



Broadening Participation in America's Science and Engineering Workforce

Executive Summary

**The Executive Summary
of the 1994-2003
Decennial &
2004 Biennial
Reports to Congress**



CEOSE
Committee on Equal Opportunities in Science and Engineering

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Committee on Equal Opportunities in Science and Engineering

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Committee on Equal Opportunities in Science and Engineering (CEOSE)

CEOSE is charged with advising the National Science Foundation (NSF) on policies and programs to encourage full participation by women, minorities, and persons with disabilities in science, technology, engineering, and mathematics (STEM). This committee consists of 15 members, each serving a term of three years. The members are researchers and scholars from the STEM fields, and constitute a broad and diverse group drawn from academia, professional organizations, government agencies, and industry. Designated committee members serve as liaisons to the Advisory Committees of each NSF Directorate and major office.

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PREFACE

“First, it is NOT about the total number of scientists and engineers the nation may or may not need. It’s easy to get distracted by trends and statistics cited in the news and debates about whether the demand for science, engineering and technological workers is greater or less than the supply. It IS about including a larger proportion of women, under-represented minorities and persons with disabilities in the scientific workforce, no matter the size of that workforce. Whatever the numbers turn out to be, we need a robust and varied mix, and that means broadening participation. . . .”

- Joseph Bordogna, Deputy Director, NSF¹

The global and local challenges of the technological world of today reverberate with a call—a call for the best minds to work together to advance and apply science, technology, engineering, and mathematics (STEM)—enabling us to understand and deal with growing complexity. This call also inspires possibilities, as people with diverse ways of working, thinking, and learning engage in challenging, fulfilling, and exciting work in STEM areas. For the United States, it means that continuing technological leadership depends on the healthy development of the science and engineering talent of *all* its citizens. Further, equity and justice demand that all Americans have the opportunity to develop their talents to the fullest. Linking these two concepts, the National Science Foundation, as the agency established in 1950 to “promote the progress of science; to advance the national health, prosperity and welfare; and to secure the national defense,”² is also expected to lead the development of STEM talent. Ensuring access and opportunity to all in pursuit of that goal has been a crucial challenge, one that was addressed by the U.S. Congress in the Science and Engineering Equal Opportunities Act of 1980.

Institutions that propel the STEM enterprise in the United States are at a critical stage as the world faces unprecedented challenges. Global economies and conditions are changing rapidly. The nature and role of STEM disciplines are also changing. Perhaps more than ever, various disciplines and research areas are developing not just to satisfy innate human curiosity, but because there are large and complex societal problems to solve. Many of these vital, exciting and challenging problems are characterized by increasing complexity, ambiguity, uncertainty, and rapidly changing conditions. Solutions to these problems require the best minds and facilities to work together. Among these are problems of ecosystems and the environment, human population, disease, and perhaps most important, the education of all so that we continue to have a flourishing, just and participatory democra-

¹ “Remarks on the 10-year Anniversary Celebration of the Philadelphia Louis Stokes Alliance for Minority Participation,” October 8, 2004. http://www.nsf.gov/news/speeches/bordogna/04/jb041008_lsamp.jsp.

² “NSF Creation and Mission,” <http://www.nsf.gov/about/glance.jsp>.

cy. New fields are emerging in which the individual has to learn to bridge, blend, and integrate traditionally separate fields. The National Science Foundation is among the agencies that have responded to these challenges by continually reviewing and re-designing its research and education programs to meet the changing demands.

The need—indeed, the imperative—to include ALL Americans in bringing the best of creativity and innovation to the entire STEM enterprise is more vital than ever. The ethical imperatives of equity and justice, along with many pragmatic reasons dictate this need. Among them are the reality of changing demographics, the need to include multiple ways and intelligences to produce the best science and technology, and the changing number of foreign STEM professionals entering the United States. Ensuring broad representation in the STEM workforce is therefore critical.

As a committee originally established to address the problem of the shrinking pool of American scientists and engineers and the growing global competition for science and engineering talent, CEOSE over the last 25 years has worked to understand, assess and provide recommendations for addressing the issues involved in broadening participation in STEM. CEOSE membership has always consisted of scientists, technologists, engineers, and mathematicians working actively in these fields who display concern with these larger issues and who are dedicated to broadening representation in STEM.

In this report, CEOSE of 2003-2004 has taken a concerted look at the Committee's history and arrived at a set of conclusions and recommendations about the current state of representation in and emerging needs of the U.S. STEM workforce. In order to complete this work, the Committee has had to call on the staff of the National Science Foundation to provide large amounts of data and information. The support extended by the NSF staff has been invaluable. During the course of its service and deliberations and the compilation of this report, the Committee has come to a deeper understanding of the functioning of NSF. It lauds the Foundation for its vision, outstanding work, and dedication to its mission.

It is the sincere hope of the Committee that the observations and recommendations in this report will provide meaningful and timely perspectives to Congress for making decisions that will help strengthen the programs of the National Science Foundation and the efforts in the nation at large to build a healthy, diverse STEM workforce, one with “audacious capabilities that enable (it) to work robustly across boundaries, to handle ambiguity, to integrate, to innovate, to communicate, and to cooperate.”³

³ “NSF Creation and Mission,” <http://www.nsf.gov/about/glance.jsp>.

EXECUTIVE SUMMARY

Broadening participation in the sciences and engineering has been a slow, complex process in which lessons are still being learned at the individual, institutional, and societal levels. Rising awareness of the need to overcome barriers to the inclusion of women, minorities, and—later—disabled persons, motivated Congress to enact the Science and Engineering Equal Opportunities Act of 1980, which created the Committee on Equal Opportunities in Science and Engineering (CEOSE). Subsequently, the National Science Foundation (NSF) and its grantee community have paid increasing attention to including these underrepresented groups in higher numbers and percentages in science, technology, engineering, and mathematics (STEM).

The full report⁴ satisfies the requirements—pertinent to CEOSE—of the NSF Reauthorization Act of 2002 (H.R. 4664) by summarizing the first 25 years (1980-2004) of CEOSE, describing NSF policies and programs related to broadening participation in STEM, and analyzing trends in participation during the second half of this period. Compared with 1980, persons from underrepresented groups now are submitting a modestly greater proportion of proposals to NSF, appear to be participating in modestly greater numbers and proportions as NSF reviewers, and have become an increased fraction of the professional staff at NSF.

Although participation has grown measurably, progress has been slow and uneven across underrepresented groups, across science and engineering fields, and across career paths. Moreover, it is not possible to determine with certainty what caused these modest improvements. Significantly, there is still a long way to go before individuals from underrepresented groups have full access to STEM education and opportunities. Yet, access is merely the critical first step toward participation and leadership. Only by developing truly unbiased and open environments for STEM education and career progression can our nation benefit from the full range and strength of ideas, talents, and potential for leadership available within our citizenry.

From Pipelines to Pathways

Early efforts to broaden participation focused primarily on encouraging individuals from underrepresented segments of the population to enter STEM disciplines. This “pipeline” metaphor is a way of looking at the persistence of women, minorities, and persons with disabilities in STEM statistically. It emphasizes attracting students into the STEM “pipeline” when they are young, and spotlights the points at which “leaks” occur, differentially draining away individuals from underrepresented groups. Today, many efforts to make science and engineering more inclusive are paying attention instead to the multiplicity of “pathways” by which persons from underrepresented groups can enter and progress through STEM careers. Creating viable pathways requires addressing the tough issues related to what invites children to learn science (*attraction*), what causes young people to choose

⁴ Table of Contents for the full report is on page 11 of this summary.

to keep learning mathematics and science (*retention*), and what then leads students to graduate (*persistence*) and continue into STEM careers (*attachment*).

From Individual Support to Institutional Transformation

Whereas support and encouragement for individuals are necessary, these interventions have proven to be insufficient to attract, retain, and advance women, minorities, and persons with disabilities in STEM fields. Aspects inherent to the nature of STEM and the institutions within which STEM activities are conducted in the United States appear to result in a marked paucity of women, minorities, and disabled persons, especially at leadership levels.

The NSF was among the first agencies to recognize and act on the need for institutional transformation, along with individual support, to broaden participation in a sustainable manner and on a large scale. Institutional change, however, is proving to be slow and hard, and is only in its early stages. Anecdotal evidence suggests that for successful institutional transformation, factors affecting persistence and attachment of students and professionals demand attention. Such factors are little understood and continue to require focused research. These factors include curriculum, teaching approaches, mentoring, career opportunities, role models, decision-making processes, reward structure, resource allocation, and ways of collaborating. In addition, it will be necessary to overcome the low societal expectations and common biases about the roles and capabilities of women, minorities, and persons with disabilities.

The challenge of designing and implementing institutional transformation that will promote and sustain inclusion is hampered by inertia in each institution, by a dearth of knowledge about specific institutional factors and their effects, and by numerous hidden biases. From the standpoint of providing role models, an institution with significant numbers of STEM faculty, senior scientists and engineers, and STEM administrators who are from underrepresented groups provides an image of the profession as one that is diverse and with a climate that is inclusive. Yet the demographic profile of STEM faculty at research-extensive educational institutions remains rather homogeneous, despite systematic increases in the numbers and percentages of STEM Ph.D.s earned by women and underrepresented racial and ethnic minority group members.

A National Imperative

The importance of broadening participation in STEM among underrepresented U.S. minorities is heightened as foreign graduate students, scientists, and engineers are increasingly choosing to pursue professional opportunities and graduate study in other countries. This context further underscores the value and urgency of NSF's efforts to expand our home-grown STEM talent pool, and invite bright U.S. citizens from all backgrounds and regions into STEM.

Past and Present NSF Policies and Programs for Broadening Participation in STEM

Chapter 1 summarizes the policies and programs implemented by NSF since 1994 to increase the size, talents, and diversity of America's science and engineering workforce at all levels. Two major education-related policies support funding for (1) undergraduate, graduate, and postdoctoral education and (2) research on STEM learning by underrepresented groups. Program-investment policies emphasize the Foundation's commitment to increase access to STEM education and career opportunities both by boosting funding for projects aimed at enlarging participation by underrepresented groups, and by "embedding diversity" in all NSF programs.

Foundation-wide programs targeting women increased opportunities for career advancement, enhanced the ability of women faculty to conduct research at the top-ranked research institutions, and sponsored research on science and mathematics learning by females. Programs targeting underrepresented minorities funded institutions to enhance instruction and mentoring of minorities, supported minority individuals by providing graduate or postdoctoral fellowships, and assisted minorities with Ph.D.s to enter into the professoriate. Two types of programs focused on persons with disabilities: programs to develop innovative and effective techniques for educating disabled students in STEM, and grant supplements providing funds for equipment or assistance that allows persons with disabilities to work on NSF-funded research projects. Several other programs with systemic objectives incorporated an emphasis on broadening participation. These programs included graduate traineeships that integrate education and research, systemic education-improvement initiatives in urban and rural school districts, state-level capacity building to stimulate competitive research, and the *Presidential Awards for Excellence in Science, Mathematics, and Engineering Mentoring (PAES-MEM)*.

Between 1997 and 2002, NSF simplified, focused, and strengthened accountability for its merit-review policies. Grant applicants and reviewers now are required to address explicitly both the intellectual merit and broader impacts of proposed projects. Moreover, a separate policy emphasizes the need to have diversity among reviewers, in order to broaden the perspectives included in proposal review. With respect to its own workforce, NSF is using policy levers to make measurable progress in its strategic goal to increase diversity. Its directorates must prepare, follow, and update recruitment plans that seek strong representation of women, minorities and, persons with disabilities among staff, advisors, and panelists.

Trend Analysis of NSF's Activities to Increase Diversity in Science and Engineering between 1994 and 2003

Chapter 2 summarizes the results of a quantitative analysis of the trends in participation in STEM during the past ten years. It focuses on (1) NSF grant-giving to U.S. citizens who are underrepresented in STEM, (2) NSF investment in programs that help increase access to education and employment in STEM, and (3) the diversity of NSF's own science and engineering workforce. Between 1994 and 2003, the number of proposals submitted by persons underrepresented in STEM rose substantially: by 73% for women, 69% for underrepresented minorities, and 51% for persons with disabilities, while the total number of proposals submitted increased by only 33%. Throughout the decade, the proposal success rates for women, underrepresented minorities and persons with disabilities have been comparable to the foundation-wide average of 31%. Their average grant size, however, is about 15% smaller than that for non-minority males.

Some of NSF's investments in programs targeting access, opportunity, and education specifically for groups underrepresented in STEM have helped broaden participation. Such targeted programs continue to remain below 5% of the Foundation's budget. These targeted investments increased by about \$115 million during the past decade (from \$130 million in 1994 to \$245 million in 2003), while the NSF's total budget increased by \$2,382 million (from \$2,987 million to \$5,369 million). The diversity of NSF's STEM workforce also increased, and is now slightly higher than that of the overall U.S. STEM workforce.

A Historical Review of CEOSE Findings and Recommendations to the National Science Foundation: 1980 to 2002

Chapter 3 summarizes the findings and recommendations of CEOSE since its creation. Throughout that period, CEOSE consistently reiterated the inadequate access that persons from underrepresented groups have to education and employment opportunities in STEM; the need for research to understand and improve attraction, retention, persistence, and attachment; and the need for data sufficiently detailed to disaggregate by gender, race, ethnicity, and disability status. CEOSE recommendations focused on removing barriers, advancing research to expand the relevant knowledge base, and improving data collection and quality. Interaction and responsiveness between CEOSE and NSF's leadership was strong, and CEOSE recommendations appear to have contributed to several changes in NSF's diversity-related policies and programs.

Recommendations for Broadening Participation in Science and Engineering and the 2004 Biennial Report of CEOSE

Chapter 4 is the *CEOSE 2004 Biennial Report* and presents a summary distilled from the study of policies, programs, trends, and CEOSE history presented in Chapters 1 through 3, integrated with the issues of focus during the 2003-2004 biennium. During those two years, in addition to working on this report, the Committee applied significant effort in six directions:

- (1) Research and Data: Discussion of research needs; data sources, importance, and challenges; and possible uses of data for broadening participation;
- (2) Mentoring: Sponsorship of a mentoring workshop to review the status of the literature and practice on mentoring; creation within a CEOSE subcommittee of an action agenda for mentoring;
- (3) Policy Levers and Merit-Review Criteria: Examination of the merit-review criterion related to broader impacts as a policy lever to broaden participation;
- (4) Role of Research Universities, NSF Grantee Institutions, and Centers in Broadening Participation: Discussions of the role in broadening participation of the institutions that set the ethos of the STEM enterprise;
- (5) Tribal Colleges: Firsthand examination of two tribal colleges to gain a deeper appreciation of the particular needs of this particular group of institutions; and
- (6) Community Colleges: Discussion of the role of community colleges in broadening participation.

Recommendations

During its deliberations and the writing of this report, CEOSE developed recommendations to NSF in four areas and to itself in four areas, setting priorities and directions for its next biennium. The recommendations and their context are discussed in detail in Chapter 4.

Recommendations to NSF:

(1) **Accountability**. NSF should expand its systematic and objective evaluation to assess, understand, and report the effectiveness and impact of its programs and policies on broadening participation by:

- a. Continuing to obtain, refine, and disaggregate data and factors related to the

participation and advancement of persons from underrepresented groups in STEM education and careers.

b. Working with the STEM community to develop specific goals, timelines, and metrics, and using them to motivate, track and hold grantee institutions accountable for progress.

c. Building assessment and outcome reporting related to broadening participation into NSF program design and accountability expectations, where appropriate.

(2) *Research.* NSF should sponsor additional social science research that will advance understanding of the causes and effects of progress in and barriers to broadening participation in STEM at all levels—from learners to leaders. The relevant individual and institutional factors include mentoring, organizational climate, and the structure, culture, and nature of the systems that constitute the STEM enterprise in the United States. Additionally, NSF should ensure that women, underrepresented minorities, and persons with disabilities are included in the planning and implementation of all research areas, especially those identified for its major investments. It should be noted that the area of “human and social dynamics,” identified as one of the areas for major investments by NSF, provides an ideal programmatic framework to include research on these aspects of the STEM enterprise.

(3) *Policy Levers.* NSF should continue to employ and design new policy levers that focus the attention of principal investigators and their institutions on diversity aspects of the broader-impacts criterion, on embedding diversity goals in their research, and on designing and implementing sustainable institutional change that helps STEM become more inviting and supportive of women, underrepresented minorities, and persons with disabilities at all levels.

(4) *Tribal Colleges.* To engage and advance more Native Americans in STEM, NSF should enhance research capacity and research opportunities at Tribal Colleges by, for example, supporting more faculty exchanges and innovative distance-education and research technologies, expanding collaborations with research institutions, and helping Tribal Colleges and their faculty become competitive at proposal writing and aware of grant opportunities.

Recommendations for CEOSE Priorities and Directions in the 2005-2006 Biennium:

(1) *Widening Pathways into STEM.* It is timely for CEOSE to focus attention on the role of community colleges and other institutions whose mission focuses on workforce preparation for underrepresented groups as a vital pathway for access into STEM. Given the growing understanding of the role of research participation in attracting and retaining students in STEM, CEOSE should identify ways for NSF to expand quality research opportunities at these institutions and in other communities and settings with populations dominated by groups underrepresented in STEM.

(2) *Institutional Transformation.* CEOSE should seek to understand the elements necessary to transform institutions into entities, that are supportive of a diverse population of students and faculty, engage leaders of NSF grantee institutions in the goal of broadening STEM participation, and thereby recommend to NSF some means by which it can propel institutional transformation through its policies and programs.

(3) *Evaluation.* Key programs and projects at NSF and grantee institutions need systematic formative and summative evaluation with respect to their impact on broadening participation, to understand what works, what does not work, and why. CEOSE should establish a subcommittee on assessment and evaluation, to provide a mechanism for deeper engagement in this area.

(4) *Communication.* CEOSE should develop and implement a communications plan for becoming better known and recognized in the science, engineering, and related policy communities. It should foster additional interactions, collaboration, and sharing with other agencies and sectors. Broad dissemination of this report and its findings can be an effective starting point.

Today, the United States and the world face unprecedented challenges, many of which require the expertise and efforts of teams of people with strong STEM credentials to understand and solve. Broadening participation in STEM by ensuring access and opportunity for all remains the mission of CEOSE and the surest strategy for bringing the best ideas, highest creativity, and greatest innovation to the STEM enterprise and the service of the nation. Notwithstanding progress to date, much more remains to be done.

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