADVANCE-like programs focused on racial equity, as well as targeted ADVANCE-like programs for community colleges and minority-serving institutions.

During the October 2021 meeting, CEOSE discussed the "Leadership Roles of MSIs in STEM Education and Workforce Development" with leadership from the EDU and MPS directorates and the NSB. In addition to updates on such long-standing broadening participation programs as Tribal Colleges and Universities Program (TCUP), Centers of Excellence in Science and Technology (CREST), and Historically Black Colleges and Universities-Undergraduate Program (HBCU-UP), and more recently the Improving Undergraduate STEM Education: Hispanic Serving Institutions Program (HSI), CEOSE members also learned about new initiatives that partner MSIs with MPS-funded centers (e.g. Partnerships for Research and Education in Physics, Partnerships for Research and Education in Chemistry (PREC), and an NSF Alliance (IGEN) focused on equity and inclusion in graduate education that grew out of the well-respected Fisk-Vanderbilt Bridge program). CEOSE members praised the impact of these programs and suggested that they be mined for data and best practices to

The A-SCENE

With NSF support, the Autism Self-advocacy Center for Equity and Neurodiversity in Engineering (The A-SCENE) is creating a comprehensive and fully interconnected system of programs and supports to ensure that neurodiverse students can access and succeed in engineering majors and careers. The A-SCENE partnership between Vanderbilt University and Fisk University, an HBCU, is developing a timely, innovative, sustainable, and replicable model to provide educational and research experiences for more than 250 engineering students while building a community and inspiring a broader paradigm of neuro-inclusive engineering. The A-SCENE builds on unique strengths at both Vanderbilt and Fisk, including the Frist Center for Autism & Innovation, the Fisk-Vanderbilt 3+2 program in engineering, and the College Autism Network. NSF funded the A-SCENE in FY 2022 as one of seven new Centers for Equity in Engineering, which are supported by NSF's Broadening Participation in Engineering program. NSF Centers for Equity in Engineering are designed to catalyze a culture change in the education of engineers and create equitable and inclusive practices that recruit and retain a diverse community of students.

inform institutional transformation around broadening participation. They also emphasized the importance of looking at other long-term investments (e.g., center grants) as opportunities to both glean best practices and provide incentives for institutional transformation.

CEOSE also participated in discussions about the critical role that HBCUs play in the research ecosystem and the need to prioritize their competitiveness. To that end, Dr. Tammi Fergusson (White House Initiative on HBCUs) met with the committee in February 2021 to share the Federal HBCU Competitiveness Strategy, which comprises plans from 35 federal agencies. CEOSE members praised the NSF for its plans, which included leveraging the diverse perspectives of HBCU researchers, educators, and community partners in pursuit of discovery and innovation; resourcing HBCU faculty to both establish their research agendas and improve the knowledge transfer within the HBCU network; and enhancing technical support to HBCUs. This call for NSF to support institutional transformation at HBCUs is consistent with recommendations in the report from the Committee on the Future of NSF EPSCoR, which include providing support to enhance the research infrastructure at MSIs, two-year colleges, primarily undergraduate institutions, and other institutions that serve students and researchers from populations underrepresented in STEM.

Many of the conversations around institutional transformation focused on elevating underrepresented scientists and engineers to "positional" leadership roles that wield the influence, power and money necessary to effect change. While recognizing the importance of such leadership, CEOSE members also highlighted the need for diverse leaders who lack such authority but can influence institutional transformation in other ways. CEOSE urged NSF to lead by example by focusing on diversity within its executive team and even within the membership of CEOSE itself.

CEOSE also engaged in discussions about institutional transformation within NSF. CEOSE members commended NSF for its aspiration to be a "model agency" in promoting data-driven decision-making to effect institutional transformation and broaden participation, in accordance with the Foundations for Evidence-Based Policymaking Act of 2018 and in using the levers suggested by Dr. Marrongelle in February 2021 (see box on following page). Along those lines, CEOSE members were pleased to learn about the Racial Equity Task Force, with working groups focused on both external (i.e., grantees) and internal (i.e., within NSF) audiences. It appears the working groups are positioned to have impacts on NSF employees, applicants and program participants.

The conversations of 2021-22 have codified CEOSE's commitment to promoting institutional transformation to broaden participation, enhance excellence, and spur innovation in STEM. This commitment to promoting institutional transformation is among the "bold leadership actions" that NSF can make to "to create, integrate and make visible elements within and across its programs to enhance broadening participation of persons from populations underrepresented and underserved in STEM."

Postdoctoral Women of Color Leading Career Advancement Efforts in the Biological Sciences

Black women are 7% of the U.S. population aged 25-64 but earn only 3% of Ph.D.s in biology and hold only 1% of Ph.D.-level biology faculty positions at four-year institutions. Recognizing the underrepresentation of Black women at all levels of science, NSF postdoctoral fellow in biology Manuella R. "Rossie" Clark-Cotton is working to implement a mentoring program linking Black female postdoctoral researchers with established scientists who can help launch the postdocs into careers in STEM. In these efforts, she is partnering with the North Carolina Women of Color Research Network and conducting outreach to universities in the area around the North Carolina Research Triangle.

Another NSF postdoctoral fellow in biology, Jasmine Childress, has worked with the Black Ecologists section of the Ecological Society of America, A Womxn of Color Space, and uses social media to expand the network of Black ecologists. Childress will also hold workshops for underrepresented graduate students looking to secure a postdoctoral opportunity.

NSF levers for inspiring institutional transformation

What NSF has been doing internally to respond to the missing/invisible millions initiative was the focus of a presentation by Dr. Marrongelle. The data projects close to four million people are needed in the year 2030 for the S&E workforce to be representative of the US population. Within NSF, there are racial equity and sexual harassment task forces, accountability stakeholders, and long-standing communities dedicated to BP. NSF has five major levers of influence – funding, policies, partnerships, communications and reputation. The key strategy is partnering to effect institutional change and transformation. CEOSE members suggested that data or accountability as another lever of influence. CEOSE Minutes, June 10-11, 2021.

1) Funding
2) Internal and external policies
3) Partnerships
4) Internal and external communications
5) Reputation of advisory boards (e.g., NSB, CEOSE, etc.)

Upcoming meetings and the next biennial report

In the third report of this trilogy and in future meetings, CEOSE will focus on individuals from populations severely underrepresented in STEM. In addition to bringing visibility to the inclusion and belonging barriers of these individuals, CEOSE plans to be forward thinking about several other areas, such as minority-serving institutions and a hybrid STEM working environment, while continuing to emphasize STEM leadership, data-driven decision-making and accountability.

The role of minority serving institutions

As articulated by NASEM's 2019 report, *Minority Serving Institutions: America's Underutilized Resource for Strengthening the STEM Workforce*, "currently there are roughly 700 two- and four-year MSIs, which educate nearly 30% of all U.S. undergraduates. MSIs traditionally fall into two categories. The first category includes historically Black colleges and universities and tribal colleges and universities, which were established for the express purpose of providing access to higher education for persons from specific minoritized populations. The second includes colleges and universities, such as Hispanic-serving institutions, that are designated as MSIs by the U.S. Department of Education because they meet thresholds for enrollment (i.e., the percentage of students of color enrolled) and institutional expenditures. Importantly, the number of enrollment-based MSIs has grown significantly in the past 20 years, the report notes, and many more can be expected to emerge in coming decades as the nation's demographics continue to change."[17]

This is a broad base that could provide support for potential STEM field graduates; however, it is so broad in scope that it is likely that different mechanisms of engagement by federal science and technology sponsors are needed to maximize the potential of those institutions that can in the near term (between now and 2030) drive the development of a more diverse STEM workforce.

The depth of the challenge is staggering. As the NASEM MSI report notes, "21st century advances require the United States to expand its science, technology, engineering and mathematics (STEM)-capable workforce, both in terms of the quantity and diversity of the individuals who enter these fields and in the quality of their contributions. In fact, evidence suggests that the nation will need one million more STEM professionals than it

17 National Academies of Sciences, Engineering, and Medicine. 2019. *Minority Serving Institutions: America's Underutilized Resource for Strengthening the STEM Workforce*. Washington, DC: The National Academies Press. Available at https://doi.org/10.17226/25257.

is on track to produce in the coming decade."[18] The problem is likely to be compounded in the future. Why? As the MSI report so well states:

"In 2016, nearly 50% of the nation's population 0-17 years of age was nonwhite; based on current projections, by 2060, two-thirds of the nation's youth will be of color (U.S. Census Bureau 2015, 2018). A clear takeaway from these population estimates is that the educational outcomes and STEM readiness of students of color will have direct implications on the nation's economic growth, national security and global prosperity."[19]

Broadening participation at the state, institutional, and individual levels

Action is needed to adjust federal research and development funding policy to target a growing percentage of dollars to states whose institutions of higher education have been less competitive for federal grants. The recently passed "CHIPS and Science Act" directs NSF to ensure that as much as one in every five dollars goes to EPSCoR states in the coming fiscal years. NSF EPSCoR, now in existence for more than four decades, seeks to balance federal research dollars through broadening the geographic and institutional diversity of states participation in NSF funding. While the program emphasizes the geographic diversity of awards, broadening the participation of individuals and institutions is also a relevant area of needed growth within the program. Created as an "experimental" program to stimulate geographic diversity, this well-intentioned program has elevated few states from the narrow class of competition created by its existence.

Furthermore, very few MSIs within EPSCoR jurisdictions, or non-EPSCoR jurisdictions for that matter, have achieved R2 (Doctoral Universities-High Research activity) status in the Carnegie Classification of Institutions of Higher Education. For example, there is just one HBCU from an EPSCoR jurisdiction with R2 status despite dozens of candidate institutions within the 28 states and territories that are eligible for EPSCoR status.

These data are a reminder of the "missing millions" and the need to fully engage institutions with a track record of graduating STEM students of color who come from challenging backgrounds and whose pre-college credentials are not necessarily in the top 10% of their high school graduating classes. Additional debate is needed, but one model to consider is the recent "HBCU RISE Act, which instructs the Department of Defense to encourage HBCUs currently classified as R2 to reach R1 status within a decade.

2023-2024 CEOSE report

The next report will cover 2023 and 2024. It will be the third report in the trilogy focused on the theme *Making Visible the Invisible*. The next report will focus on addressing challenges and opportunities in acknowledging and valuing persons from populations severely underrepresented in STEM, such as persons with disabilities, or individuals who are neurodiverse, Native Americans and individuals who elect not to be categorized, and women in skilled technical workforce. CEOSE will continue to work with the National Science Board, NCSES, and our federal liaisons to develop suggestions for increasing the inclusion of persons from populations severely underrepresented in STEM, making more "visible" their voices, perspectives, and experiences.

18 Ibid., p.1.

19 Ibid, p. 13.

2021-2022 Recommendations and suggested actions

NSF has made extensive progress on broadening participation of persons from populations underrepresented in STEM through bold, foundation-wide programming investments such as NSF's Eddie Bernice Johnson INCLUDES Initiative and the Science of Broadening Participation as well as by supporting directorate-level efforts such as the CISE BPC (Broadening Participation in Computing) plan requirement[20].These programs represent substantial investment, but more is needed to highlight, and effectively address, the challenges and opportunities that intersectionality presents in the STEM enterprise. For example, future program solicitations that target investments in broadening participation and/or developing a diverse workforce should explicitly call out and address intersectionality.

See the ADVANCE solicitation as an example:

> *All NSF ADVANCE proposals are expected to use intersectional approaches in the design of systemic change strategies for STEM faculty in recognition that gender, race and ethnicity do not exist in isolation from each other and from other categories of social identity. (NSF 20-554)*

In this report, CEOSE has two specific recommendations for NSF. The first recommendation is directly related to Figure 2 in the 2019-2020 CEOSE report and Figure 1 in this current report. CEOSE's second recommendation is in support of the Envisioning the Future of EPSCoR report that answers the question, "… [A]re there novel strategies or changes to the current strategies that would enable NSF EPSCoR and its jurisdictional partners to achieve its mission more effectively?"

Thus, CEOSE ended the 2021-2022 biennium with the development of the following two recommendations:

Recommendation 1:
Utilize intersectional analysis to remove barriers to the participation of persons from various populations historically underrepresented in STEM fields, so as to meet more effectively the needs of society and maximize the nation's scientific investment. This requires that NSF invest in obtaining and analyzing higher resolution data about investigators' identities, demographic characteristics and institutions to develop strategies and programmatic interventions.

Recommendation 2:
Develop metrics and utilize an intersectional analytical framework in implementing and assessing the recommended actions for the NSF EPSCoR portfolio from the future of NSF EPSCoR report. Recommendations and suggestions in the report are exemplary strategies that can be undertaken nationally to promote broadening participation and institutional transformation in the STEM enterprise.

20 https://www.nsf.gov/cise/bpc

In many ways, NSF's goal to grow a STEM workforce that engages diverse voices and reflects the demographics of our nation will require a heavy lift. Some of the changes called for in this report (e.g., institutional transformation) may take decades, perhaps even generations to achieve. However, there are other things that NSF can do immediately to leverage its leadership role and effect change. Some of those actions are described in the table below.

Table 3. Suggestions for immediate actions for an NSF portfolio where all identities can thrive

Self-Reporting:	Develop and implement a strategic effort to gather intersectional information from various populations (grant applicants, students, etc.). Often, when such questions are posted, people do not disclose or feel comfortable sharing their identities; therefore, it is necessary to motivate people by presenting the goals for asking these questions and explaining how this information is necessary (and would be used). There may be a need for experimentation to determine the type of language that enhances reporting (various ways to frame the question).
Programming:	Develop and issue solicitations that target investments in broadening participation and/or developing a diverse workforce—such as NSF 22-634—that currently do not but should, in the future, explicitly include topics specifically related to intersectionality. Increase the funding opportunities that address specific issues that women of color face (not just women). See more support for evidence-based actions in Appendix E.
Communication:	Communicate the importance of intersectionality in data sets. Creating these data sets is necessary in order to understand how to improve conditions within the scientific community for those from intersectional populations. This, in turn, will benefit both NSF and the broader scientific community. It will also position STEM disciplines to telegraph a message of inclusivity to diverse populations with multiple identities.
Data Analysis:	Invest more resources in innovative data analysis strategies to highlight the challenges and opportunities of intersectionality in the STEM enterprise. Leverage these analyses as training opportunities for students from diverse communities, who may be particularly interested in the data and their potential to broaden participation in STEM.
Accountability:	Hold researchers accountable for "diversifying diversity" as they address disparities and lack of inclusion from the perspective of intersectionality to deliver relevant, equitable solutions. Additionally, request the agency to report on the status of broadening participation with an intersectional lens component.
Representation:	Leverage the data collection, analysis and communications strategies outlined above to ensure that demographics of panelists, ad hoc reviewers, NSF rotators, and professional NSF permanent staff reflect the agency's commitment to broadening participation and the nation's need to engage the "missing millions."

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APPENDICES A-F

APPENDIX A:

Brief review of the literature about the promise and challenges of diversity on science teams

Organizational research has established that diversity on a variety of types of teams has positive effects on creativity, innovation and productivity (Hong & Page, 2004; Woolley et al., 2010; Jackson and Joshi, 2011; Bear and Woolley, 2011; Gibbs et al., 2019).

Several recent studies have focused on the benefits and challenges of diversity on scientific teams in particular (Díaz-García et al., 2013; Smith-Doerr et al., 2017; NASEM, 2023). Scientific discovery is enhanced when informed by diverse viewpoints, approaches, and research questions (Margolis & Fisher 2003). The expansion of research agendas and scientific breakthroughs have coincided with women's headway into traditionally male-dominated disciplines (Nielsen et al., 2018). Notwithstanding the important limitations of using citation databases to measure research (Sugimoto and Larivière 2018), bibliometric research has become a useful way to measure the impacts of diverse science teams although more of this research has focused on gender diversity because approximating racial-ethnic diversity through algorithmic analysis of author names is more challenging. Campbell et al., (2013) found that among ecology and environmental scientists, authorship teams with at least one woman received 34% more citations than publications produced by homogeneous teams and that peers perceive the publications produced by gender-diverse teams to be of higher quality. More recently, based on a study of research teams through an examination of 6.6 million papers published across the medical sciences since 2000, Yang et al., 2022, found that science teams made up of men and women produce papers that are more novel and highly cited compared to same-gender teams. In reference to racial-ethnic diversity, Freeman and Huang, 2014, examined the ethnic identity of authors in over 2.5 million scientific papers written by U.S.-based authors from 1985 to 2008 and found that greater homophily among co-authors is associated with publication in lower-impact journals and with fewer citations.

However, despite the promise of scientific impact and innovation on diverse research teams, there are many barriers to reaching this potential. Simply including diverse individuals in a scientific team can be difficult and does not in and of itself guarantee the expected benefits. In the absence of a social and institutional environment in which all team members and their perspectives and knowledge are included and valued, diversity on teams can lead to lower levels of cooperation, higher levels of conflict, low psychological safety among members, and biased perceptions and discrimination towards members of differing backgrounds (Jackson and Joshi, 2011; Galinsky et al., 2015; Sung and Choi, 2019). Institutions of higher education are notorious for engendering social environments that are not welcoming to women and faculty of color. Despite decades of programs and interventions to improve these conditions, women and faculty of color have been persistently marginalized in, and excluded from, STEM and faculty careers (NASEM 2020a; NASEM 2020b).

Faculty members from populations historically underrepresented in STEM who manage to enter careers in academia may be less likely to participate in research collaborations, and their participation in research networks may develop later in their careers (Kyvik & Teigen 1996; Fox & Mohapatra 2007; Misra, et al., 2012; Kegen 2013; Abramo, et al., 2013). Negative perceptions and doubts about the expertise of scientists and engineers from populations underrepresented in STEM may prevent them from being chosen as collaborators (Rossiter 1993; Heilman and Haynes 2005; Bornmann, et al., 2007; Knobloch-Westerwick 2013; Glynn & Huge 2014; Joshi 2014). In addition, research has suggested that scientists and engineers from populations underrepresented in STEM may face various barriers in winning research grants from federal agencies (Ginther, et al., 2011; Yang, et al., 2013; Ginther, et al., 2016), which likely impacts their participation.

Aside from being excluded, there is also evidence that women and faculty of color themselves may opt out of interdisciplinary collaboration, or limit their collaborations to certain people, because they are aware that white and/or male counterparts might oftentimes receive more credit for shared ideas and publications (Del Carmen and Bing 2000; Feldon, et al., 2017; Rubin and O'Connor, 2018). This results in self-segregation, which decreases the potential for the positive effects of diversity among collaborative teams.

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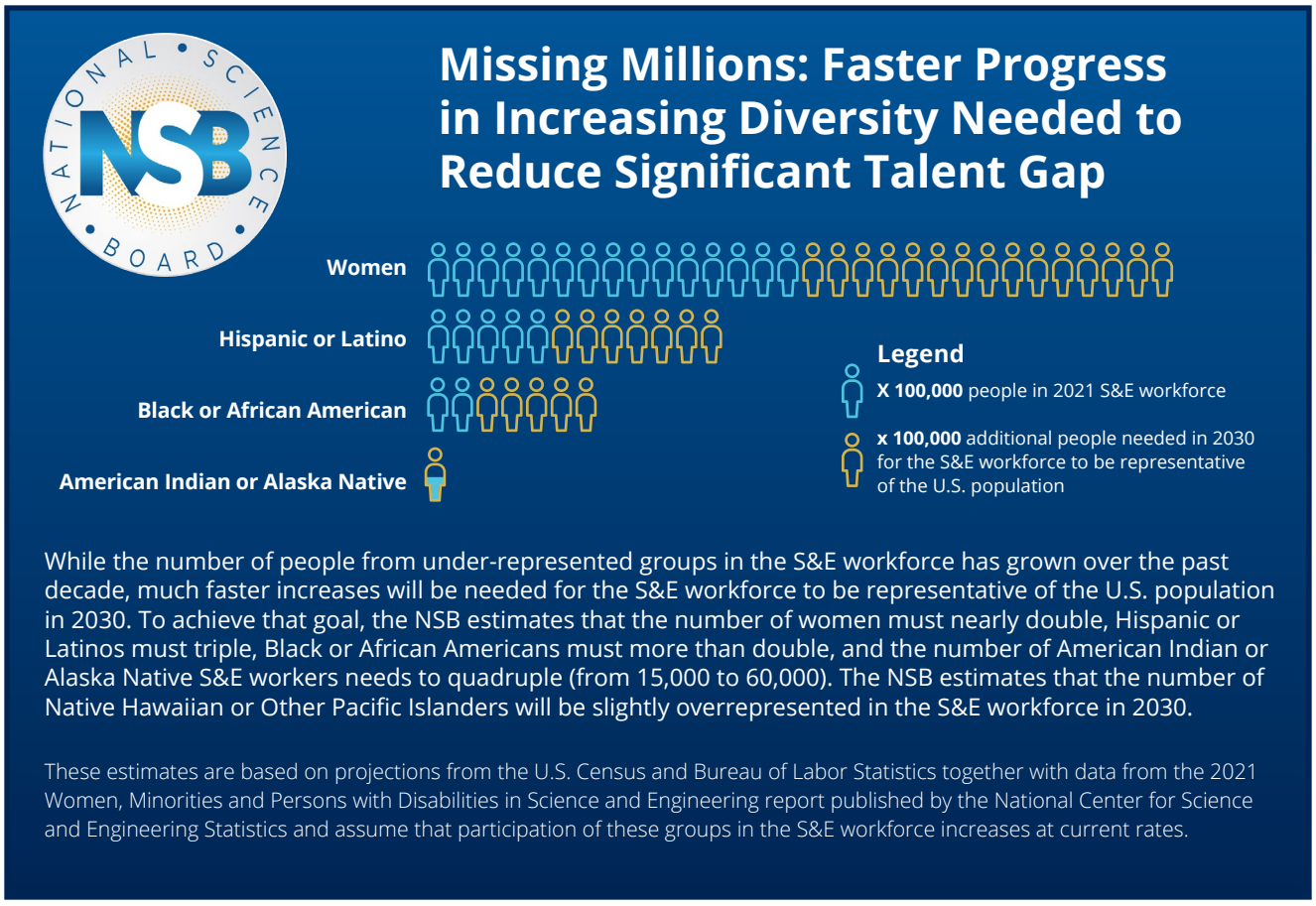
APPENDIX B:

Overview of the status of broadening participation in STEM

Broadening participation

According to the report The State of U.S. Science and Engineering 2022,[21] "The U.S. STEM workforce relies on STEM-trained workers with a broad range of educational credentials. STEM education equips Americans with the S&E skills and knowledge needed to participate in the STEM workforce. STEM education also leads to better public perceptions and understanding of science and the broader impact of its role in society." As the data from that report and others like it show, there is a cohort of Americans now referred to as the "missing millions," the number of women, Blacks and Hispanics missing from STEM fields proportionate to their presence of the population as a whole. It is imperative that policy makers at all levels of government act to find ways to broaden participation in STEM fields, and that means changing investment in the institutions of higher education that can accelerate preparing more students from these populations.



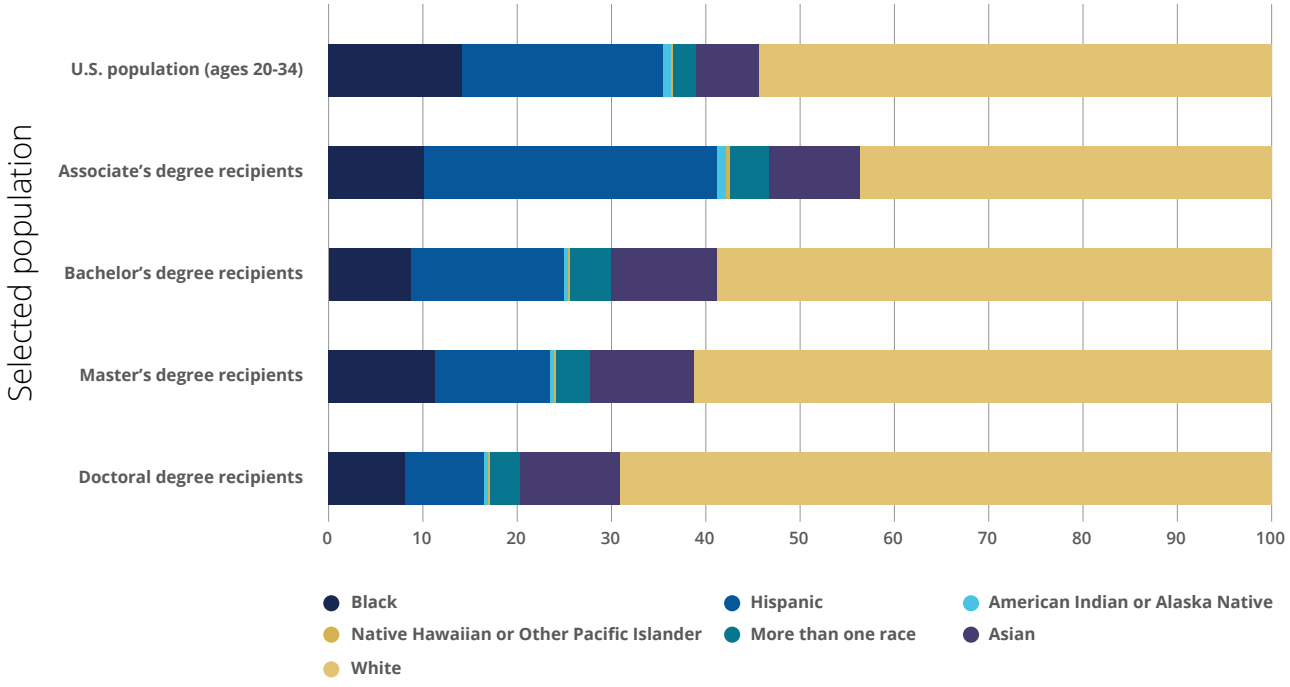
21 National Science Board, National Science Foundation. 2022. Science and Engineering Indicators 2022: The State of U.S. Science and Engineering. NSB-2022-1. Alexandria, VA. https://ncses.nsf.gov/pubs/nsb20221

Science and engineering higher education in the U.S.

The report states that the nation's S&E enterprise depends heavily on recipients of higher education degrees in S&E. "The number of degrees in S&E fields across all degree levels increased from 561,000 in 2000 to 1,087,000 in 2019, an increase in percentage share of S&E degrees from 24% to 27%. However, many demographic populations of Americans remained underrepresented among S&E degree recipients. Blacks were underrepresented at all degree levels. Hispanics, American Indians and Alaska Natives were underrepresented at all but the associate degree level (Figure 4)."

This underrepresentation is compounded by the finding that increases in the cost of undergraduate education have far exceeded inflation or increases in average family income, contributing to concerns about the affordability of higher education. As a more affordable option, many students from underrepresented populations are entering STEM careers through the less expensive community college path. The community college pathways prepare students to directly enter the STEM workforce with associate degrees or nondegree credentials such as certificates or to transition to 4-year institutions. From the report: "In 2019, the United States awarded 104,000 associate degrees in S&E fields and 123,000 in S&E technologies. Degrees in S&E technologies have a more applied focus than S&E degrees and include technician degree programs in engineering, health sciences, and other S&E fields. In addition, students can also earn certificates in S&E technologies. Community colleges awarded most (65%) of the 258,000 certificates earned in S&E technologies in 2019."

Figure 4 Representation of race or ethnicity in the U.S. population and among S&E degree recipients: 2019



Additionally, the data for higher education degree production revealed the following:

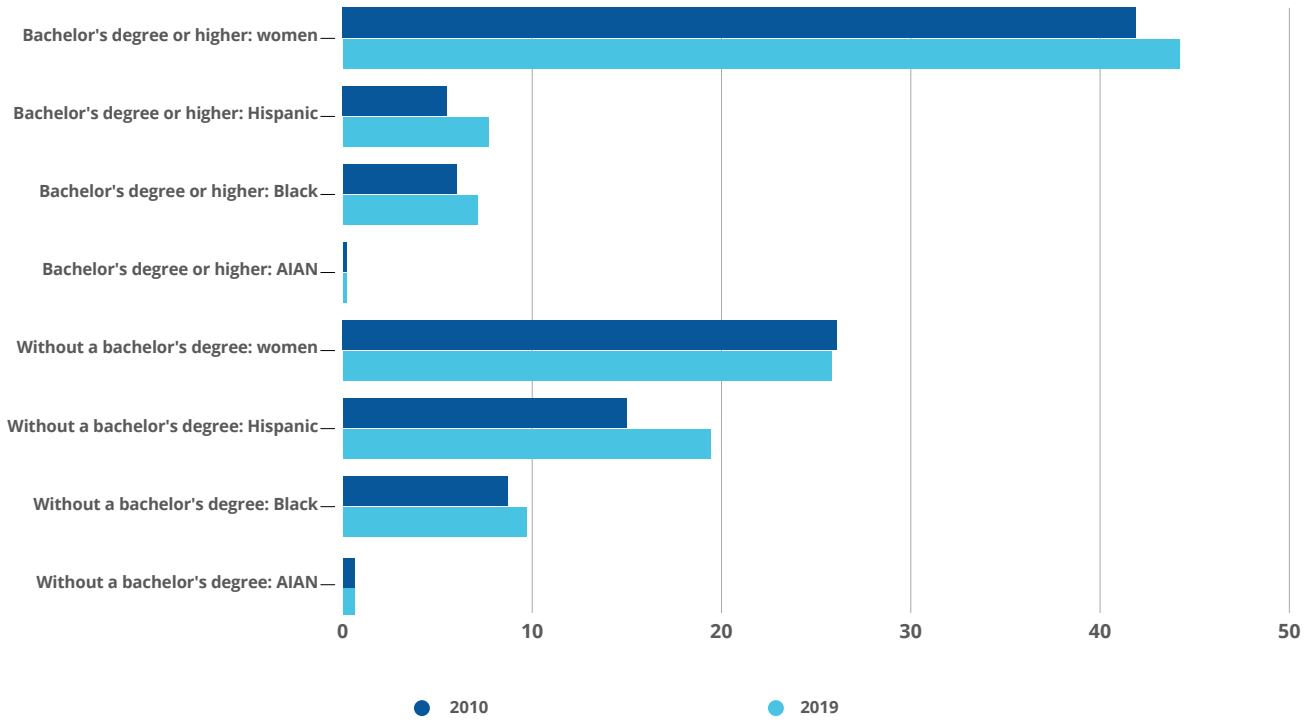
> *Bachelor's degrees account for nearly 70% of all S&E degrees awarded, with the largest numbers awarded in social sciences, followed by biological and agricultural sciences. Master's degrees either prepare students for some STEM careers or mark a step toward obtaining a doctoral degree. The number of master's degrees awarded in S&E fields more than doubled from 2000 to 2019. Increases were most pronounced in computer sciences and engineering, largely driven by students on temporary visas. In 2019, S&E fields accounted for 65% of doctorates conferred by U.S. universities, with S&E doctorate awards rising faster since 2000 than total doctorate awards. Across fields, the largest percentage increases since 2000 occurred in engineering, computer sciences, and medical sciences.*

U.S. STEM workforce

The American STEM workforce comprises over 36 million people in diverse occupations that require STEM knowledge and expertise. The Science and Engineering Indicators now defines the STEM workforce as encompassing all workers who use science and engineering skills in their jobs rather than defining the workforce based on degree level. "This new definition more than doubles the number of individuals classified within the STEM workforce by including 16 million workers with at least a bachelor's degree and 20 million workers without a bachelor's degree."

The report provided the following analysis of the demographic composition of the STEM workforce displayed in the figure below:

Figure 10 Demographic composition of the STEM workforce: 2010 and 2019



Women make up about one-third of the STEM workforce, less than their representation in the employed U.S. population (48%). The share of women in STEM grew from 32% in 2010 to 34% in 2019. However, this growth was due to the increase in the proportion of women with a bachelor's degree or higher in STEM, growing from 42% (5 million women) in 2010 to 44% (7 million women) in 2019 (Figure 10). The proportion of women in the STW remained unchanged at around 26% in both 2010 and 2019.

The distribution of women with a bachelor's degree or higher was uneven among the different types of STEM occupations. In 2019, women accounted for 48% of life scientists and 65% of social scientists but only 35% of physical scientists, 26% of computer and mathematical scientists, and 16% of engineers.

Blacks, Hispanics, American Indians and Alaska Natives collectively represented 30% of the employed U.S. population but 23% of the total STEM workforce in 2019. Consequently, they were underrepresented in STEM, largely driven by their underrepresentation among STEM workers with a bachelor's degree or higher. The share of Hispanic or Latino workers in the STW (19%) was similar to their share of the U.S. workforce in 2019 (18%). However, they were underrepresented among STEM workers with at least a bachelor's degree (8%). The share of Blacks in the STEM workforce was similarly distributed with 10% in the STW and 12% in the U.S. working population, compared with 7% among STEM workers with a bachelor's degree or higher.

A challenge to U.S. STEM workforce needs remains a high reliance upon international citizens. The 2022 Science Indicators report further clarifies:

In 2019, foreign-born workers (regardless of citizenship status) accounted for 19% of the STEM workforce, increasing from 17% in 2010. Foreign-born workers with a bachelor's degree or higher comprise a larger share of the STEM workforce (23%) than do those without a bachelor's degree (16%). Foreign-born workers with a bachelor's degree or higher accounted for 21% of workers in S&E occupations at the bachelor's degree level, 38% at the master's degree level, and 45% at the doctorate level, with the highest shares as computer and mathematical scientists for all degree levels.... Foreign-born workers also make up a substantial portion (26%) of STEM workers at all education levels in knowledge- and technology-intensive (KTI) industries, but they are more concentrated among the pharmaceutical, computer, electronic and optical products; scientific R&D; software publishing; and information technology (IT) service industries. Among foreign-born STEM workers in KTI industries, a little over half of them are U.S. citizens. About 50% of foreign-born workers in the United States whose highest degree was in an S&E field were from Asia, with India (22%) and China (11%) as the leading birthplaces."

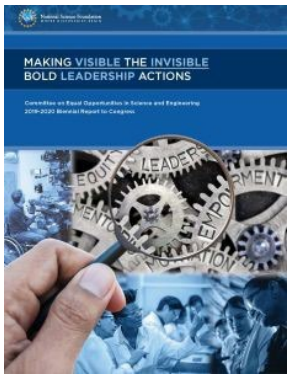
While the U.S. prides itself on being a free and open society, with a proud history of welcoming legal immigrants into its workforce, it remains concerning that the percentage of those in certain science and engineering fields are foreign born. As international students are less prone to seek an education in the U.S. after the coronavirus pandemic, we must have a national strategy to adjust our domestic output of these workers to compensate for this change or face severe skill shortages for decades to come.

APPENDIX C:

NSF responses to CEOSE recommendations from 2011-2012 to 2019-2020 biennial reports

The Committee on Equal Opportunities in Science and Education, or CEOSE, advises the U.S. National Science Foundation (NSF) on how to advance its policies and activities to encourage full participation of persons from populations underrepresented in the STEM enterprise. The committee releases biennial reports to Congress to convey these recommendations.

This appendix provides exemplars of actions that the Foundation has implemented in response to CEOSE's recommendations from 2011-2012 to 2019-2020. It is organized to highlight recent examples of responsiveness to the most recent 2019-2020 report, focused on bold leadership actions, followed by the updates of NSF-supported projects and activities related to the recommendations in the previous five biennial reports to demonstrate the importance that the Foundation continues to place on the sound advice and innovative recommendations received from CEOSE.



Making visible the invisible: Bold leadership actions 2019–2020 (PDF, 6.44 MB)

In this report, CEOSE recommends that the National Science Foundation demonstrate and promote bold leadership actions to create, integrate and make visible elements within and across its programs to enhance broadening participation of persons from populations underrepresented and underserved in STEM.

NSF response

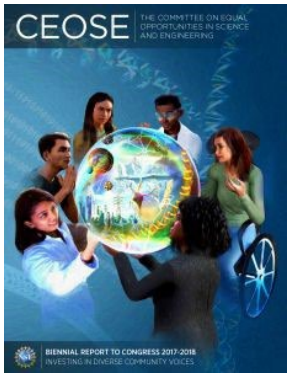
NSF actions have included:

- Meaningful actions linked to the Director's Accessibility and Inclusion Pillar such as Director's established task forces—the Racial Equity Task Force and the Task Force for Implementation of Measures to Combat Sexual Assault and Harassment in the United States Antarctic Program, as well as having a diverse Executive Leadership Team.
- Infusion of inclusiveness in overall operations of the agency as stated in recent strategic plans: Leading the World in Discovery and Innovation, STEM Talent Development and the Delivery of Benefits from Research - NSF Strategic Plan for Fiscal Years (FY) 2022 - 2026 and National Science Foundation (NSF) Diversity, Equity, Inclusion, & Accessibility (DEIA) Strategic Plan 2022-2024.
- Implementation of actions in response to the NSB's recent resolutions that require enhancing the merit review process regarding the quality of reviews and fuller understanding of the Broader Impacts criterion:

    mandatory training for all proposal reviewers to further promote fair and transparent consideration of all proposals, mitigate implicit bias, and optimize written reviews.

the addition of at least one Broader Impacts expert on committees of visitors to provide informed analysis and specific recommendations and thereby improve the current review process.

- New NSF BP programs and activities, such as CISE Minority-Serving Institutions Research Expansion Program, TIP's Enabling Partnerships to Increase Innovation Capacity, Geoscience Opportunities for Leadership in Diversity-Expanded Network, Leading Culture Change Through Professional Societies of Biology, Racial Equity in STEM Education, Launching Early-Career Academic Pathways in the Mathematical and Physical Sciences, Mid-Career Advancement, Emerging Frontiers in Research and Innovation Planning Grants to Promote Diverse Participation, Broadening Participation in STEM Entrepreneurship and Innovation.
- New conceptual frameworks such as NSF's Equity Ecosystem and GRANTED.
- Other bold actions reported by senior leaders, including (now EDU): Taking Action: COVID-19 Diversity, Equity and Inclusion Challenge; a dedicated BP program officer in the SBE Directorate and a "Diversifying Diversity" convening; efforts of the IRES program that doubled the awards to R2, PUI, and MSI institutions; and GEO's emphasis on BAJEDI (Belonging, Access, Justice, Equity, Diversity, Inclusion) leaders.
- The Agency Priority Goal to Improve Representation in the Scientific Enterprise.



Investing in diverse community voices 2017–2018
(PDF, 2.65 MB)

In this report, CEOSE advises NSF to give increased attention to including diverse community voices across its research and education portfolios through community-driven projects. They suggest NSF fund research that focuses on building inclusive, community-engaged STEM communities to promote STEM participation on the ground and at all ages, as well as to reap the scientific benefit of the insights of people from diverse settings, neighborhoods and circumstances in the innovation cycle.

Updated NSF response

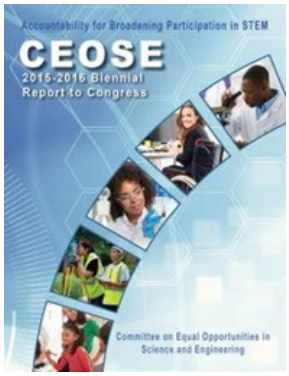
NSF has increased its engagement of diverse listening sessions for informing future directions. For example, the EDU Directorate held diverse stakeholder listening sessions for gathering community input on charting the future of STEM education. Another example of collecting diverse community input is the collection of data from written comments and listening sessions for the visioning activity of NSF EPSCoR.

More recent programmatic efforts have included the following: Cultural Transformation in the Geoscience Community; EPSCoR Research Infrastructure Improvement Program: Bridging EPSCoR Communities; the Mobilization Track of the CISE Computing in Undergraduate Education solicitation; and the Regional Innovation Engines.

Recently funded projects included:

- Collaborative Research: Establishing a Network and Framework for Informal STEM Education for Youth in Native Communities.
- SCC-PG: Preparing the Next-Generation Rural Workforce Through Inclusive and Place-Based Smart and Connected STEM Educational Delivery Models.
- A Power of Place Learning Experience & Research Network to Support Community College Student Success and Civic Engagement.
- Developing a Place-based STEM Education Model for Cultural Connections to Alaska Science.
- Sociocultural and Place-Aware Civil and Environmental Engineering Scholars.
- CAREER: A Quantitative Analysis of Spatial Inequality and Place-based Policies.
- GP-IN: Broadening Pathways to an Undergraduate Degree in Geosciences: Collaboration between Johns Hopkins University and the Baltimore City Ingenuity Project.
- Examining the Efficacy of a Co-Designed Culturally Sustaining STEM Learning Ecosystems Model for Youth, Their Families, and Informal Educators in Rural Communities.
- ADVANCE Partnership: Promoting Equity and Inclusion to Facilitate Retention of Faculty through Evidence- and Place-Based Intervention Training.
- Supporting Talent with Aligned Resources for STEM Students.
- Cultivating Relationships: Partnering with Teachers and Tribes to Integrate Indigenous and School STEM Knowledge.
- NSF Convergence Accelerator Track J: Network Of User-engaged Researchers Building Interdisciplinary Scientific Infrastructures for Healthy food (NOURISH).
- BPC-DP: Culturally Relevant Physical Computing for Sustainability Programs for Native Hawaiian Students; Preparing Early Engineers through Context, Connections and Community (PEEC3).
- REU Site: Using Data Science Tools to Improve Neighborhoods.

In this report, CEOSE recommends developing an accountability framework for assessing the development of the bold new initiatives advocated for in its first two reports and for assessing NSF's overall broadening participation portfolio.

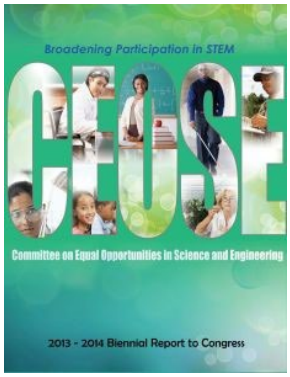


Accountability for broadening participation 2015–2016 (PDF, 5.93 MB)

Updated NSF response

NSF's Eddie Bernice Johnson INCLUDES Initiative has a multiple-layer approach to measuring and reporting progress and success, as well as sharing what does and does not work. The principal investigators submit project-level evaluation plans (that are reviewed as part of the merit review process) and keep the Foundation updated about project progress via NSF's annual reporting requirement, often attaching their external evaluation reports. The participating institutions in the National Network have worked closely with the INCLUDES Coordination Hub to develop the shared measurement system of common metrics to track progress toward broadening participation and collaborative infrastructure outcomes. In FY 2022, the initiative began an external contract for evaluation to document and assess:

- Emerging evidence of success.
- Organizational contexts and conditions that influence the sustainability of the INCLUDES National Network and its efforts.
- Shared measures and partnership reporting efforts.
- Collaborative infrastructure maturity in funded Alliances.



Broadening participation in STEM 2013-2014 (PDF, 1.7 MB)

In a follow-up to their previous report, the committee recommends five practical components to further strengthen broadening participation of persons from populations underrepresented in STEM: implementing effective pre-K to 20+ system of STEM pathways, providing stable and direct support for individuals who

represent BP, furthering the science of broadening participation, conducting field experiences to understand and mitigate the barriers to BP, and recognizing the field-specific nature of BP.

Updated NSF response

The INCLUDES Portfolio grew from launch pilots that focused on the BP challenge(s) of one or more of these areas, along with technical assistance activities and conferences for finding novel solutions to implement these components, to large-scale alliance awards that have model approaches covering these various components, such as:

- PreK to 20+ system of STEM pathways: First2 Network Alliance; STEM Pathways for Underrepresented Students to Higher Education Network.
- Direct support for individuals: Computing Alliance of Hispanic-Serving Institutions; The Alliance of Persons with Disabilities for Inclusion, Networking, and Transition Opportunities.
- Science of BP/BP research: STEM Core Alliance; Alliance for Identity-Inclusive Computing Education.
- Barrier mitigation: Alliance for Inclusive and Diverse STEM Faculty; STEM Opportunities in Prison Settings Alliance.
- Field/disciplinary focus: Supporting Emerging Aquatic Scientists Islands Alliance; Engineering PLUS.

Detailed descriptions of types of funding opportunities are provided below.
Design and development launch pilot projects:

- Test and deliver collaborative strategies and models for broadening participation in STEM.
- Engage partners in testing the feasibility of a process for change, building infrastructure for collaborative change, and identifying potential mechanisms for sustaining activities.
- Measure and report on results and share findings with the National Network and other stakeholders.

Collaborative change consortia are a new project type for NSF INCLUDES. Consortia collaborate for impact at city, state, and/or regional levels. These projects:

- Address a critical broadening participation challenge in STEM.
- Implement, study, and scale up systemic strategies.
- Engage diverse partners.
- Build infrastructure to foster collaboration, operationalize the five design elements of collaborative infrastructure, and conduct rigorous and innovative research that contributes to the knowledge base on broadening participation in STEM.

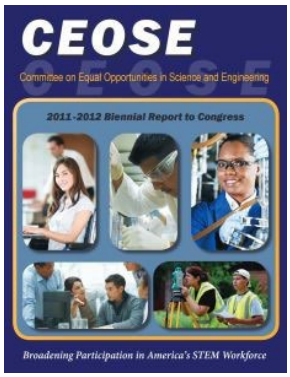
Alliances also engage diverse partners to implement, study, and scale up systemic strategies, but at a national level.

Network connectors:

- Expand the impact of active or previously funded NSF INCLUDES projects;
- Offer new opportunities for collaboration across the NSF INCLUDES National Network;
- Explore novel ideas that bring a community of NSF-funded projects into the NSF INCLUDES National Network;
- Offer efforts to equitably scale up innovative and evidence-based approaches to broaden participation in STEM;
- Build on the work of the National Network in developing shared goals, measures, and mutually reinforcing activities to build collaborative infrastructure for broadening participation in STEM;

- Communicate knowledge and results from the NSF broadening participation portfolio of programs and projects, NSF Center-scale activities, or other major Foundation investments; or
- Communicate findings from the science of broadening participation research community to the NSF INCLUDES National Network, especially pertaining to new efforts to translate basic research into practice.

Conferences are also supported under the new solicitation. Note that the project types receiving proposals in FY 2023 are design and development launch pilots, collaborative change consortia, network connectors, and conferences. Alliance proposals will be received in October 2023, along with network connectors and conferences.



Broadening participation in America's STEM workforce 2011–2012 (PDF, 2.09 MB)

In this report, CEOSE recommends NSF implement a bold new initiative, focused on broadening participation of persons from populations underrepresented in STEM, similar in concept and scale to NSF's centers, that emphasizes institutional transformation and system change; collects and makes accessible longitudinal data; defines clear benchmarks for success; supports the translation, replication and expansion of successful broadening participation efforts; and provides significant financial support to individuals who represent the broadened participation sought by NSF.

The NSF response was NSF INCLUDES (Inclusion across the Nation of Communities of Learners of Underrepresented Discovers in Engineering and Science), established as one of 10 Big Ideas in 2016, and renamed as NSF's Eddie Bernice Johnson INCLUDES Initiative in 2022. The key principles are:

1. **Broadening Participation in STEM** – Funded projects, at all levels, are collaborative efforts that demonstrate significant advances in the preparation and participation of persons from demographic populations that have been historically excluded and/or underserved in STEM, relative to reported baseline measures, and at the unit of change of institutions and systems.
2. **Enabling Sustainable Change in Systems** – Funded projects take actionable steps to transform policies, practices, relationships, approaches, and/or mindsets, in order to make STEM cultures more inclusive and broaden participation in STEM.
3. **Scaling Up Outcomes in Ways That Advance Equity** – Funded projects will scale up proven and promising strategies in equitable ways, which include: a) understanding who is most impacted by the challenge(s) being addressed, b) partnering with the groups identified as beneficiaries of the project's work in the development and implementation of plans to scale-up, and c) ensuring that mechanisms for scale up will distribute power and resources across participating organizations.
4. **Building Collaborative Infrastructure** – All funded projects must operationalize five design elements of collaborative infrastructure in ways that catalyze and accelerate systemic change. The design elements are: 1) shared vision, 2) partnerships, 3) goals and metrics, 4) leadership and communication, and 5) expansion, sustainability, and scale.

APPENDIX D:

Relevant BP tables

The following charts and tables are taken from the *FY2020 Merit Review Digest*.

Proposals, Awards, and Funding Rates, by PI Type

		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
All PIs (data from Table 7)	Proposals	51,562	48,613	48,999	48,051	49,620	49,285	49,415	48,321	41,024	42,723
	Awards	11,192	11,524	10,829	10,958	12,007	11,877	11,447	11,702	11,243	12,168
	Funding Rate	22%	24%	22%	23%	24%	24%	23%	24%	27%	28%
Female PIs	Proposals	11,488	10,795	11,152	11,142	11,444	11,598	11,322	10,858	9,076	9,511
	Awards	2,602	2,775	2,556	2,669	3,007	3,032	2,962	2,943	2,843	3,059
	Funding Rate	23%	26%	23%	24%	26%	26%	26%	27%	31%	32%
Male PIs	Proposals	35,211	32,932	32,866	31,625	32,411	31,528	30,046	28,180	22,277	22,217
	Awards	7,739	7,816	7,316	7,286	7,810	7,512	6,930	6,884	6,157	6,406
	Funding Rate	22%	24%	22%	23%	24%	24%	23%	24%	28%	29%
PIs from underrepresented racial or ethnic groups	Proposals	3,441	3,291	3,303	3,268	3,383	3,331	3,403	3,498	2,714	2,699
	Awards	735	718	651	681	788	778	806	853	766	786
	Funding Rate	21%	22%	20%	21%	23%	23%	24%	24%	28%	29%
New PIs[20]	Proposals	19,238	17,943	17,635	17,405	18,276	18,348	18,757	18,596	15,654	16,221
	Awards	2,976	3,063	3,013	3,108	3,320	3,510	3,319	3,257	3,252	3,473
	Funding Rate	15%	17%	17%	18%	18%	19%	18%	18%	21%	21%
Prior PIs	Proposals	32,324	30,670	31,364	30,646	31,344	30,937	30,658	29,725	25,370	26,502
	Awards	8,216	8,461	7,816	7,850	8,687	8,367	8,128	8,445	7,991	8,695
	Funding Rate	25%	28%	25%	26%	28%	27%	27%	28%	31%	33%
PIs with Disabilities	Proposals	543	483	488	468	562	496	491	453	373	384
	Awards	107	134	122	99	120	110	120	114	103	116
	Funding Rate	20%	28%	25%	21%	21%	22%	24%	25%	28%	30%

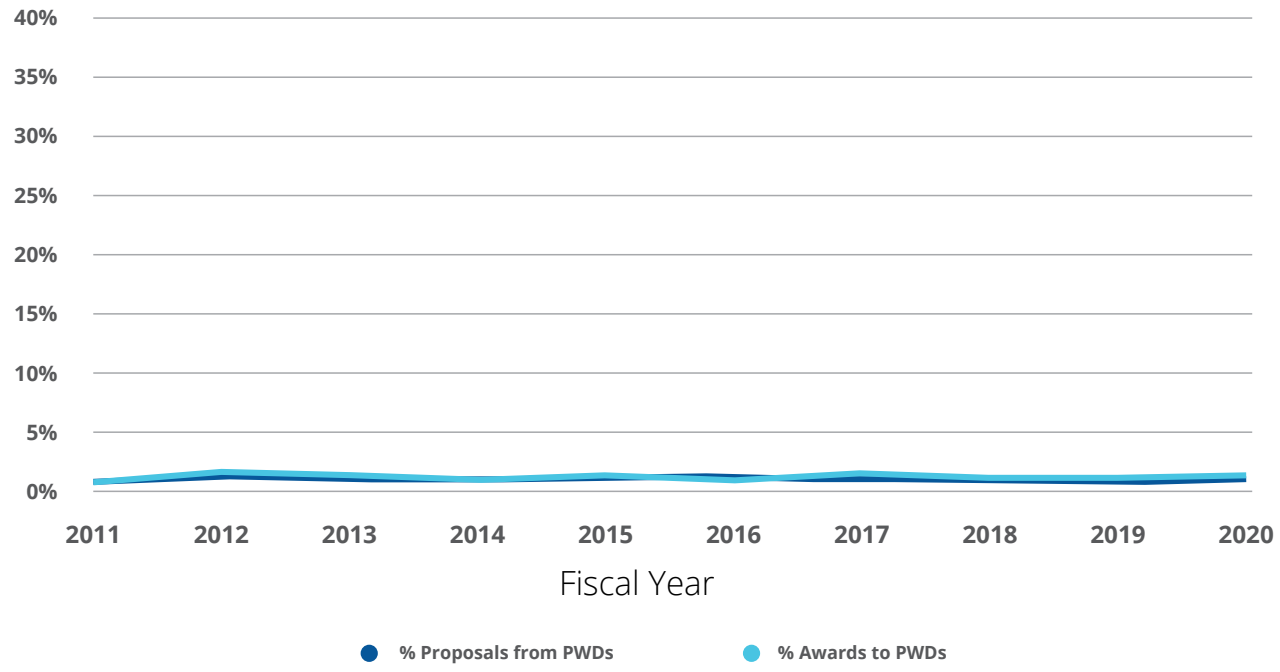
Proposals, Awards, and Funding Rates, by PI Race and Ethnicity

		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
American Indian/Alaska Native	Proposals	129	83	113	103	104	99	134	112	90	79
	Awards	36	18	28	36	25	29	39	29	33	35
	Funding Rate	28%	22%	25%	35%	24%	29%	29%	26%	37%	44%
Black/African American	Proposals	1,201	1,154	1,124	1,123	1,102	1,134	1,135	1,159	929	845
	Awards	243	263	203	204	233	264	266	262	246	229
	Funding Rate	20%	23%	18%	18%	21%	23%	23%	23%	26%	27%
Native Hawaiian/Pacific Islander	Proposals	42	40	32	30	30	41	30	30	47	21
	Awards	11	6	5	5	2	7	5	5	14	4
	Funding Rate	26%	15%	16%	17%	7%	17%	17%	17%	30%	19%
Asian	Proposals	10,829	10,382	10,511	10,538	11,148	11,623	11,552	11,362	9,141	8,227
	Awards	1,907	1,914	1,887	1,925	2,256	2,168	2,166	2,127	2,073	2,105
	Funding Rate	18%	18%	18%	18%	20%	19%	19%	19%	23%	26%
White	Proposals	33,200	30,596	30,766	29,624	30,099	29,031	27,804	25,744	20,400	18,790
	Awards	7,826	8,020	7,372	7,390	7,902	7,748	7,170	7,138	6,389	6,198
	Funding Rate	24%	26%	24%	25%	26%	27%	26%	28%	31%	33%
Multiracial	Proposals	433	448	439	425	495	508	550	550	467	394
	Awards	99	113	110	114	151	124	143	154	132	122
	Funding Rate	23%	25%	25%	27%	31%	24%	26%	28%	28%	31%
Hispanic or Latino	Proposals	2,019	1,934	1,956	1,921	2,053	1,950	1,993	2,105	1,549	1,684
	Awards	438	412	401	411	495	459	460	534	449	499
	Funding Rate	22%	21%	21%	21%	24%	24%	23%	25%	29%	30%

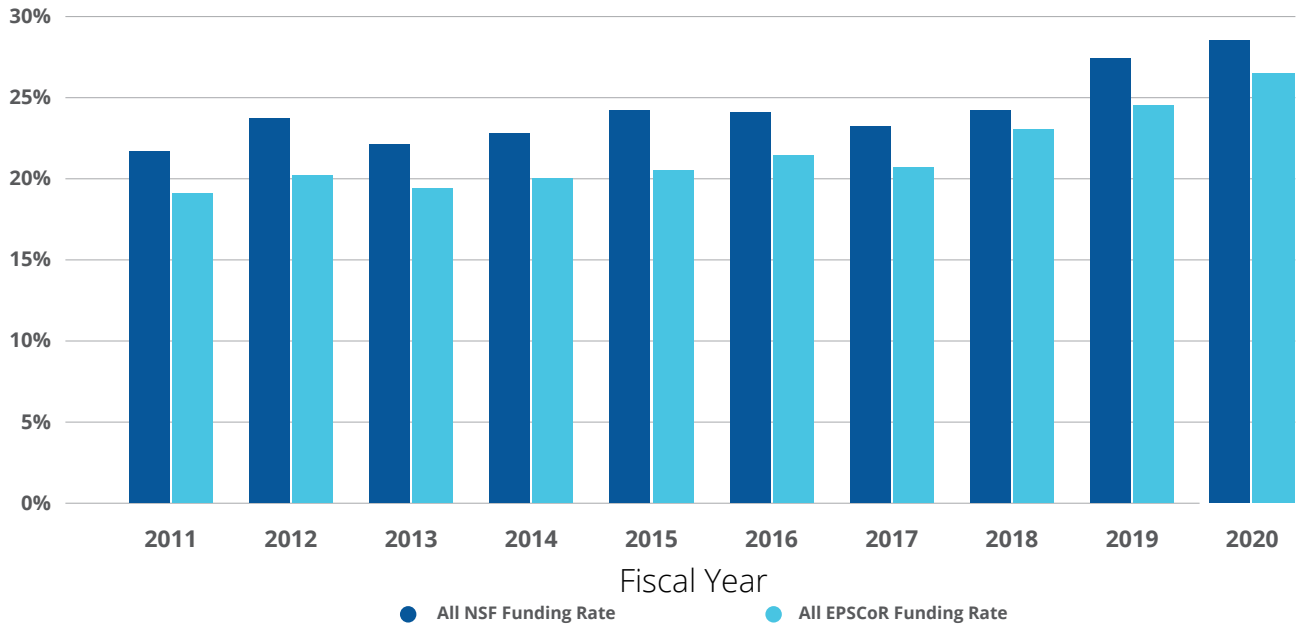
FY 2020 Proposals, Awards, and Funding Rates, by PI Gender*

		Total	Female	Male	Unknown
NSF	Proposals	42,723	9,511	22,217	10,995
	% of Total		22%	52%	26%
	Awards	12,168	3,059	6,406	2,703
	Funding Rate	28%	32%	29%	25%
BIO	Proposals	3,783	1,147	1,792	844
	% of Total		30%	47%	22%
	Awards	1,369	465	660	244
	Funding Rate	36%	41%	37%	29%
CSE	Proposals	7,932	1,350	4,604	1,978
	% of Total		17%	58%	25%
	Awards	1,971	392	1,132	447
	Funding Rate	25%	29%	25%	23%
EHR	Proposals	4,337	1,592	1,539	1,206
	% of Total		37%	35%	28%
	Awards	996	395	328	273
	Funding Rate	23%	25%	21%	23%
ENG	Proposals	9,181	1,435	4,840	2,906
	% of Total		16%	53%	32%
	Awards	2,406	424	1,285	697
	Funding Rate	26%	30%	27%	24%
GEO	Proposals	3,721	1,017	2,024	680
	% of Total		27%	54%	18%
	Awards	1,552	463	820	269
	Funding Rate	42%	46%	41%	40%
MPS	Proposals	8,612	1,423	5,296	1,893
	% of Total		17%	61%	22%
	Awards	2,552	473	1,629	450
	Funding Rate	30%	33%	31%	24%
OIA	Proposals	482	97	265	120
	% of Total		20%	55%	25%
	Awards	172	38	92	44
	Funding Rate	36%	37%	35%	37%
OISE	Proposals	428	94	251	83
	% of Total		22%	59%	19%
	Awards	74	20	42	12
	Funding Rate	17%	21%	17%	14%
SBE	Proposals	4,247	1,356	1,606	1,285
	% of Total		32%	38%	30%
	Awards	1,076	391	418	267
	Funding Rate	25%	29%	26%	21%

Percentage of Proposals from and Awards to PIs with a Disability (PWDs)



Proposal Funding Rates for EPSCoR Jurisdictions and all NSF Proposals



Proposal Funding Rates, by EPSCoR Jurisdiction (Date under the state name is the year the state joined EPSCoR)

		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
ALL NSF	Awards	11,192	11,524	10,829	10,958	12,007	11,877	11,447	11,702	11,243	12,168
	Proposals	51,562	48,613	48,999	48,051	49,620	49,285	49,415	48,321	41,024	42,723
	Funding Rate	22%	24%	22%	23%	24%	24%	23%	24%	27%	28%
ALL EPSCoR Jurisdictions	Awards	1,848	1,960	1,897	1,892	1,980	1,676	1,457	1,585	1,508	1,684
	Proposals	9,640	9,680	9,766	9,477	9,679	7,815	7,041	6,806	6,149	6,346
	Funding Rate	19%	20%	19%	20%	20%	21%	21%	23%	25%	27%
Alabama 1985	Awards	98	110	94	102	85	102	116	113	98	137
	Proposals	614	669	647	665	583	607	655	672	525	549
	Funding Rate	16%	16%	15%	15%	15%	17%	18%	17%	19%	25%
Alaska 2000	Awards	71	65	60	50	49	59	61	56	52	63
	Proposals	213	199	221	205	246	193	169	149	156	157
	Funding Rate	33%	33%	27%	24%	20%	31%	36%	38%	33%	40%
Arkansas 1980	Awards	40	33	46	33	30	35	45	45	41	49
	Proposals	246	229	260	207	184	196	222	229	177	186
	Funding Rate	16%	14%	18%	16%	16%	18%	20%	20%	23%	26%
Delaware 2003	Awards	70	79	70	67	64	80	50	77	65	69
	Proposals	292	278	287	283	273	301	257	278	261	260
	Funding Rate	24%	28%	24%	24%	23%	27%	19%	28%	25%	27%
Guam 2012	Awards	2	2	1	0	2	0	3	0	2	1
	Proposals	5	8	7	4	6	2	3	1	2	3
	Funding Rate	40%	25%	14%	0%	33%	0%	100%	0%	100%	33%
Hawaii 2001	Awards	80	60	54	68	62	78	64	71	68	70
	Proposals	285	281	282	294	267	285	234	217	199	215
	Funding Rate	28%	21%	19%	23%	23%	27%	27%	33%	34%	33%
Idaho 1987	Awards	37	47	41	35	37	41	40	38	30	54
	Proposals	202	185	214	230	234	206	203	201	175	172
	Funding Rate	18%	25%	19%	15%	16%	20%	20%	19%	17%	31%
Iowa 2019	Awards	114	116	113	116	121	133	113	120	121	124
	Proposals	613	558	566	524	578	573	552	576	483	491
	Funding Rate	19%	21%	20%	22%	21%	23%	20%	21%	25%	25%
Kansas 1992	Awards	88	91	65	67	94	71	92	73	82	100
	Proposals	423	402	393	389	407	396	430	410	334	348
	Funding Rate	21%	23%	17%	17%	23%	18%	21%	18%	25%	29%
Kentucky 1985	Awards	64	63	58	68	69	83	59	67	51	67
	Proposals	437	434	391	401	399	399	377	336	286	295
	Funding Rate	15%	15%	15%	17%	17%	21%	16%	20%	18%	23%
Louisiana 1987	Awards	102	88	91	74	99	91	88	111	93	105
	Proposals	621	484	463	402	460	459	470	501	377	435
	Funding Rate	16%	18%	20%	18%	22%	20%	19%	22%	25%	24%
Maine 1980	Awards	42	46	52	48	50	44	42	55	38	43
	Proposals	209	182	211	201	189	175	185	183	158	154
	Funding Rate	20%	25%	25%	24%	26%	25%	23%	30%	24%	28%
Mississippi 1987	Awards	42	43	28	32	40	47	43	53	36	43
	Proposals	287	264	262	260	240	256	224	253	190	218
	Funding Rate	15%	16%	11%	12%	17%	18%	19%	21%	19%	20%

Proposal Funding Rates, by EPSCoR Jurisdiction (Date under the state name is the year the state joined EPSCoR)

		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Montana 1980	Awards	35	50	50	45	51	52	59	59	46	70
	Proposals	222	204	214	183	210	183	229	191	150	197
	Funding Rate	16%	25%	23%	25%	24%	28%	26%	31%	31%	36%
Nebraska 1992	Awards	60	40	59	51	59	58	62	68	50	50
	Proposals	309	258	305	281	307	300	326	297	230	238
	Funding Rate	19%	16%	19%	18%	19%	19%	19%	23%	22%	21%
Nevada 1985	Awards	37	29	33	58	40	42	38	54	59	55
	Proposals	263	236	217	245	230	266	281	296	248	261
	Funding Rate	14%	12%	15%	24%	17%	16%	14%	18%	24%	21%
New Hampshire 2004	Awards	61	75	64	64	65	74	62	65	61	72
	Proposals	282	280	273	295	253	285	256	244	210	217
	Funding Rate	22%	27%	23%	22%	26%	26%	24%	27%	29%	33%
New Mexico 2001	Awards	91	69	81	76	88	107	92	80	84	82
	Proposals	416	399	404	398	474	449	379	394	307	320
	Funding Rate	22%	17%	20%	19%	19%	24%	24%	20%	27%	26%
North Dakota 1985	Awards	23	18	21	26	20	32	21	24	15	31
	Proposals	161	161	172	174	171	185	150	147	114	115
	Funding Rate	14%	11%	12%	15%	12%	17%	14%	16%	13%	27%
Oklahoma 1985	Awards	79	68	59	69	68	76	76	56	70	71
	Proposals	460	384	394	339	388	372	377	342	303	292
	Funding Rate	17%	18%	15%	20%	18%	20%	20%	16%	23%	24%
Puerto Rico 1985	Awards	19	9	8	16	15	22	14	34	16	18
	Proposals	163	153	105	86	102	90	111	115	74	73
	Funding Rate	12%	6%	8%	19%	15%	24%	13%	30%	22%	25%
Rhode Island 2004	Awards	131	146	127	138	131	132	125	145	135	106
	Proposals	400	393	399	404	361	349	351	390	336	305
	Funding Rate	33%	37%	32%	34%	36%	38%	36%	37%	40%	35%
South Carolina 1980	Awards	108	117	115	97	117	98	103	113	99	93
	Proposals	650	562	594	585	603	556	565	495	427	435
	Funding Rate	17%	21%	19%	17%	19%	18%	18%	23%	23%	21%
South Dakota 1987	Awards	24	20	28	32	25	24	23	23	26	26
	Proposals	162	150	163	135	139	150	155	131	102	121
	Funding Rate	15%	13%	17%	24%	18%	16%	15%	18%	25%	21%
U.S. Virgin Islands 2002	Awards	3	2	0	2	1	3	3	6	3	2
	Proposals	11	5	8	7	3	10	11	11	6	8
	Funding Rate	27%	40%	0%	29%	33%	30%	27%	55%	50%	25%
Vermont 1985	Awards	22	24	21	22	18	24	27	31	16	26
	Proposals	121	90	89	104	96	133	127	94	78	68
	Funding Rate	18%	27%	24%	21%	19%	18%	21%	33%	21%	38%
West Virginia 1980	Awards	21	32	22	23	37	29	28	29	22	31
	Proposals	151	163	158	159	187	169	175	139	127	130
	Funding Rate	14%	20%	14%	14%	20%	17%	16%	21%	17%	24%
Wyoming 1985	Awards	31	20	18	24	27	21	21	19	29	26
	Proposals	122	105	115	129	129	128	119	90	114	85
	Funding Rate	25%	19%	16%	19%	21%	16%	18%	21%	25%	31%

APPENDIX E:

Summary of NASEM reports emphasizing gender equity in the context of intersectionality

This a summary of the findings and recommendations from two NASEM reports:

1. 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
2. National Academies of Sciences, Engineering, and Medicine. 2021. *Transforming Trajectories for Women of Color in Tech*. Washington, DC: The National Academies Press. https://doi.org/10.17226/26345

The following two findings from the NASEM Promising Practice report relate to issues regarding intersectionality:

FINDING 2-3: In addition to experiences of heightened bias, sexual harassment, and microaggressions, women of color in science, technology, engineering, mathematics, and medicine (STEMM) frequently experience:

a. Isolation (i.e., experience a sense of invisibility or hypervisibility) and exclusion from social network supports usually available to men.
b. A sense of "not belonging" in STEMM.
c. "Racial battle fatigue," which is the "cumulative result of a natural race-related stress response to distressing mental and emotional conditions" that adversely affects the health and achievements of students and faculty of color.
d. Racial harassment.
e. Cumulative disadvantages, such as interest on debt, and disadvantages, such as lower salary and delayed promotion, which accrue over time.
f. Expectations that they must work harder, including working extended hours, to fit the ideal worker norm despite having had fewer role models who have successfully managed these expectations, fewer culturally competent mentors, and less access to informal professional networks.

FINDING 2-4: There is less research on the factors that drive the underrepresentation of women with disabilities, LGBTQIA women, and international women, but the available research suggests that these groups face significant barriers in STEMM due to their intersectional identities.

The recommendations relevant to NSF and funding agencies that emerged from the Promising Practices report are as follows:

RECOMMENDATIONS	IMPLEMENTATION ACTIONS
RECOMMENDATION 1: The legislative and executive branches of the U.S. government should work together to increase transparency and accountability among federal agencies by requiring data collection, analysis, and reporting on the nature, impact, and degree of investment in efforts to improve the recruitment, retention, and advancement of women in STEMM, with an emphasis on existing efforts that take an intersectional approach.	**Action 1-A:** The director of the White House Office of Science and Technology Policy, in collaboration with the National Institutes of Health (NIH) and National Science Foundation (NSF) co-chairs of the Subcommittee on Safe and Inclusive Research Environments of the Joint Committee on the Research Environment, should annually catalog, evaluate, and compare the various efforts by the federal science agencies to broadly support the recruitment, retention, and advancement of women in science, engineering, and medicine. The director should task the subcommittee with publishing an annual, open-access report, modeled after NSF's summary table on programs to broaden participation in their annual budget request to Congress, that documents existing programs at each agency, with particular emphasis on programs that take an intersectional approach, accounting for the experiences of women of color and women of other intersecting identities (e.g., women with disabilities, LGBTQIA), and the qualitative and quantitative impact of these programs, using program evaluation metrics and data, when collected.
RECOMMENDATION 2: Federal agencies should hold grantee institutions accountable for adopting effective practices to address gender disparities in recruitment, retention, and advancement and carry out regular data collection to monitor progress.	**Action 2-A:** Federal funding agencies should carry out an "equity audit" for grantee institutions that have received a substantial amount of funding over a long period of time to ensure that the institution is working in good faith to address gender and racial disparities in recruitment, retention, and advancement. [refer to report for more information] **Action 2-B:** Federal agencies should consider institutional and individual researchers' efforts to support greater equity, diversity, and inclusion as part of the proposal compliance, review, and award process. To reduce additional administrative burdens, agencies should work within existing proposal requirements to accomplish this goal. For example, NSF should revise the guidance to grantees on NSF's "Broader Impact" statements, and NIH should revise the guidance to grantees on the "Significance" section in the research plan to include an explicit statement on efforts by the prospective grantee and/or institution to promote greater equity, diversity, and inclusion in science, engineering, and medicine. While many grantees currently describe equity, diversity, and inclusion efforts as part of these sections of NSF and NIH proposals, historically, these sections of the proposals have served, first and foremost, to document the societal impact of the research (e.g., addressing climate change, curing cancer, etc.). The latter function of these sections of the proposal is critical and should not be replaced by the description of equity, diversity, and inclusion efforts. Rather this section of the proposal should be expanded to include commentary on both of these critical components of federally funded research. Proposals should be scored and taken seriously in funding recommendations by review panels and funding decisions by agency personnel. If such sections of proposals are given different consideration by different institutes, departments, and directorates, effort should be made to standardize the weight given to these sections of the proposal across the agency. For example, the National Science Board could carry out a review of past NSF awards to determine how the NSF Directorates have accounted for gender equity, diversity and inclusion among the metrics evaluated in proposals submitted to NSF.

RECOMMENDATIONS	IMPLEMENTATION ACTIONS
RECOMMENDATION 6: Federal agencies should support efforts and research targeted at addressing different profiles of underrepresentation in particular scientific, engineering, and medical disciplines throughout the educational and career life course. Implementation Actions	**Action 6-A:** Given that women are underrepresented in computer science, engineering, and physics as early as the undergraduate level, agencies that support research, training, and education in these fields should incentivize institutions to adopt educational practices that research shows can improve interest and sense of belonging in these fields among women. For instance, the NSF director should direct the deputy directors of the NSF Directorates for Engineering, Computer and Information Science and Engineering, and Mathematical and Physical Sciences to set aside funding and work collaboratively with the Education and Human Resources Directorate to support education grants. Refer to the report for more details. **Action 6-B:** Across all science, engineering, and medical disciplines, federal agencies should: • Address funding disparities for early-career women researchers, particularly for women of color. • Directly (e.g., through supplements) and indirectly (e.g., through specific programs) support the work-life integration needs of women (and men) in science, engineering, and medicine; and • In addition to programs designed to support mentorship, support investigation into the impact of sponsorship on advancement of both white women and women of color into leadership roles in science, engineering and medicine.
RECOMMENDATION 8: Federal agencies and private foundations should work collaboratively to recognize and celebrate colleges and universities that are working to improve gender equity.	**Action 8-A:** NIH and NSF should collaborate to develop a recognition program that provides positive incentives to STEMM departments and programs on campuses to make diversity, equity, and inclusion efforts a high priority. See report for more details. **Action 8-B:** Federal agencies should provide financial assistance to institutions that would like to be recognized for their efforts to improve diversity, equity, and inclusion. These grants would support the resource-intensive data collection that is required to compete for these awards and would be granted on a needs-based justification, with priority given to under-resourced universities.

The recommendations regarding the role of government in addressing the underrepresentation of women of color in tech from the Transforming Trajectories report are complementary to those included in the Promising Practices report. Three recommendations are highlighted below:

RECOMMENDATIONS	IMPLEMENTATION ACTIONS
RECOMMENDATION 5-1: Government efforts aimed at addressing the underrepresentation of particular groups in tech should intentionally account for intersectionality	**5-1 A:** Any legislation aimed at addressing issues of underrepresentation in STEM and in tech should take an intersectional approach that considers the unique experiences of women of multiple marginalized identities. **5-1 B:** Government efforts calling for data collection related to groups underrepresented in STEM and in tech should clearly indicate that such data be disaggregated by race/ethnicity and gender (to the extent possible given the need to protect anonymity of individuals) and should require qualitative as well as quantitative data collection, especially when the numbers are small enough that qualitative data would provide more meaningful information. **5-1 C:** Program solicitations and descriptions at federal agencies should be explicit in directing prospective grantees to take an intersectional approach. History demonstrates that unless policies, practices, programs and individuals embrace an intersectional approach to promote diversity, equity and inclusion in our institutions, women of color will not benefit from these efforts.
RECOMMENDATION 5-2: Federal agencies should submit to Congress an overview of their programs that support the recruitment, retention and advancement of women of color in tech with their annual budget request as NSF currently does in its Summary Table on Programs to Broaden Participation. If agencies do not create such annual reports voluntarily, Congress should mandate that agencies do so. **RECOMMENDATION 5-4:** Federal agencies should incentivize grantee institutions' efforts to improve diversity, equity and inclusion through accountability measures.	**5-4 A:** Prospective grantees' plans to promote diversity, equity and inclusion should be reviewed by review panels and agency personnel and should be a determining factor in awarding or renewing funding to an institution, in addition to technical merit. Grantees should include a description of the impact of their efforts to promote diversity, equity and inclusion in annual reports and requests for funding renewals. **5-4 B:** Federal agencies should invest in programs that incentivize institutional efforts to take a culturally responsive, intersectional approach in promoting diversity, equity and inclusion in tech through award and recognition programs, such as the SEA Change effort led by the American Association of the Advancement of Science, which is currently funded by the National Science Foundation, the National Institutes of Health and a number of private foundations. **5-4 C:** Federal agencies should carry out periodic "equity audits" for grantee institutions to ensure that the institution is working in good faith to take an intersectional approach to address gender and racial disparities in recruitment, retention, and advancement. Refer to report for additional information. **5-4 D:** Federal agencies should consider institutional and individual researchers' efforts to support greater equity, diversity, and inclusion as part of the proposal compliance, review, and award process. To reduce additional administrative burdens, agencies could work within existing proposal requirements to accomplish this goal. For example, NSF could revise the guidance to grantees on its broader impact statements and the National Science Board could carry out a review of past NSF awards to determine how the NSF directorates have accounted for gender equity, diversity and inclusion among the metrics evaluated in proposals submitted to NSF. Federal agencies can play a powerful role in holding grantees accountable and by incentivizing action at institutions. If these recommendations are implemented with an intentional focus on intersectionality, it is the committee's opinion that they could be a positive force for holding institutions accountable for working in good faith to address the underrepresentation of women of color in tech education and careers.

APPENDIX F:

2019-2020 CEOSE letter to colleagues and report handout

Committee on Equal Opportunities in Science and Engineering (CEOSE)

www.nsf.gov/od/oia/activities/ceose

Established by Congress to advise the National Science Foundation concerning the implementation of the Science and Engineering Equal Opportunities Act and other policies and activities to encourage the full participation of women, underrepresented minorities, and persons with disabilities in scientific, engineering, and professional fields.

October 28, 2021

Dear Colleague:

The Committee on Equal Opportunities in Science and Engineering (CEOSE) is charged by the United States Congress to advise the National Science Foundation (NSF) on policies and programs that encourage full participation by women, underrepresented racial and ethnic groups (African Americans, Hispanics/Latino Americans and Native Americans), and persons with disabilities within all levels of the United States' science, technology, engineering, and mathematics (STEM) enterprise and to transmit to the Director of NSF every two years a report on its activities during the previous two years and proposed activities for the next two years.

In the recently completed *2019-2020 CEOSE Biennial Report to Congress – Making Visible the Invisible – Bold Leadership Actions*, CEOSE introduces the theme, Making Visible the Invisible. This broad theme serves to recognize that much of the work and understanding related to broadening participation and diversity, equity, inclusion and belonging remains unacknowledged, misunderstood, undervalued, and understudied. CEOSE calls on NSF to do more to increase knowledge and awareness of invisibility issues in STEM communities and acknowledge meaningful leadership actions for transformational change.

CEOSE recommends that NSF demonstrate and promote bold leadership actions to create, integrate and make visible elements within and across its programs to enhance broadening participation of underrepresented groups in STEM. The enclosed summary provides an overview of the *2019-2020 CEOSE Biennial Report to Congress*. The full report can be found at the CEOSE website at www.nsf.gov/od/oia/activities/ceose.

Best regards,

The CEOSE Advisory Committee

MAKING VISIBLE THE INVISIBLE

Developing innovative approaches for broadening participation in science, technology, engineering, and mathematics (STEM) continues to be an urgent matter for the Nation.

Data continue to show that although gains have been made by most demographic groups in most S&E disciplines, overall participation of women, underrepresented racial/ethnic groups, and persons with disabilities within STEM fields is still disproportionately low. The Committee on Equal Opportunities in Science and Engineering (CEOSE) is calling attention to broadening participation efforts through the action-focused theme ***Making Visible the Invisible***.[1] This broad theme serves to recognize that much of the work and understanding related to broadening participation and diversity, equity, inclusion and belonging remains unacknowledged, misunderstood, undervalued, and understudied. Through the ***2019-2020 CEOSE Biennial Report to Congress: Making Visible the Invisible — Bold Leadership Actions***, and future reports, CEOSE will make recommendations to bring to the forefront the knowledge, experiences, and perspectives so critical to realizing measurable systemic change to broadening participation.

WITHIN *MAKING VISIBLE THE INVISIBLE* THEME, THREE CONSECUTIVE CEOSE REPORTS WILL FOCUS ON

- **Inclusive excellence in leadership**
- **Critical issues in defining and understanding intersectionality**
- **Addressing challenges and associated opportunities to acknowledge and value severely underrepresented groups, such as persons with disabilities, neurodiverse individuals, Native Americans, individuals of LBGTQ communities, and other underserved communities**

It is NSF's responsibility to provide the ***"intellectual and scientific leadership to develop a truly inclusive STEM enterprise that fully and effectively engages all of our citizens."*** This begins with viewing broadening participation as a solution and not a problem.

SUMMARY

Broadening participation is not a problem to be fixed, but a critical strategy to promote and advance scientific research and learning that will develop a STEM workforce that is representative of all US citizens.

[1]Key recommendations from previous CEOSE reports include: a single recommendation for a bold new initiative to broaden participation (2011-2012); five proposed specific components of a plan for implementation of the new initiative, which became INCLUDES (2013-2014); a recommendation for an accountability framework for assessment of broadening participation activities (2015-2016); and a recommendation for inclusion of diverse voices across research and education portfolios at NSF (2017-2018).

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BOLD LEADERSHIP ACTIONS

At a fundamental level, leadership includes behaviors that guide, influence, and mobilize others toward a common vision, goal, or objective.

For the 2019-2020 report, CEOSE is emphasizing leadership as it takes place in decision-making, relationship building and networking, the development of individuals to be leaders, and a willingness in all people to make hard decisions, serve as models and examples, accept responsibility, and be held accountable.

The NSF INCLUDES initiative is a visible example of commitment and emphasis placed on broadening participation. The National Network strives to bring other perspectives and participants into the NSF INCLUDES community, regardless of whether they have received NSF INCLUDES funding. And NSF's leadership further emphasized its commitment to broadening participation by naming the NSF INCLUDES initiative as one of NSF's 10 Big Ideas, championed by NSF's 14th director, Dr. France Cordova.

In 2020, the NSF welcomed its 15th director, Dr. Sethuraman Panchanathan. Continuing NSF's commitment to broadening participation, Director Panchanathan has explicitly addressed issues of broadening participation in articulating his vision, ***"The resources, funding, and different initiatives NSF is deploying to support inclusivity and broaden participation are the seeds for building a STEM community that reflects the whole nation. The alliances and networks that we are building to connect programs and share resources and best practices are key to strengthening these efforts and extending their reach. But the final piece is the need for leaders to institutionalize these efforts and make them self-sustaining cultures of inclusivity that are embedded within communities."***

Leadership is demonstrated through decisions, actions, and opportunities, at the organization and individual levels. Leadership matters because leaders make funding decisions, admit students to STEM graduate programs, decide when/if communities are invited to partner in NSF-funded projects, and determine if the microculture of their research teams is inclusive. In demonstrating its leadership and empowering leadership within its staff, advisors, and the communities it serves, NSF can do more to increase knowledge and awareness of invisibility issues in STEM communities, identify the participation and advancement of underrepresented groups in the scientific enterprise and acknowledge meaningful ***leadership*** actions for transformational change.

The ***2019-2020 CEOSE Biennial Report to Congress: Making Visible the Invisible — Bold Leadership Actions*** highlights recent activities and examples of NSF-funded projects and programs representative of inclusive excellence in leadership and suggests specific opportunities for NSF to strengthen its strategy to promote and advance scientific research and learning through visible leadership actions.

> ***CEOSE recommends that NSF demonstrate and promote bold leadership actions to create, integrate and make visible elements within and across its programs to enhance broadening participation of underrepresented groups in STEM.***

Please visit ***www.nsf.gov/od/oia/activities/ceose*** to view the full report.

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APPENDIX G:

Envisioning the future of NSF EPSCoR report summary

ENGAGE. ENRICH. EXPAND. EMPOWER.

A coordinated national response is required to meet the challenge of increased global leadership in the scientific enterprise and to grow the number of students pursuing degrees in science, technology, engineering, and mathematics (STEM).

NSF EPSCoR was created to grow research and education capacity to address national and global challenges requiring significant funding in research and infrastructure. By supporting geographic diversity, the program distributes federal funding more equitably to jurisdictions receiving less funding in terms of research and infrastructure.

NSF EPSCoR has the following goals:

- **Catalyze research capability across and among jurisdictions;**
- **Establish STEM professional development pathways;**
- **Broaden participation of diverse groups/institutions in STEM;**
- **Effect engagement in STEM at national and global levels; and**
- **Impact jurisdictional economic development.**

Beginning in March 2021, the Committee on Equal Opportunities in Science and Engineering (CEOSE), formed a subcommittee that embarked on a visioning process to examine the results of NSF EPSCoR and provide recommendations for improvement. The subcommittee found that NSF EPSCoR facilitated collaboration in areas of high national STEM priority (e.g., artificial intelligence, advanced manufacturing, climate resilience).

ENHANCING GEOGRAPHIC DIVERSITY

To support research and innovation across the nation, NSF EPSCoR provides support to states and territories that traditionally receive less research funding. In 2022, 28 jurisdictions (25 states and three territories) are eligible for EPSCoR support.

View full document here

CEOSE MEMBERSHIP

***Current Member**
****Term began in 2022**

Dr. John M. M. Anderson*
Dean

College of Engineering and Architecture
Howard University
Washington, DC 20059

Dr. Gilda A. Barabino*
President and Professor

Olin College of Engineering
Needham, MA 02492

Dr. Suzanne Barbour *
Dean of the Graduate School

Vice Provost for Graduate Education
The Graduate School
Duke University
Durham, NC 27708

Dr. Tabbetha Dobbins**
Vice President for Research

Dean of the Graduate School Division of University Research
Department of Physics & Astronomy
Rowan University
Glassboro, NJ 08028

Dr. Ryan E. Emanuel *
Associate Professor

Dept. of Environmental Sciences and Policy
Nicholas School of the Environment
Duke University
Durham, NC 27708

Dr. Kaye Husbands Fealing, Vice Chair*
Dean of Ivan Allen College of Liberal Arts - Ivan Allen Jr. Chair

Georgia Institute of Technology
Atlanta, GA 30332

Dr. Jose D. Fuentes, Chair*
Professor of Meteorology

Department of Meteorology
Pennsylvania State University
State College, PA 16801

Dr. Ann Quiroz Gates*
Senior Vice Provost Faculty Affairs

Director CASHI INCLUDES Alliance
The University of Texas at El Paso
El Paso, TX 79902

Dr. Juan E. Gilbert
The Banks Preeminence Chair in Engineering

University of Florida
Department of Computer & Information Science and Engineering
Gainesville, FL 32611

Dr. Sandra Graham**
Distinguished Professor and Presidential Chair in Education and Diversity

Department of Education
University of California - Los Angeles
Los Angeles, CA 90095

Dr. Charles Isbell
Dean of Computing and John P. Imlay Jr. Chair

Georgia Institute of Technology
Atlanta, GA 30332

Dr. Alicia Knoedler, Former Vice Chair
Former Vice President for Research and Innovation

Miami University
Oxford, OH 45056

Dr. Cynthia Lindquist*
President

Cankdeska Cikana Community College
Spirit Lake Dakota
Fort Totten, ND 58335

Dr. Gabriel Lopez*
Professor

Department of Chemical and Biological Engineering
The University of New Mexico
Albuquerque, NM 87131

Dr. Daniela Marghitu*
Faculty Coordinator and Director

Education and Assistive Technology Lab
Samuel Ginn College of Engineering
Auburn University
Auburn, AL 36849

Dr. James R. Martin II*
Vice Chancellor for STEM Research and Innovation

Swanson School of Engineering
University of Pittsburgh
Pittsburgh, PA 15261

Dr. Robert Eugene Megginson
Arthur F. Thurman Professor

University of Michigan
Department of Mathematics
Ann Arbor, MI 48109

Dr. Vernon Morris*
Professor of Chemistry and Environmental Sciences

Director of the School of Mathematical and Natural Sciences
Arizona State University
Phoenix, AZ 85306

Dr. Timothy Pinkston**
George Pfleger Chaired Professor of Electrical and Computer Engineering
Vice Dean for Faculty Affairs

USC Viterbi School of Engineering
University of Southern California
Los Angeles, CA 90089

Dr. Susan Renoe*
Associate Vice Chancellor

Division of Research, Innovation and Impact

Assistant Professor

School of Journalism
University of Missouri
Columbia, MO 65211

Dr. Lydia Villa-Komaroff
Founder and Principal

Intersections SBD
Chestnut Hill, MA 02467

Dr. Barbara E. Walker**
Director, Strategic Research Initiatives
Special Assistant to the Executive Vice Chancellor for Diversity Initiatives

UC Santa Barbara
Santa Barbara, CA 93106

Dr. David K. Wilson*
President

Morgan State University
Baltimore, MD 21251

Dr. Nai-Chang Yeh*
Thomas W. Hogan Professor of Physics

California Institute of Technology
Pasadena, CA 91125

NSF CONTACTS

Ms. Una Alford
Program Analyst

Office of Integrative Activities
Office of Director, NSF

Dr. Bernice Anderson
Senior Advisor and CEOSE Executive Secretary

Office of Integrative Activities
Office of Director, NSF

Dr. Alicia J. Knoedler
Office Head and CEOSE Executive Liaison

Office of Integrative Activities
Office of Director, NSF

Ms. Jolaina Jeff-Cartier
Staff Associate

Office of Integrative Activities
Office of Director, NSF

Dr. Suzanne Iacono
Former OIA Office Head and CEOSE Executive Liaison

National Science Foundation
Alexandria, VA 22314

IMAGE DESCRIPTIONS AND CREDITS

FRONT COVER:
Intersectionality design – Giovanni Rodriguez

Sidebar 1:
Cross, K. J., Hughes, B.E., Farrell, S. (Ed.). (2022). Queering STEM Culture in US Higher Education: Navigating Experiences of Exclusion in the Academy. Routledge.
Credit: Emily Alicia Affolter, Ph.D, Prescott College
Award # 1748473, 1748499 and 1935777

Sidebar 2:
The figure shows the 2022 group of interns (and their home institutions), as well as their Tufts mentors and language interpreters. Left to right: Front row interns: Ryan Ong (RIT), Yiyuan Steve Wufeng (RIT), Nathan van Gennip (Gallaudet), Coco Xu (RIT), Gigi Zheng (RIT), Meghan Luebehusen (RIT). Middle row: Daniel Goldstein (Tufts); Ryo Shimada (Tufts), Prof. Ayse Asatekin (Tufts), Prof. Peggy Cebe (Tufts), ASL interpreter Lauren Parlapiano. Top row: Sam Hocking (Tufts), Luca Mazzaferro (Tufts), Jack Thomas (Tufts), Anuja Jayasekara (Tufts), ASL interpreter Mark Riley.
Credit: Dr. Peggy Cebe of Tufts University
Award # 2003629

Sidebar 3:
Portrait of diverse creative team working in office with focus on young woman using wheelchair at business meeting.
Credit: Shutterstock/SeventyFour
Award # 2017017

Sidebar 4:
P.I. Aradhna Tripati in the lab.
Credit: University of California Los Angeles
Award # 2228198

Sidebar 5:
Caption: NCWIT Graphic
Credit: NCWIT theory of change: Litzler, E., DuBow, W., Bradberry, A., & Kelley, C.; NCWIT mission and approach conceptualization: Sanders, L., Barker, L. & Ashcraft, C.; NCWIT founders: Sanders, L., Schnabel, R., & Whitney, T.
Award # 2216561

Sidebar 6:
Figure 4. Neighborhood clusters by social distancing sensitivity (SDS) score.
Credit: Kontokosta, C. E., Hong, B., & Bonczak, B. J. (2022). Measuring sensitivity to social distancing behavior during the COVID-19 pandemic. Scientific reports, 12(1), 16350.
Award # 1926470

Sidebar 7:
Two African American students in graduate cap and gowns.
Credit: Shutterstock/Prostock-Studio

Sidebar 8:
Round-table panelists discussing the role of undergraduate institutions in advancing technology and innovation.
Credit: Courtesy of Union College

Sidebar 9:
Students viewing computational model.
Credit: Brian Persinger

Sidebar 10:
Participants in Native FEWS Alliance Conference in California, April 2022.
Credit: Photo courtesy of Karletta Chief and Torran Anderson - University of Arizona
Award # 2120001

Sidebar 11:
New doctorate recipients join hands at commencement in 2015 at Howard University. NSF's Build and Broaden program is kick-starting research collaborations at minority-serving institutions like Howard.
Credit: Justin D. Knight/Howard University

Sidebar 12:
Jazmyn Littles is working on high-performance perovskite solar cells in professor Dawen Li's lab at the University of Alabama.
Credit: The University of Alabama
Award # 2225852

Sidebar 13:
Local high school students participate with the researchers during interactive sessions using cards representing intersectional perspectives, such as rurality and indigeneity. Some of the students will become part of a cohort exploring long-term pathways to STEM entrepreneurship.
Credit: Robert G. DelCampo, University of New Mexico
Award # 2122553

Sidebar 14:
Breanna Thompson, NTU-PREM student, with Dr. Bredan Deveney, her Harvard MRSEC mentor, working on Breanna's summer research project at Harvard University on August 19th 202.
Credit: Robert Graham, Harvard University MRSEC
Award # 2122195

Sidebar 15:
A-SCENE participants at the University of Connecticut discussing neurodiversity innovations in engineering education.
Credit: Marisa Chrysochoou, University of Connecticut
Award # 2217621

Sidebar 16:
Image 1 Photo of Manuella Clark-Cotton sharing the significance of a community and network across Diversity in Science programming.
Image 1 *Credit: Manuella Rossette Clark-Cotton.*
Image 2 Photo of Jasmine Childress holding a tarantula in the field. Image 2 Credit: *Jasmine Necole Childress*

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