Broadening Participation in America's Science and Engineering Workforce

The 1994-2003 Decennial & 2004 Biennial Reports to Congress

CEOSE
Committee on Equal Opportunities in Science and Engineering

CEOSE 04-01
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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.

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, underrepresented 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, NSF[1]

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 democracy.

[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.

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.

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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).

This report 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 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 from underrepresented groups provide 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 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 have 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 have 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 have 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 (PAESMEM).*

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 of persons from underrepresented groups 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 the 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.

INTRODUCTION

As required by the National Science Foundation Reauthorization Act (H.R. 4664) of 2002, this report is a review of the last twenty-five years (1980-2004) of work of the Committee on Equal Opportunities in Science and Engineering (CEOSE) and an assessment of the work of NSF during that period on broadening participation in the fields of science, technology, engineering and mathematics (STEM).

Establishment of CEOSE

CEOSE is a committee originally established by the Science and Engineering Equal Opportunities Act of 1980, which was enacted to address the problem of the shrinking pool of American scientists and engineers and the growing global competition for science and engineering talent. The Act authorized the National Science Foundation (NSF) to undertake or support comprehensive programs for science and engineering education, training, and research. It declared that "… it is the policy of the United States to encourage men and women, equally, of all ethnic, racial and economic backgrounds to acquire skills in science, engineering and mathematics, to have equal opportunity in education, training and employment in scientific and engineering fields,"[1] and authorized the Foundation to undertake or support a comprehensive science education program to increase the participation of minorities in science and technology and to initiate research at minority institutions.

The Act required a Committee on Equal Opportunities in Science and Engineering (CEOSE) to be established within the National Science Foundation. The purpose of CEOSE was set forth in the Act [42 U.S.C. §1885c SEC. 36 (a)]:

> *"The Committee shall provide advice to the Foundation concerning (1) the implementation of the provisions of this Act and (2) other policies and activities of the Foundation to encourage full participation of women, minorities, and other groups currently underrepresented in scientific, engineering, and professional fields."*

The 15-person membership of CEOSE is drawn from all sectors - academia, the non-profit sector, industry and government.

The original act specifically mentioned women and minorities and called for equal opportunities to be provided for them and other underrepresented groups. The current charge spells out more specifically these underrepresented groups as "women, minorities and persons with disabilities." The specific mention of persons with disabilities first occurred in 1997 in an administrative amendment in the Science and Engineering Equal Opportunities Act wherein Congress amended the original wording.[2]

[1] 42 U.S.C. §1885, Section 32(b), Findings and Policy.

[2] 2 H.R.105-063, Section 202, Administrative Amendments.

Reporting Requirement of CEOSE Activities

A biennial report is required of CEOSE under the Science and Engineering Equal Opportunities Act:[3]

> *"Every two years, the Committee shall prepare and transmit to the Director 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."*

H.R. 4664, the National Science Foundation Reauthorization Act of 2002, added a ten-year review to the biennial report requirement of CEOSE (Sec. 20):

> *As part of the first report required by section 36(e) of the Science and Engineering Equal Opportunities Act (42 U.S.C. 1885c(e)) transmitted to Congress after the date of enactment of this Act, the Committee on Equal Opportunities in Science and Engineering shall include(1) a summary of its findings over the previous 10 years; (2) a description of past and present policies and activities of the Foundation to encourage full participation of women, minorities, and persons with disabilities in science, mathematics, and engineering fields, including activities in support of minority-serving institutions; and (3) an assessment of the trends in participation in Foundation activities, and an assessment of the success of Foundation policies and activities, along with proposals for new strategies for the broadening of existing successful strategies toward facilitating the goals of that Act.*

This report contains this required review and the 2004 Biennial Report. The report concludes with the recommendations of CEOSE for broadening participation in view of the assessments conducted in the reviews and the work during the past two years.

Historical Context of the Science and Engineering Equal Opportunities Act and CEOSE

According to the Bureau of Census, the number of women and racial/ethnic minorities has been increasing in post-secondary education as well as in the country's total workforce since 1980.[4] White males, who have traditionally occupied the overwhelming majority of professional jobs in the sciences and engineering, have been entering these fields at a declining rate. Between 1968 and 1997, the percentages of white males declined in total college enrollment, in Bachelor's Degrees overall and in Bachelor's Degrees in science and engineering.[5] Despite these trends and the nation's need for more scientists and engineers, participation of women and minorities in STEM education and employment has not grown at a rate comparable to other fields.

[3] 42 U.S.C. §1885c SEC. 36. (e)

[4] U.S. Bureau of the Census. Statistical Abstracts of the United States, 1999.

[5] *Women, Minorities and Persons with Disabilities in Science, and Engineering: 2002.* Arlington, VA: National Science Foundation, July 2003, p. xiv.

Over the past several decades, the American government, industry, and academia have relied heavily on scientific and technological talent from foreign countries. This reliance has placed America in strong international competition for scientists and engineers. According to the National Science Board, "Global competition for S&E talent is intensifying, such that the United States may not be able to rely on the international S&E labor market to fill unmet skill needs."[6] The terrorist attacks of September 11, 2001 on the United States have further highlighted concern about America's reliance on foreign resources in general.

The National Science Foundation has tried to address these issues vigorously since 1980. In its 2001-2006 GPRA Strategic Plan, the Foundation articulated outcome goals for NSF investments in terms of *People, Ideas, Tools, and Organizational Excellence*:

> "People *to develop a diverse, internationally competitive and globally-engaged workforce of scientists, engineers and well-prepared citizens.*
>
> Ideas *to provide a deep and broad fundamental science and engineering knowledge base.*
>
> Tools *to provide widely accessible, state-of-the-art science and engineering infrastructure.*
>
> Organizational Excellence *to operate an agile and innovative organization that fulfills its mission through leadership and state-of-the-art business practices".*[7]

The plan further states that "Issues of equal opportunity in science and engineering are addressed by all four of the outcome goals." While the four goals are intertwined, it is the PEOPLE goal that forms the primary focus of CEOSE work and of this report.

Outline of Report

The first three chapters address the three requirements of H.R. 4664. Chapters 1, 2 and 3 are based on detailed studies of NSF annual reports, CEOSE biennial reports, program information, statistics, databases, and interviews with leading administrators. Numerous NSF personnel, from the Director and Deputy Director to program directors and officers, collected and provided the data necessary for the compilation of this report and gave of their time as we reconstructed the historical trends of NSF programs and events. Previous CEOSE committee members and members of other organizations also provided information.

Chapter 1 describes the past and present policies and programs of the NSF designed to encourage full participation of women, minorities, and persons with disabilities in STEM education and the workforce. Chapter 2 is an assessment of the trends in participation of these underrepresented groups and the

[6] *The Science and Engineering Workforce. Realizing America's Potential.* National Science Board of the National Science Foundation, August 14, 2003, p. 1.

[7] NSF Strategic Plan FY 2003-2008, September 30, 2003.

success of the Foundation's policies and activities. Chapter 3 provides the required review of CEOSE's findings during the ten-year period from 1993 to 2002 as required by Congress. Because the history of CEOSE has never been documented, the report also takes a retrospective look at CEOSE since its inception in 1980.

Chapter 4, the final chapter, is the Biennial Report for 2004 and provides an account of the activities of CEOSE during this period, along with recommendations and proposals for the broadening of participation in STEM.

In Chapters 1, 2, and 3, the details of the frameworks used to conduct the studies are presented. In Chapter 1, we analyze the past programs and policies using a framework adapted from the Foundation's *investment model*, which NSF uses to describe its purpose and functions. This model looks for the yield from the investment of resources, using the vehicles of programs. The investment yield of the model focuses on four areas: people, ideas, tools, and organizational excellence. For purposes of the present study, however, the primary concern is with people, i.e., NSF's return on investment from helping to produce a more diversified STEM workforce. The framework's broad purview helped to ensure that all relevant policy and activity points throughout the Foundation's investment enterprise were captured and included in the study's findings.

In Chapter 2, we assess the trends in participation in NSF's activities. To answer questions about the efficacy of the policies and program activities with regard to increasing the participation of women, minorities, and persons with disabilities, we analyzed NSF's grant-giving and the merit-review system, its support of the programs and initiatives that increase access for underrepresented populations, and the change in diversity among NSF's science and engineering staff.

In Chapter 3, we summarize the findings and accomplishments of CEOSE over the first two decades of its existence, 1980-2002, as provided in the biennial reports from 1981. In addition to highlighting the activities and accomplishments of CEOSE, this historical review provides a basis for subsequent assessment of NSF's impact on the diversity of America's science and engineering workforce, as well as future directions of CEOSE.

In Chapter 4, we synthesize the results of the preceding three chapters and provide an overview of the progress made by NSF in broadening participation in science and engineering. Based on the synthesis and CEOSE's findings from 2003-2004, we offer several recommendations to NSF for continuing its efforts to increase diversity in STEM. Finally, using the Committee's standard biennial reporting format, we summarize CEOSE's activities and deliberations in 2003-2004.

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

Key Results

- Since the Science and Engineering Equal Opportunities Act of 1980, NSF has continued to strengthen policies and programs to broaden participation of women, minorities and persons with disabilities in science and engineering.
- During the period from 1994 to 2003, NSF reformulated and enforced its merit-review criterion, and its funding and workforce policies designed to broaden participation of underrepresented groups in the nation's science and engineering enterprise.
- During this same period, NSF increased its financial investments in programs targeted to underrepresented groups by 87.5%, from $130.43 million to $244.60 million. The Foundation's total budget increased 79.7% from $2.987 billion to $5.369 billion, meaning that targeted investment in participation programs increased slightly although it remained below 5% of the total budget.
- The impact or investment yield of many of NSF's diversity-producing programs was evaluated. Overall, the results of these evaluations show that the programs are helping to increase the participation of women and underrepresented minorities in the science and engineering professions. Evaluation results on the impact of programs for persons with disabilities are not yet available.
- NSF's newly revised broader-impacts criterion (Important Notice 127) was intended to promote increased attention by proposers to diversity and other societal issues. NSF has not yet established a tracking and reporting mechanism to determine the number of proposals that actually address diversity.

Since the enactment of the Science and Engineering Equal Opportunities Act of 1980, the National Science Foundation has continued to seek ways to increase access to STEM education and employment for women, minorities, and persons with disabilities. During the period between 1994 and 2003, the Foundation pursued new policies and program-funding strategies that were designed to further its aim to help increase the diversity of America's scientists, engineers, and technologists.

How the Chapter Is Organized

The framework for conducting the analysis of NSF diversity policies and programs is first described. This framework was adapted from the Foundation's investment model, which NSF uses to describe its purpose and functions (Figure 1-1).[1] Next, specific policies that were created or sustained during the 1994-2003 period are reviewed in terms of their intent and impact on broadening participation. Following this is a review of major NSF funding programs that were designed to increase the numbers of underrepresented persons within the science and engineering pipeline and workforce. The chapter ends with a conclusion of the findings.

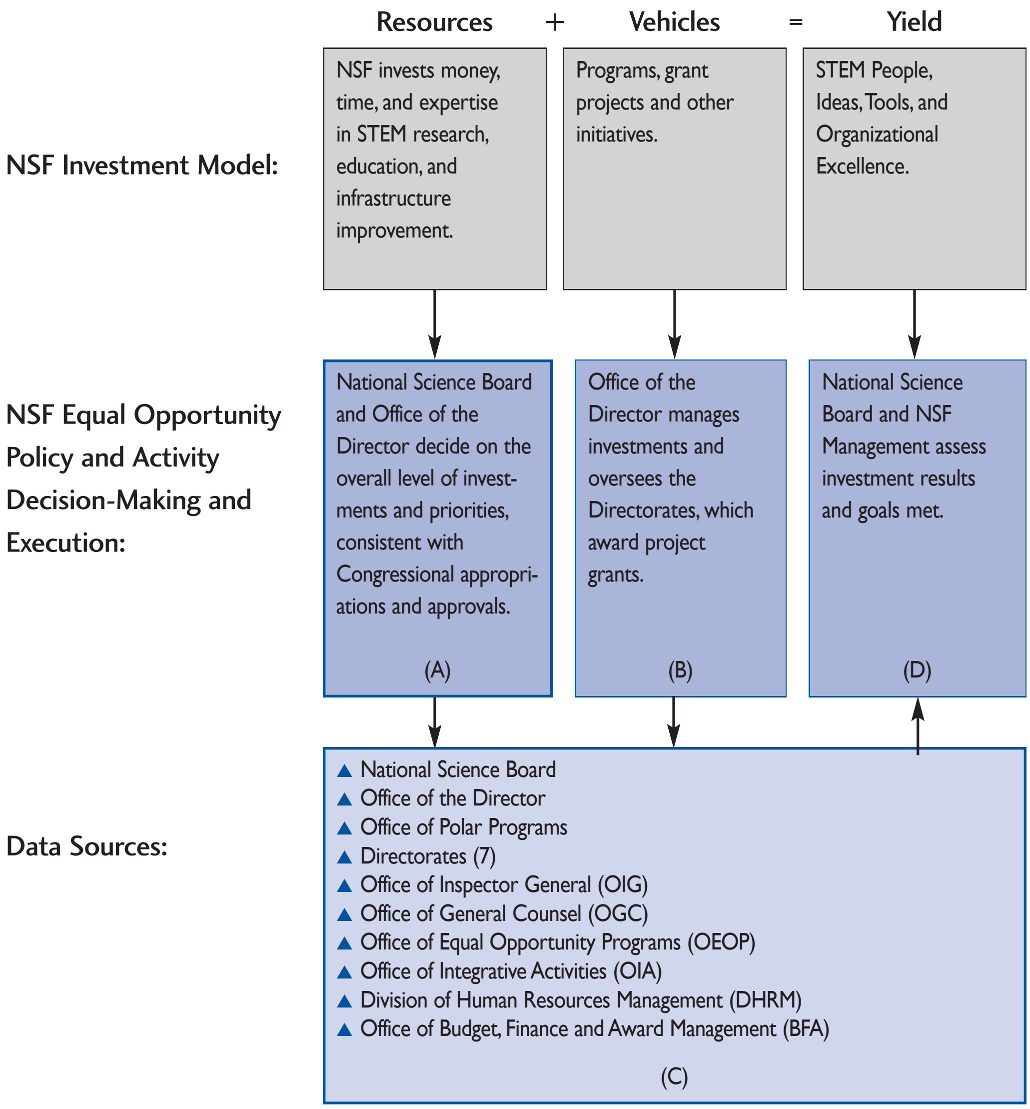
The questions that guided the study are:

> What policies did the National Science Foundation newly implement or continue during 1994-2003 that promote and support increased access to and participation in STEM by women, underrepresented minorities, and persons with disabilities?
>
> What program activities did the National Science Foundation create to provide education and career advancement opportunities for these underrepresented groups in STEM?
>
> What evidence is there that these policies and program activities yielded results that actually affected or could potentially improve the representation of women, minorities, and persons with disabilities among the nation's scientists, technologists, engineers, and mathematicians?

[1] NSF Strategic Plan FY 2003-2008, September 30, 2003, p. 4.

Figure 1-1

Framework for Describing NSF Equal Opportunity Policy and Program Investment Process



Letters (A) to (D) in Figure 1-1 above represent points in the NSF investment and management decision-making process, from which equal opportunity policies and activities emanate and operate. The directorates, divisions, and offices indicated in Figure 1-1 were the specific sources from which the policy and activity data were obtained through document reviews and staff interviews.

NSF POLICIES TO BROADEN PARTICIPATION

The National Science Board establishes all policies of the National Science Foundation within the framework of authority provided by Congress and the President. These include policies related to increasing demographic diversity within the STEM workforce. The Director of NSF may also issue policies that are sanctioned by the Board. For purposes of this report, policies refer to written statement(s) issued by the National Science Board or the NSF Director in support of increasing participation of underrepresented groups in STEM or statements that direct NSF's Assistant Directors and other management staff to implement or enforce specific actions intended to increase participation of underrepresented groups in STEM. Such statements are in the form of board resolutions, announcements, NSF Important Notices, and memoranda from the NSF Director.

During the period from 1994 to 2003, the National Science Foundation issued numerous policies intended to increase access to educational, training, and employment opportunities in STEM for women, underrepresented minorities, and persons with disabilities. We have grouped these policies into four categories: (1) educational opportunities, (2) program investments, (3) merit review of grant proposals, and (4) STEM workforce opportunities. These four categories reflect the primary areas of focus of NSF's efforts in promoting, increasing, and sustaining participation of underrepresented groups among the nation's scientists and engineers.

Policy Yield

The yield of each of these policies is described here in terms of concrete results that lay the groundwork for or promote increased diversity and participation of underrepresented groups within the science and engineering fields.

NSF-Supported Engineering Research

Education Opportunity Policies

NSF has articulated policies that are supportive of education in science and mathematics throughout the curriculum, from kindergarten to graduate school and beyond. To follow are examples of education policies of the Foundation intended to improve the teaching and learning process for women, minorities, and/or disabled persons. NSF has also emphasized the need for initiatives to enhance skill-building for underrepresented groups through widening access to graduate and postdoctoral education opportunities.

Federal Role in Science and Engineering Graduate and Postdoctoral Education (1997)

In response to a request from the Office of the Vice President to provide its views on science and engineering education policy, the National Science Board affirmed that the Federal government should support partnerships between research and non-research institutions. The goals of these partnerships are to produce high-quality scientists and engineers and improve the transition from undergraduate to graduate programs for underrepresented students. The Board emphasized that this transition is especially important for reaching minority undergraduates.[2]

Yield: NSF took the lead on this policy initiative by supporting several grant programs that sought to strengthen ties between research-intensive and non-research institutions of higher education. One example is the *ADVANCE* program, which provides tool-kits and best practices for enhancing faculty diversity and opportunities for female scientists and engineers to conduct research at leading research universities. Another example is the *Historically Black Colleges and Universities-Undergraduate Program*, which provides assistance to improve the research infrastructure of minority-serving institutions and collaborations with research-intensive institutions.

Educating the National STEM Workforce (1999)

The National Science Board supports the need for research and application to STEM learning by underrepresented groups at the undergraduate level. Also, the Board supports research into how funding of institutional and individual educational initiatives can facilitate participation of underrepresented groups.[3]

Yield: NSF's *Gender Diversity in Science, Technology, Engineering, and Mathematics* program was established in part to support research into the learning process of females in the STEM areas and to help close the gender achievement gap in science on the pre-college and college levels. The Foundation's *Program for Persons with Disabilities* also supports research aimed at enhancing the learning and teaching process for disabled students. While NSF has supported numerous programs that include an emphasis on learning supports for minority students, such as mentoring, the Foundation did not offer grant opportunities during the study period that are focused on research on the learning process of minority students at the pre-college and college levels.

NSF Program Investment Policies

One of the overarching goals of NSF GPRA strategic plans since 1997 has been to invest in activities that enhance diversity in the science and engineering workforce. Within this context, NSF has crafted policies that guide its investment strategies and priorities in funding programs that specifically address the needs of underrepresented groups. These investment policies are intentionally developed to increase broad-based acceptance and continuation of grant initiatives aimed at assisting these groups in accessing research and education resources.

Embedded Diversity (1999)

To ensure a broad focus on diversity throughout the Foundation, the NSF Director issued a direc-

[2] NSB 97-235, February 26, 1998, *The Federal Role in Science and Engineering Graduate and Postdoctoral Education*
[3] NSB-99-179, July 29, 1999. *Education and Human Resources Committee Workplan* (www.nsf.gov/nsb/documents/2000/nsb99179/ehrwkplanedit 1199.doc).

tive to the directorates that research and education grants within all of the disciplines must include opportunities for women, minorities, and persons with disabilities. The directive also encouraged proposers to include underrepresented persons within their proposed projects.[4]

Yield: All of the directorates have since participated in one or more of the Foundation-wide programs for underrepresented groups. With the exception of the Mathematical and Physical Sciences Directorate, all of the directorates also have offered their own grant programs specifically targeted to underrepresented groups.[5] The Office of Polar Programs has participated in foundation-wide programs for underrepresented groups, but has yet to offer its own targeted programs.

Enhance Federal Funding to Achieve Increased Participation through Diversity (1999)

The National Science Board supports federal government initiatives "...that direct substantial new support to students and institutions in order to improve success in S&E study by American undergraduates from all demographic groups" and to "...expand funding for programs that best succeed in graduating underrepresented minorities and women in S&E".[6]

Yield: NSF took the lead by substantially increasing its investments in programs that support enhanced participation of women, underrepresented minorities, and persons with disabilities in STEM. In 1994, 4.4% (or $130.43 million) of NSF's total budget of $2,987.22 million was allocated for research and education programs for underrepresented groups. This percentage increased to 4.6% (or $244.60 million) of NSF's total budget of $5,369.34 million in 2003. Overall, the amount of NSF funding for programs to support participation increased by 87.5% between 1994 and 2003, while NSF's total budget increased by 79.7% during this same period.[7]

NSF Proposal Merit-Review Policies

The Foundation's proposal review process is guided by policies that ensure (1) all proposal applications submitted to NSF receive an equitable review and (2) proposals are carefully reviewed in terms of their scientific merit and their broader impact or societal value.

Reformulation of Merit-Review Criteria (1999)

In 1981, the National Science Board adopted a merit-review standard for proposals, which consisted of four criteria: (1) research performance competence of the principal investigator and supporting institution, (2) intrinsic merit of the proposed research, (3) utility or relevance of the research, and (4) effect of the proposed research on the infrastructure of science and engineering. To simplify these criteria and to link NSF's strategic plan to the merit-review process, a task force of the NSB

[4] Deputy Director of NSF, Dr. Joseph Bordogna, October 1999.

[5] Findings obtained from survey interviews of Assistant Directors and document reviews.

[6] NSB-03-69, August 14, 2003, *The Science and Engineering Workforce, Realizing America's Potential,* p. 20.

[7] Budget amounts for diversity programs and total NSF budget were obtained from the NSF Office of Budget, Finance and Award Management.

recommended revised merit-review criteria.[8] Based on this recommendation, the Board approved and issued in 1997 a reformulated merit-review policy that consists of two criteria: (1) intellectual merit and quality of the proposed research or educational activity and (2) the broader impacts of the proposed activity.[9] The intent of the new broader-impacts criterion of the 1997 policy was to require proposers to address areas of societal concern within the context of the proposed activity, including the area of broadening participation of underrepresented groups within STEM. To ensure the proposers pay attention to the new criterion, NSF issued a policy in 1999 that emphasized the importance of addressing the broader-impacts criterion in the preparation and review of proposals submitted to NSF.[10]

The definitions of the merit-review criteria are as follows:[11]

> ***Criterion 1.*** *What is the intellectual merit of the proposed activity?* Address any or all of these concerns: How important is the proposed activity to advancing knowledge and understanding within its own field or across different fields? How well qualified is the proposer (individual or team) to conduct the project? To what extent does the proposed activity suggest and explore creative and original concepts? How well conceived and organized is the proposed activity? Is there sufficient access to the necessary resources?
>
> ***Criterion 2.*** *What are the broader impacts of the proposed activity?* Address any or all of the following concerns: How well does the activity advance discovery and understanding while promoting teaching, training, and learning? How well does the proposed activity broaden the participation of underrepresented groups (e.g., gender, ethnicity, disability, geographic)? To what extent will it enhance the infrastructure for research and education, such as facilities, instrumentation, networks, and partnerships? Will the results be disseminated broadly to enhance scientific and technological understanding? What may be the benefits of the proposed activity to society?

Yield: Following implementation of this merit-review policy, the Senate Appropriations Committee requested that NSF commission an independent study to assess the procedure and impact of the policy. While the resulting study concluded that it was too early to assess the impact of the merit-review policy, it made recommendations to improve (1) the clarity of the criteria, (2) the awareness of applicants, reviewers, and program staff, and (3) metrics for tracking and assessing applicant and staff compliance with the new policy.[12] However, based on a 2001 report prepared by the Director of NSF for the National Science Board, the Foundation did not meet its goal to get reviewers and program officers to address both merit-review criteria.[13]

8 NSB/MR-97-05, March 18, 1997, NSB-NSF Merit Review Task Force Final Recommendations.

9 NSB-97-72, March 28, 1997. Resolution Approved by the National Science Board At Its 342nd Meeting, March 27-28, 1997, Concerning New General Criteria for Merit Review of Proposals.

10 NSF Important Notice #125, September 20, 1999.

11 See Footnote # 8.

12 Study conducted by the National Academy of Public Administration, 2000.

13 *Report to the National Science Board on the National Science Foundation's Merit Review Process Fiscal Year 2001.*

Enforcement of Broader-Impacts Criterion (2002)

In an effort to increase compliance with the new merit-review policy, NSF in its *Grant Proposal Guide* (GPG) 2002 required that principal investigators must address both merit-review criteria in separate statements within the one-page Project Summary. The GPG also reiterated that the broader impacts resulting from the proposed project must be addressed in the Project Description and described as an integral part of the narrative. Based on a subsequent review of grant applications submitted to NSF for funding, the Director of NSF issued a policy stating that NSF will return without review proposals that do not separately address both merit-review criteria in the Project Summary page of the application.[14]

Yield: Compliance with the revised merit-review criteria policy improved significantly, following the issuance of this enforcement policy. Beginning in FY 2003, NSF returned 276 or 0.7% of all proposals submitted for funding consideration. Over 90% of reviewer evaluations of proposals addressed the scientific merit and the broader-impact merits of the proposed projects, compared to 84% in FY 2002 and 69% in FY 2001. Although changes made to the broader-impacts criterion were intended to promote increased attention by proposers to diversity and other societal issues, NSF has yet to establish a foundation-wide mechanism for reporting on the number of grant proposals that specifically address diversity within their broader-impacts statements.[15]

Importance of Proposal Reviewer Diversity (2000)

The Director of NSF emphasized reviewer diversity and the importance of having reviewers from diverse backgrounds (of gender, race/ethnicity, and disability status) to ensure that a wide range of perspectives is taken into consideration in the grant review process. NSF also encouraged reviewers to provide demographic profile information, which enables the NSF to monitor reviewer diversity.

Yield: In FY 2001, NSF established a policy and system to electronically request voluntary demographic data from the reviewers in order to determine participation levels of underrepresented groups in the NSF reviewer pool. The return rate for the requested demographic information has been very low. Of the 37,943 reviewers who submitted proposal reviews in 2002, only 3,507 (or 9%) volunteered their demographics. One-third (33%) of these respondents indicated they were members of an underrepresented group.[16]

In FY 2003, the rate of volunteered demographics improved to 13%. Again, one-third (34%) reported that they were members of an underrepresented group.[17] The low response rate to the NSF request has been attributed to the absence of legal leverage to require reporting of reviewer back-

[14] NSF Important Notice #127, July 8, 2002.

[15] *Report to the National Science Board on the National Science Foundation's Merit Review Process Fiscal Year 2003.* An attempt was made by the Geosciences Directorate, using a non-random sample of 673 proposals received in 2003. The study was conducted during a May 2003 review panel. The results showed that increasing participation was one of the least addressed areas in proposals submitted for review. The most frequently addressed areas of broader impact included intrinsic value of proposed project to society, providing research experience for undergraduate and graduate students. No conclusions should be drawn from this one study, however, because the limited sample was not representative of the Foundation as as a whole. Results of the study were provided to the present study team by the Assistant Director for Geosciences.

[16] *Report to the National Science Board on the National Science Foundation's Merit Review Process Fiscal Year 2002.*

[17] Ibid.

ground information. NSF is working hard to remedy this shortcoming. NSF uses FastLane on its website for proposal submissions and reviews. The FastLane screen on which reviews are required to be entered is being redesigned, so that reviewers are asked their demographics when they enter into the system to write their reviews.

STEM Workforce Diversity and Development Policies

Building a STEM workforce that is reflective of America's demographic diversity and ingenuity is of major importance to our nation. In keeping with this national goal, NSF has adopted equal opportunity hiring, training, and career advancement policies intended to diversify its own workforce of scientists, engineers, and technologists.

Directorate Recruitment and Selection Plan (1999)

The Director of NSF issued a policy requiring all NSF directorates and offices to implement recruitment and selection plans for addressing diversity issues relating to their organizations. The plans are to ensure that all reasonable efforts are made to obtain a diverse pool of qualified personnel and to maintain a systematized reporting mechanism for monitoring implementation of the plans.[18]

Yield: Increasing diversity among NSF's STEM workforce has become a major goal of the Foundation's strategic plan. Additionally, each of the Foundation's directorates has a plan of action to increase and maintain diversity among staff and advisory committees, and to provide access for women, underrepresented minorities, and persons with disabilities to the directorate and division grants.

Equal Opportunity and Diversity at NSF (2000)

The National Science Foundation reaffirmed its commitment to equal opportunity and diversity in the workplace. The aim of NSF is to develop a workforce with a sense of value, responsibility, and strong work ethic. Additionally, it is committed to creating a work environment that respects individual differences and encourages employees to grow to their full potential as valued members of the Foundation's team.[19]

Yield: During the period from 1994 to 2003, there was a low percentage of underrepresented minorities and persons with disabilities among the professional scientists and engineers employed at NSF. African Americans, for instance, made up almost one-third of all NSF staff, but only 6% of the scientists and engineers employed by the Foundation. African Americans were more prevalent in program support and business operation positions. The percentages of Native American and Hispanic scientists employed by NSF were likewise very low. Women were far more represented among the Foundation's scientists than minorities and individuals with disabilities. Women made up

[18] NSF Director Memorandum to Staff, April 22, 1999.
[19] O/D-94-18, March 6, 2000, OEO Policy Statements On Equal Opportunity and Sexual Harassment.

approximately 60% of all NSF employees and almost 40% of NSF's scientists and engineers during 1994-2003.[20] While NSF has made strides in building a demographically diversified workforce, more remains to be done.

NSF PROGRAMS FOR BROADENING PARTICIPATION

The primary activity of NSF for broadening participation is to invest financial resources in education, research infrastructure, and career advancement programs. Described in this section are mainly foundation-wide grant programs that were funded by NSF during the 1994-2003 period.[21] Some of these programs were established during this period, and some were established prior to 1994 and remained operational during the period under study. A timeline illustrating major programs of NSF is included in Appendix B.

Evaluation of Investment Impact

Evaluation of NSF-funded projects occurs on multiple levels. First, each project is required to evaluate itself and report evaluation results to NSF on its achievements. Second, the Foundation utilizes panels called "Committees of Visitors" (COVs), which consist of external volunteer scientists, engineers, educators, managers, and evaluation experts. The COVs assess NSF grant programs at least once every three years in terms of meeting GPRA goals: proposal-review standards including diversity, grant project management, and project outcomes. Third, the Directorate or Office Advisory Committee reviews the activities of the directorates and management offices, and assesses their effectiveness in meeting the Foundation's goals and objectives. Finally, NSF contracts with outside evaluators to conduct outcome and impact studies of some funded projects.

Outcome and impact evaluations deal respectively with short-term and long-term effects of an intervention. In keeping with the framework of the present report, the focus here was on the impact or long-term return of the NSF investments, specifically the yield or gain in number of underrepresented persons within the STEM pipeline and workforce. As such, attempts were made to obtain impact evaluation data to include within the program descriptions. In some cases, impact evaluation findings could not be obtained because corresponding data were not available or because of the relative newness of a program.

Women-Focused Programs

Professional Opportunities for Women in Research and Education (POWRE)

Prior to 1997, NSF offered a number of programs to improve research and career advancement opportunities for women in science and engineering. To link and strengthen these programs, NSF

[20] Data obtained from NSF Office of Equal Opportunity Programs.

[21] The individual Directorates of NSF also offer discipline-specific grant programs for underrepresented groups in science, technology, engineering and mathematics .

combined them into a single program *(POWRE)* in 1997. Specific opportunities offered under this umbrella program included planning grants to develop research projects, research grants that enable women to serve as principal investigators at major research institutions, and career advancement awards to outstanding women in academia. In its first year, a total of 129 *POWRE* awards were made to individual women, with a total investment of approximately $8.67 million. By FY 2000, 170 *POWRE* awards were made, with an investment increase to $13.5 million. *POWRE* was merged into the *ADVANCE* program in 2001.

Yield: Because of the short duration of the *POWRE* program, no formal evaluation had been scheduled by the COV or other evaluation consultants.

ADVANCE: Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers

The *ADVANCE* program initiated in 2001 seeks to understand and address the factors in academic institutions that work against women's full participation and advancement to senior faculty and academic leadership ranks. Program opportunities have included awards to (1) facilitate early career success, (2) engage in professional societies, and (3) recognize institutions that are systematically committed to examining and referencing academic practices and policies that are barriers to women's advancement. The program is based on research and lessons learned from NSF's earlier programs for women. In FY 2001, awards up to $750,000 per year for five years were made to nine universities. The *ADVANCE* portfolio also included 35 fellowship awards and 13 leadership awards to individuals. The NSF investment for *ADVANCE* in FY 2001 equaled $8.95 million and increased to $17.2 million by FY 2003.

Yield: A full outcome evaluation of the *ADVANCE* program has yet to be undertaken. However, an evaluation of the fellowship component indicated that the *ADVANCE* awards have facilitated research productivity, contributed to retention of recipients in academia, and increased their likelihood of obtaining a tenure-track position. Evaluation findings from the institutional transformation sites also support the program's positive impact on retention of women STEM faculty.[22]

Gender Diversity in Science, Technology, Engineering, and Mathematics Education (GDSE)

The *GDSE* program (originally called *Program for Women and Girls*) was established in 1993 and continues to be operational. There are three major goals of the *GDSE* program. The first is to fund research that increases the knowledge base for improving the learning of science and engineering by female students and closing the gender gap in academic performance in science, technology, engineering, and mathematics. The second goal is to support demonstration projects of model teaching approaches, innovative pedagogies, and curriculum materials for gender-inclusive teaching practices.

[22] *A Report on the National Science Foundation's Efforts to Assess the Effectiveness of Its Education Programs*. Directorate of Education and Human Resources, Division of Research, Evaluation and Communication, August 1996, pp. 35-36.

The third goal of *GDSE* is to support efforts to disseminate evidence-based knowledge to educational practitioners and policy makers. Between 1994 and 2003, 284 NSF awards were made under the *GDSE* program. In FY 1994, NSF invested $14.7 million in this program and the level was $10.5 million in FY 2003.

Yield: During 1999 and 2000, the Urban Institute, an independent evaluator, conducted a study of *GDSE*. The findings showed that the program had significantly contributed to the knowledge-base about the learning process for females in science and engineering through published articles, developed instructional products, and documented best practices in teaching science in gender inclusive settings. The study further found that the *GDSE* program is the nation's largest funder of efforts to increase participation of females in STEM and has developed model interventions that have been institutionalized after NSF funding has ended. The *GDSE*-funded projects have improved policy and practice in classrooms, and provided models for replication.[23]

Minorities-Focused Programs

The Centers for Research Excellence in Science and Technology (CREST)

The *CREST* program was established in 1987 with the goal of increasing participation in STEM by making substantial financial investments (up to $1,000,000 per year for up to two 5-year cycles) to upgrade the research capabilities and infrastructure of research-productive minority institutions. The *CREST* program replaced the *Research Improvement in Minority Institutions (RIMI)* program, which was begun in 1982. The *RIMI* program was discontinued in 1995 because it was not having the desired impact on the quality of research at minority institutions. *RIMI* provided smaller and shorter-duration grants than its successor in supporting faculty research, and the acquisition of research equipment. The eight *CREST* Centers and *RIMI* awards together have supported over 420 faculty and 1,570 college students. Funding for the *CREST* program in FY 1994 was $8.8 million and dropped slightly to $8.7 million in FY 2003. During this ten-year period, a total of 54 *CREST* awards were made to the eight centers.

Yield: A 2001 COV assessment of *CREST* grantees underscored the general success of this NSF program. The COV assessment panel found a number of commendable outcomes. A big strength of *CREST* is the synergistic play between research and education in which *CREST* Centers have partnered with other NSF-sponsored research projects utilizing graduate students who have gained research experience. Some *CREST* Centers have excelled in scientific discovery (e.g., Los Angeles center's use of innovative methods for extra-solar planet discovery and development of probes for breast cancer). The *CREST* Centers have exposed significant numbers of minority undergraduates and graduate students to NSF-funded programs, thereby increasing their awareness of education,

[23] *Summary Report on the Impact Study of the National Science Foundation's Program for Women and Girls*. Washington, DC: The Urban Institute, December 2000.

research, and training opportunities for the sciences and engineering fields. The COV panel recommended that *CREST* Centers should be recognized also for their work and contribution to scientific discovery.[24]

Louis Stokes Alliances for Minority Participation (LSAMP)

The *LSAMP* program is another major NSF investment, which is aimed at increasing the number of minority students who receive a baccalaureate degree in science, technology, engineering, or mathematics. The program's ultimate goal is to encourage these students to pursue a graduate degree in a STEM field. Unlike traditional programs that provide financial aid, *LSAMP* supports alliances among community colleges, four-year colleges, graduate schools, and industry to reach its goals, rather than funding individual student scholarships or individual institutions. Another unique aspect of *LSAMP* is that it targets undergraduates who demonstrate an interest in and aptitude for one of the STEM professions and provides the students with mentoring and opportunities for hands-on research experience through the alliances. *LSAMP* was begun in 1991 and continues to date. It currently has 28 active alliances in 24 states. NSF funds an alliance in 5-year cycles. In FY 1994, it initially invested $25.6 million in *LSAMP* and increased its investment to $31.8 million by FY 2003. Between 1994 and 2003, NSF awarded 88 grants under *LSAMP*.

Research Opportunities For LSAMP Scholars

Yield: A study designed to target best practices in programs to increase participation in STEM identified the mentoring, research opportunities, and sense of community among students, mentors, and faculty as being most valuable to the *LSAMP* student participants.[25] Moreover, a follow-up evaluation study of students who participated in *LSAMP* found that 51% graduated from college with a GPA of 3.2 or higher; 80% took additional courses in a STEM area after graduating with a Bachelor's Degree; two-thirds of all graduates have pursued at least a Master's Degree in fields that include engineering, biology, and health sciences; over one-half had attained a Master's Degree; and 62% reported that their most recent full-time job was in a STEM related area.[26]

Historically Black Colleges and Universities Undergraduate Program (HBCU-UP)

Since 1998, NSF has provided funds for *HBCU-UP* to support comprehensive strategies to strengthen STEM teaching and learning. The program's overarching aim is to encourage improved access and retention of minority students in science and engineering tracks and subsequent employment in the STEM workforce. The program is funded through cooperative agreements over a 5-year period, which represents an expansion over the previous 3-year funding cycle program for *HBCUs*. Under

[24] Committee of Visitors (COV), *A Review of Programs for Minorities and Minority-Serving Institutions.* NSF, February 1-2, 2001.

[25] Laure Sharp, et al., *Programs Promoting Participation of Underrepresented Undergraduate Students in Science, Technology, Engineering and Mathematics Fields*. Washington, DC: WESTAT, December 2000.

[26] *Life After LSAMP*. Washington, DC: The Urban Institute, 2001.

this program, NSF funds African American institutions in 12 states, the District of Columbia and the U.S. Virgin Islands. Between 1998 and 2003, NSF made 53 *HBCU-UP* awards. In FY 1998, the Foundation initially invested $5.8 million for the *HBCU-UP* and increased its investment to $18.7 million by FY 2003.

Yield: The COV's initial assessment of the *HBCU-UP* was made in 2001, three years after the start of the program. Because of the newness of the program, the assessment did not contain data on the program's impact.[27] The next COV evaluation is scheduled for 2004 and was to include an impact assessment of the program, but it was not available when this report was prepared.

Tribal Colleges & Universities Program (TCUP)

TCUP provides awards to American Indian, Native Hawaiian, and Alaskan Native-serving institutions to enhance the quality of STEM instructional and outreach programs, with an emphasis on leveraged use of technologies. The program began in 2000. NSF provides support for the implementation of comprehensive approaches to strengthen teaching and learning that can improve access to, retention within, and graduation from STEM programs. *TCUP's* primary focus is at the Associate and Bachelor's Degree levels. *TCUPs* are typically funded in two phases: implementation (Phase I) for up to 5 years and continuation to expand a project in community (Phase II) for up to 3 years. Grants are made to individual institutions as well as institutional collaborations involving several American Indian, Alaskan Native and Hawaiian Native-serving institutions. NSF initially invested $9.7 million in *TCUP* in FY 2000 and $9.5 million in FY 2003. Between FY 2000 and FY 2003, 40 *TCUP* awards were made.

TCUP Students on a Field Trip for Geosciences

Yield: Due to the newness of the *Tribal Colleges and Universities* program, an independent impact evaluation of the program has yet to be conducted and reported. A COV assessment is scheduled for 2005.

Alliances for Graduate Education and the Professoriate (AGEP)

The *Alliances for Graduate Education and the Professoriate (AGEP)* program was designed to increase the number of American students receiving doctoral degrees in the sciences, technology, engineering, and mathematics fields, with special emphasis on those groups underrepresented in these fields (i.e., African Americans, Hispanics, American Indians, Alaskan Natives, Native Hawaiians, and other Pacific Islanders). Another aim of *AGEP* is to increase the number of underrepresented minorities who will enter the professoriate in STEM disciplines. Specific objectives of the *AGEP* program are (1) to develop and implement innovative models for recruiting, mentoring, and retaining minority students in STEM doctoral programs and (2) to develop effective strategies for identifying and supporting underrepresented

[27] See Footnote # 24.

minorities who want to pursue academic careers. *AGEP* began in FY 1998, when NSF invested $4.9 million in the program. In FY 2003, NSF increased its investment in *AGEP* to $11.5 million. Between FY 1998 and FY 2003, it made 30 awards for *AGEP* projects.

Yield: The COV reviewed the *AGEP* program in 2001, but the Committee's primary focus was on the grant-making process and project activities.[28] Outcome or impact evaluation data were not available. The next COV assessment is scheduled for FY 2005.

Graduate Research Fellowship (GRF)

The current *Graduate Research Fellowship* program includes fellowships for all demographic groups. Formerly, the *Minority Graduate Fellowship (MGF)* program provided stipend support to promising science and engineering minority graduate students. The *MGF* program originated in 1978 and continued until 1998. Because of legal challenges to the program's exclusivity, it was subsumed within the NSF's *Graduate Research Fellowship (GRF)* program. Under the *GRF*, fellowship recipients receive an annual stipend of $30,000 (plus a $10,500 cost of education allowance) for up to 3 years. A total of 5,019 awards were made to minority graduate students during 1994-2003. In FY 1994, NSF invested $7.5 million in minority graduate fellowships, but in FY 2003, the estimated investment level dropped to $6.6 million. Between 1994 and 2003, a total of 4,153 fellowships were awarded to women. In FY 1994, NSF invested $2.4 million in fellowships for women, which significantly increased to $5.3 million in FY 2003.

Yield: An independent evaluation study in 2002 investigated the impact of the *GRF* program and found that *GRF* is most valued by fellows and academic officials for its prestige and the choices it affords fellows. Using cohorts of *GRF* participants from 1979-1983 and 1984-1988, the study noted that a high percentage of *GRF* fellows completed their Ph.D.s, i.e., 68.5% from the 1979-1983 and 73% from the 1984-1988 cohorts.[29] Unfortunately, the study team was unable to compare these doctoral completion rates with that for S&E graduate students in general. According to NSF's Division of Science Resource Statistics, reliable and comparable long-term doctoral failure/completion rates for S&E graduate students in general are not yet available.

The gap between female and male *GRF* fellows earning doctorates narrowed considerably over the last two decades (i.e., 1984 to 2003). The Ph.D. completion rate for underrepresented minorities in the study's 1979-1983 cohort of *Graduate Research Fellows* was 50%, as compared with 68.5% for the whole cohort. In 1984-1988, the completion rate for minority fellows increased to 61%. However, a significant gap between minority and non-minority fellows attaining a doctorate in science and engineering remained: 61% for minorities versus 74% for non-minorities in the 1984-1988 cohort study.

Based on the overall findings of the 2003 COV assessment of the *GRF*, the stipends and education allowances continue to enable students to pursue their graduate studies. With regard to minorities,

[28] Ibid.

[29] *National Science Foundation Graduate Research Fellowship Program. Final Evaluation Report.* San Francisco, CA: WestEd, September 2002.

the program's outreach efforts have significantly increased the number of minority applicants and awardees. This represented an improvement, reversing the decline of minority applicants, which occurred immediately after the *Minority Graduate Fellowship* was terminated. The COV, however, indicated that a further increase in the number of successful minority applicants was warranted.[30]

Minority Postdoctoral Research Fellowship (MPRF)

The *MPRF* program is sponsored by the Foundation's Biological Sciences and the Social, Behavioral, and Economic Sciences directorates. The *MPRF* was begun in 1990 with the aim to provide minority Ph.D.s with postdoctoral training of the highest quality to prepare them for leadership positions in science and engineering. Specifically, the program was designed to afford recent minority doctorate recipients with opportunities to obtain additional research experience with top-rated scientists and engineers and to help them gain multidisciplinary perspectives and research skills. Fellows receive a stipend of $50,000 per year for 2-3 years. The award also includes institutional and research-related allowances. Between 1994 and 2003, the *MPRF* program awarded 156 fellowships. Most of the awards were from the Biological Sciences Directorate. NSF invested a total of $1.14 million in this program in FY 1994 and $2.70 million in FY 2003.

Yield: A 2004 study of the outcomes and impact of the *MPRF*, covering the period from 1990 to 2002, found that 75% (or 98 of 131) of the former fellows surveyed were employed at institutions of higher learning, mainly doctorate-level research universities. A large majority (80%) said the *MPRF* program enabled them to develop professional experience they would not have otherwise developed, helped them to enhance their research skills, and to focus their research interests. Ninety (or 54%) of the awardees from the 1990-2002 cohort applied for research grants as principal investigators, and 81% of the 90 have received one or more grants from the National Institutes of Health. Of 45 former BIO fellows who submitted research proposals to NSF, 82% were funded.[31]

Programs Focused on Persons with Disabilities

Facilitation Awards for Scientists and Engineers with Disabilities (FASED)

The *FASED* program was designed to encourage individuals with disabilities to participate in STEM education, by providing funds for equipment or assistance required to perform research on a NSF-funded project. *FASED* was established in 1994 and ended in 2002. During this period, 67 awards were made to persons with a disability. In FY 1994, NSF invested $0.8 million in *FASED* and $0.2 million in FY 2002.

[30] Committee of Visitors (COV) *Report for the National Science Foundation (NSF) Graduate Research Fellowship Program (GRF)*, June 17-18, 2003.

[31] *Summary of Final Report of Outcomes and Impacts of NSF's Program of Minority Postdoctoral Research Fellowships (MPRF)*. Menlo Park, CA: SRI International, March 2004.

Yield: Impact evaluation data for the *FASED* program were not available from NSF.

Program for Persons with Disabilities in STEM Education (PPD)

The *PPD* was created in 1991 with the intent of increasing the number of individuals with disabilities in STEM education and employment. To achieve this aim, the *PPD* funds efforts that increase awareness and recognition of the needs and talents of persons with a disability; promotes accessibility to instructional materials and educational technology; and increases the availability of student enrichment resources including mentoring. *PPD* grants are targeted to primary school through graduate institutions for up to $700,000 per year. Between 1994 and 2003, a total of 121 *PPD* awards were made by NSF to support demonstration, information dissemination, and research and development projects, ranging from 1 to 3 years in duration. In FY 1994, NSF invested in awards totaling $3.9 million and by FY 2003, its investment has increased to $5.0 million for *PPD* projects.

NSF-funded Educational Opportunities for Blind Students

Yield: A COV evaluation study found that the *PPD* program has been successful in developing new knowledge and techniques to assist in the learning process for disabled students enrolled in science and engineering courses. No specific impact data were included in the study.[32]

Research in Disabilities Education (RDE)

The *Research in Disabilities Education* program was established in 1994 and functioned as a companion program to *PPD*. In FY 2003, *RDE* subsumed the *PPD*. *RDE* supports grant projects focused on increasing the participation and advancement of persons with disabilities in STEM. The types of projects funded under this program include demonstration initiatives, information dissemination, and research planning for subsequent funding under the *RDE* research track. *RDE* also supports efforts that collaborate with regional alliances that promote and advocate for disabled persons in science and engineering. Between 1994 and 2003, 97 awards were made under the *RDE* program. Funds invested by NSF in the *RDE* program are included in the funds expended under the *PPD* above for FY 1994 and FY 2003.

Yield: Impact evaluation data for the *RDE* program were not available from NSF.

[32] *Report of the Committee of Visitors (COV) to the National Science Foundation Program for Gender Equity in STEM and Program for Persons with Disabilities.* May 3-4, 2000; and Committee of Visitors *Report to the National Science Foundation Program for Persons with Disabilities,* March 26-27, 2003.

Special-Focus Programs

Graduate Research Traineeship (GRT)/Integrative Graduate Education and Research Traineeship (IGERT)

The *GRT* program began in 1994 and was designed to support the research and education of talented students pursuing a Ph.D. in science and engineering. The specific objectives were to (1) stimulate the development of graduate training environments that address scientific and technological areas of national importance and (2) promote and sustain student diversity. Unlike the Graduate Fellowships program for which individuals apply, *GRT* considered only proposals from institutions that offer Doctoral Degrees. In 1997, the *GRT* program was replaced by *IGERT*, which placed an emphasis on students receiving a multidisciplinary research-based graduate education to meet the demands of the 21st century STEM workforce. The *IGERT* program also targets institutions and serves as a catalyst for students, faculty, and institutions to create innovative models of graduate education and training. Another major goal of *IGERT* is to facilitate diversity among the program participants through a National Recruitment Program that seeks women and underrepresented minority-group candidates. Between FY 1998 and FY 2003, a total of 128 *GRT/IGERT* awards were made to academic institutions. NSF invested $20.15 million in this program in FY 1998 and $57.5 million in FY 2003.

NSF-Supported Marine Biology Graduate Research Student

Yield: In 1998, NSF's Division of Research, Evaluation, and Communication conducted an outcome study of the *GRT* program using cohorts of *GRT* doctoral students from projects funded in 1992, 1993, 1994, and 1995.[33] The study found that women made up about 38% of the students in the program, minorities 11%, and disabled persons 1%. Twenty-one percent of the *GRT* trainees completed their Ph.D.s in 4 years or less by 1998, compared to the 12% completion rate for 1997. Completion rates for males and females were about the same, but the Ph.D. completion rate for minorities was lower than that for non-minorities (4% versus 13% respectively). The cumulative doctoral program attrition rate for minorities was much higher, i.e., 42%. The major reason reported by minority students for dropping out of their doctoral program was the need to seek employment.[34] Evaluation findings on the impacts of the *IGERT* program were not available.

[33] *Preparing for the 21st Century Workforce for Science, Engineering, and Mathematics: Descriptive Outcomes of the Graduate Research Traineeship (GRT) Program.* NSF, August 2000.

[34] It must be noted that the GRT data are based on a non-random sample of individual graduate students from schools that applied for and received GRT grants. It is difficult to assess the reliability and validity of estimates derived from non-random samples. The reader is, therefore, cautioned not to make direct comparisons between the doctoral completion and retention rates of GRT participants and that for graduate schools in general.

Urban Systemic Initiatives (USI)

The *USI* program was established in 1993 to address the systemic problems within urban school districts that contribute to the poor performance of urban K-12 students in science and mathematics. Through cooperative agreements with school district superintendents, NSF provides funds to a school district that has an established infrastructure for school reform and has begun systemwide change efforts. The specific goals of the *USI* program are to enable urban schools to continue experimenting with innovations; to accelerate the rate of change; and to produce improvements in student achievement in science and mathematics. Between 1995 and 2003, NSF awarded grants for 50 *USI* projects. The Foundation invested $39.34 million in FY 1995 in this program and $27.73 million in FY 2003.

Elementary Students Learning about Scientific Research

Yield: According to two evaluation studies (COV, 1999 and Systemic Research, Inc., 2001), the *USI* program strongly encourages and supports underrepresented populations to participate in standards-based science, mathematics, and technology education. The funded projects across the nation have resulted in the development and implementation of policy changes that significantly affect science and mathematics education. Sustained professional development of teachers has improved significantly. Data from various program sites provide evidence that underrepresented student enrollment and achievement in science and mathematics courses from K-12 have steadily increased as a result of *USI* interventions.[35] Another investigation that has tracked the activities and outcomes of the *USI* sites found that the number of schools in which student achievement (based on test scores) improved in mathematics increased by 91.5% over a period of three years or more, and in science, by 83.4%.[36]

Rural Systemic Initiatives (RSI)

Similar to the *Urban Systemic Initiative*, the *RSI* program seeks to promote systemic improvements in science, mathematics, and technology teaching and learning in K-12 grades in low socioeconomic rural areas. The *RSI's* aim is to ensure sustainability of improvements in science and mathematics education by encouraging community development activities along with institutional, policy, and resource allocation reforms. As such, NSF funds consortia under the *RSI* program for development and implementation of reform initiatives. Tribal Colleges and Universities are also eligible for funding under the *RSI* program. Between FY 1994 and 2003, NSF awarded 30 *RSI* grants. Between FY 1994 and FY 2003, NSF invested approximately $125.0 million in the *RSI* program.

[35] *Committee of Visitors (COV) Assessment of the National Science Foundation's Urban Systemic Initiative Program.* June 21-22, 1999; and *Academic Excellence for All Urban Students: Their Accomplishments in Science and Mathematics.* MA: Systemic Research, Inc., April 2001.

[36] *Systemic Initiatives Core Data Elements. Findings 2001-2002 School Year Collection Summary Report.* Macro International and Westat, July 2003, Table 1-7.

Yield: A COV evaluation was scheduled for 2004. Some impact data obtained from the *RSI* tracking study showed that within the participating rural school sites, the number of schools evidencing improved student achievement (based on test scores) in mathematics increased by 80.9% over a period of 3 years or more. The number of schools showing improvement in student achievement in science also increased by 92%.[37]

Presidential Awards for Excellence in Science, Mathematics, and Engineering Mentoring (PAESMEM)

The *PAESMEM* program was established by the White House in FY 1997 to recognize the importance of role models and mentors in the academic, professional, and personal lives of individuals from underrepresented groups in the science, mathematics, and engineering fields. The program identifies outstanding individuals and institutions that have contributed significantly to the development of underrepresented scientists, mathematicians, and engineers. Nominees must be individual mentors with 5 years or more of experience or institutions with 5 or more years of experience in providing mentoring services to students (pre-college, college, and graduate students). Between 1997 and 2003, 116 *PAESMEM* awards were made by NSF. In FY 1997, NSF invested $0.34 million in this program and $0.57 million in FY 2003.

Yield: Outcome evaluation information for *PAESMEM* was not available. However, a major workshop was held on mentoring in June 2004 that was jointly sponsored by NSF and the Stanford University School of Engineering. The workshop participants identified several best practices for mentoring.[38]

EPSCoR Professor and Undergraduates in Biology

Experimental Program to Stimulate Competitive Research (EPSCoR)

EPSCoR is a partnership program between the NSF and several U.S. states and territories to support the development of the science and technology resources of states through collaborative ventures between academia, industry, federal research and development enterprises, and the government. The aim of the program is to assist states to improve their research capacity by helping researchers and institutions obtain federal R&D grants. *EPSCoR* came into being in 1979. Since then, the goal of the program has broadened to include a focus on providing educational opportunities for underrepresented students and faculty in science and engineering. Currently, 23 states and Puerto Rico are eligible to participate in *EPSCoR*. In FY 1994, NSF invested $31.05 million in the program and almost tripled this to $89.21 million in FY 2003. (This does not include *EPSCoR* co-funding from the research and related activities account).

[37] Ibid.

[38] Eve Riskin, et al. (Eds.) *Mentoring for Academic Careers in Engineering: Proceedings of the PAESMEM/Stanford University School of Engineering Workshop.* October 4, 2004.

Yield: An internal impact study of *EPSCoR,* which focused on the human resource development aspects of the program, found that funds have been used to provide direct financial aid at all levels of postsecondary education. Students have been exposed to a wide range of experiences, including research and mentoring activities. The study pointed out, however, that while Asians have been well represented among graduate students benefiting from the program, underrepresented minorities in STEM, such as African Americans and Hispanics, have constituted less than 7% of the *EPSCoR*-supported students in graduate school, about the same as their representation in science and engineering nationwide.[39]

CONCLUSIONS

Since Congress enacted the Science and Engineering Opportunity Act in 1980, the National Science Foundation (NSF) has taken a lead role in national efforts to increase the size, talents, and diversity of America's science and engineering workforce. NSF has developed and implemented many internal policies and programs designed to increase participation of women, minorities, and persons with disabilities in the fields of science, technology, engineering, and mathematics (STEM). The results overall have been encouraging. NSF produced policies and procedures that have helped to facilitate improved levels of participation of underrepresented groups in STEM and invested substantial funds in education and career development programs that have yielded some concrete gains.

NSF Policies to Increase Participation in STEM

Education Policies

Given the important role of advanced education in the development of scientists and engineers, NSF has placed a greater emphasis within the last ten years on providing opportunities for underrepresented groups to access quality and advanced levels of education and training. Two major education policies were instituted by the National Science Board, the governing body of NSF, during 1996 and 1999. These policies supported funding for (1) undergraduate, graduate, and postdoctoral educational grant opportunities, and (2) research in STEM learning by underrepresented groups.

These education policies have successfully provided direction for the Foundation's funding priorities in regard to improving participation. Evaluation studies found that NSF's funds helped to improve instructional and research capacity of minority-serving institutions. Women-focused research and development efforts were successfully initiated to close the gender gap in student achievement in science and mathematics. Moreover, the evaluation studies found that some research and development projects proved beneficial for better understanding of the learning process for disabled students enrolled in science and mathematics courses.

[39] A Report on the National Science Foundation's Efforts to Assess the Effectiveness of Its Education Programs. Directorate for Education and Human Resources, Division of Research, Evaluation and Communication. August 1996, pp. 37-40.

Program-Investment Policies

The National Science Board issued a policy that strengthened its commitment to increase access to STEM education and career opportunities for underrepresented groups (i.e., enhanced federal funding to achieve increased participation through diversity, 1999). The Board recommended that the Federal government invest substantial funds into growing the nation's future STEM workforce in order for America to stay on the cutting edge of discovery in a globally competitive environment. Taking the lead, the first policy issued by the Board was a directive to NSF to increase funding for projects targeted to underrepresented American groups. The NSF Director also issued a related policy, referred to as "embedded diversity," which directed NSF to ensure that all NSF funding initiatives are open to all demographic groups.

Pursuant to these directives, funding increased substantially during the 10-year period being reported. In 1994, 4.4% (or $130.43 million) of NSF's total budget of $2,987.22 million was allocated for research and education programs for underrepresented groups. This percentage increased to 4.6% (or $244.60 million) of NSF's total budget of $5,369.34 million in 2003. Overall, the amount of NSF funding for programs to support participation increased by 87.5% between 1994 and 2003, while NSF's total budget increased by 79.7% during this same period.[40]

Prior to the "embedded-diversity" policy, NSF programs to broaden participation were separated from the mainstream of NSF grant programs. Since this new policy has been implemented, targeted programs have become more integrated into the general programs of NSF.

Merit-Review Policies

In reviewing its grant decision-making policies and in response to a CEOSE recommendation, the National Science Board instituted major changes in 1997 and 1999 in NSF's merit-review process. Grant applicants and reviewers were required by the new policies to address both the intellectual merit of their proposed projects and the broader impacts of their projects, which might include how the projects would enhance participation of underrepresented groups in STEM.

Initially, the broader-impacts criterion was ignored by many grant applicants and reviewers. As a consequence, the Board issued a further policy in 2002, stating that if both merit-review criteria were not addressed in the proposal summary, the proposal would be returned without further consideration. The effect of this enforcement policy was a dramatic increase in applicant compliance. By 2002, less than 1% of the proposals was returned because of failure to address the broader-impacts criterion. Over 90% of the reviewer evaluations in 2003 addressed the broader-impacts criterion, as compared to 84% in 2002 and 69% in 2001.

In 2000, NSF also issued a policy regarding the need to have diversity among proposal reviewers, in order to broaden the perspectives of the reviewers in assessing the merits of proposals submitted by members of underrepresented groups. Having information about gender, race/ethnicity, and disability status of the reviewers became a requisite for effective monitoring of the reviewer pool and proposal assignments. Obtaining this information, however, has been a major challenge. Since providing the information is not a legal requirement, NSF must rely upon the reviewers to volunteer the

[40] Budget figures in as-spent dollars, not adjusted for inflation.

information. While NSF has continued to request this information, the reviewer response rate has been less than 10% out of approximately 38,000 reviewers used annually. Of those who volunteer their demographics, about one-third report they are members of an underrepresented group. NSF is currently working on improving this response rate. FastLane screens on which reviewers enter the reviews now prompt the reviewers to report their ethnicity. This is expected to improve the response rate.

Internal Workforce-Diversity and Development Policies

In keeping with NSF's strategic goal to increase diversity among its staff, the Director of NSF issued a directive in 1999 requiring all directorates to prepare and abide by recruitment plans that seek to ensure representation of women, minorities and persons with disabilities among directorate staff, advisors, and reviewers. All of the directorates have complied with the directive. Their plans are submitted to the Director for review on a periodic basis.

NSF reaffirmed its commitment to diversity among its staff. As a result, significant progress has been made in the employment of women scientists and engineers within NSF. Women accounted for 60% of all NSF staff and 40% of its scientists and engineers by 2003. While NSF has made some progress in employing members of underrepresented minority groups and persons with disabilities, their representation among NSF's scientists and engineers has remained relatively low. African Americans, for example, made up almost one-third of all Foundation staff in 2003, but only 6% of the scientists and engineers. The numbers of American Indian and Hispanic scientists and engineers employed at NSF were also low. A reliable count of staff persons with disabilities was hard to obtain, given the issues of self-reporting of disabilities and confidentiality constraints. Overall, NSF's STEM demographics are higher in diversity than national STEM demographics, as reported in the next chapter on trends in NSF activities to increase diversity.

NSF Grant Programs to Increase Participation in STEM

During 1994-2003, NSF invested funds in several major programs that provided educational, training and career advancement opportunities for underrepresented groups in STEM.

Women

Four foundation-wide and multifaceted programs targeting women were funded between 1994 and 2003. These programs were funded to provide increased opportunities for career advancement in science and engineering, to enhance the ability of women faculty to conduct research at the highest-ranked research institutions, and to conduct research on the learning process of females enrolled in science and mathematics curricula. During the ten-year period, NSF increased its investment in these programs by 125.4%, from $17.10 million in FY 1994 to $38.54 million in FY 2003. Funding for women-targeted programs grew at a slightly higher rate than NSF's budget, which increased by 79.7% between FY 1994 and FY 2003.

Some impact evaluations of these women-focused programs were conducted between 1994 and 2003. Studies found that the NSF-funded research and development initiatives have successfully identified educational practices to close the gender gap in student achievement in science and mathematics. Additionally, evaluation studies found that NSF funding greatly facilitated the career advancement of women scientists in academia by providing them opportunities to work with distinguished scientists and enhancing resources to conduct research at top-rated institutions.

Minorities

Between 1994 and 2003, NSF invested in eight foundation-wide education and training programs targeted to minority individuals and minority-serving institutions. During this period, NSF increased its investments in these programs by 51.9%, from $73.17 million in FY 1994 to $111.11 million in FY 2003. Most of the minority-targeted grants funded institutions to enhance instruction and mentoring of students from high school to graduate school, and to assist those minority students with a doctorate to enter the professoriate. The other grant programs focused on individuals and were funded to provide graduate and postdoctoral fellowships, as a means for increasing the number of highly qualified Ph.D.s in science and engineering.

Several evaluation studies of the minority-focused programs were conducted. In general, the institutional programs proved to be effective in recruiting and retaining minority students in STEM education tracks. One of the studies found, for example, that as a result of NSF funding, 51% of the students involved in the NSF-funded program graduated from college with a 3.2 or higher GPA; two-thirds subsequently pursued at least a Master's Degree in science or engineering; 62% reported being employed full-time in an institutional setting; and the NSF-funded research center projects resulted in the production of valuable research and publications. Although the number of minority Ph.D.s has increased from the NSF fellowship programs, there still remained proportionately fewer minorities than non-minorities with a doctorate in a STEM field.

Persons with Disabilities

Between 1994 and 2003, NSF funded two comprehensive and foundation-wide programs targeted to persons with disabilities seeking a career in STEM. These programs were designed to support grant projects that increase awareness of the needs and talents of persons with disabilities, that demonstrate innovative practices in educating disabled students in science and engineering, and that support planning for research projects. The amount of NSF's investment in these programs increased by 26%, from $3.9 million in FY 1994 to $4.9 million in FY 2003. This rate of funding growth for programs for disabled persons was less than the overall 79.7% increase in NSF's total budget during this same time period. These programs have been evaluated and found to be successful thus far in adding to the knowledge-base and techniques for enhancing the learning process for disabled students.

Special-Focus Programs

NSF also invested in some special-focus grant programs with broad systemic and geographic objectives that included an emphasis on increasing the number of underrepresented groups in STEM. These programs included (1) graduate traineeships that integrate education and research, (2) urban and rural school district initiatives to supplement educational reform efforts in the teaching and learning of science and mathematics, (3) state-level infrastructure-building projects to assist local researchers to acquire NSF funding for STEM research and development, and (4) an awards recognition program for mentors of underrepresented students in STEM. NSF invested a total of $71.65 million in FY 1994 in these special-focus program initiatives, which increased by 178% to $187.89 million in FY 2003.

An independent evaluation study of the graduate traineeship program's impact has yet to be done. Evaluation studies of the urban and rural systemic initiatives have shown increased student achievement levels in science and mathematics in primary and secondary grade public schools, as a result of these initiatives. Grant projects under the state-level program have devoted funds effectively to improving secondary education. An impact evaluation has yet to be conducted on the mentor awards program.

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

Key Results

- Between 1994 and 2003, grant applications submitted to NSF increased by 73% for women, 69% for minorities, and 51% for persons with disabilities, while the total grant applications increased by 33%.
- Average grant award rates for these underrepresented applicants were comparable to NSF's overall award rate of 31.2%.
- Over the ten-year period (1994-2003), NSF's financial support for programs focused on women and minorities grew far more than support for programs targeting persons with disabilities.
- NSF employs a greater percentage of scientists and engineers from underrepresented groups than the overall STEM workforce of the nation. However, minorities continue to represent a low percentage of scientists and engineers compared to non-minorities, who make up more than three-fourths of the STEM workforce within NSF and nationally.
- Need for good, disaggregated data on demographics and on reasons for funding differentials among underrepresented populations remains critical.

Chapter 1 of this volume provides a review of the policies and programs of the National Science Foundation to broaden participation of women, underrepresented minorities, and persons with disabilities within America's science and engineering enterprise. This second chapter presents the results of a quantitative analysis of the Foundation's major actions to increase diversity and participation within the STEM pipeline and workforce.

Study Approach

The specific aim of the present study was to identify and analyze trends pertaining to participation policies and actions undertaken by NSF over the last 10 years (1994 to 2003). Three major areas were identified: (1) NSF grant-giving and the merit-review system used by the Foundation, (2) NSF support of programs and initiatives that help to increase access to education and employment opportunities for Americans who are underrepresented in STEM, and (3) change in diversity among NSF's science and engineering staff, as compared to change in diversity within the nation's total STEM workforce.

Data related to grant-giving (i.e., proposals submitted to NSF, grant awards made by directorates, and total awards) were obtained from the Foundation's Budget Operations and Systems Branch. Data pertaining to the merit-review process were obtained from the National Science Board Merit Review Process reports. Data regarding NSF's investments in programs targeting underrepresented groups were collected from NSF's Budget Operations and Systems Branch. Finally, demographic data on NSF's personnel were collected from NSF's Office of Equal Opportunity Programs. The reliability and completeness of these data were cross-checked. The obtained data were compared with the same data reported in other sources, such as Congressional budget requests and other documents.

Data Limitations

The study team interviewed NSF staff about possible limitations inherent in the data. Data limitations or other qualifications that were discerned from the interviews are noted in the trend analysis accordingly.

The trend analysis of underrepresented minority-grant applicants and awardees was limited by the unavailability of data disaggregated by race and ethnicity. The unavailability of data disaggregated by minority-group and gender also limited the analysis. Disaggregated data by gender and minority-group were also not available for analyzing the composition of NSF's STEM workforce.

Based on the trend analysis, the report concludes with a summary of NSF's performance in achieving its goal to increase participation of women, underrepresented minorities, and persons with disabilities in the nation's science and engineering enterprise.

Trends

Grant-Making

Each year the National Science Foundation provides a few billion dollars in grant funds to individuals and institutions for research and educational initiatives in STEM. The Foundation is, therefore, in a unique position to have a significant impact on opportunities available to groups of people who are relatively underrepresented in the nation's scientific and engineering enterprise. Recognizing this, NSF has increased its outreach activities over recent years, for example, by ensuring (1) that minority institutions, professional women's organizations, and advocacy groups for the disabled receive grant announcements, (2) that NSF staff visit minority institutions to inform students and faculty about NSF's education and research programs, and (3) that workshops are convened for members of underrepresented groups on career opportunities in science and engineering. In assessing the NSF's achievements in promoting greater access to its grant opportunities, the following questions were posed:

- Has there been an increase over the last ten years in the number of grant applications received by NSF from women, minorities and persons with disabilities?
- Has there been an increase in the grant award rates for these groups?

NSF received a total of 30,122 proposals in fiscal year 1994 and 40,075 in fiscal year 2003, which represented a 33% increase over the ten-year period. About one-third of the proposals were funded each year. The annualized median award amount was approximately $110,960 with an average grant period of 2.9 years.[1]

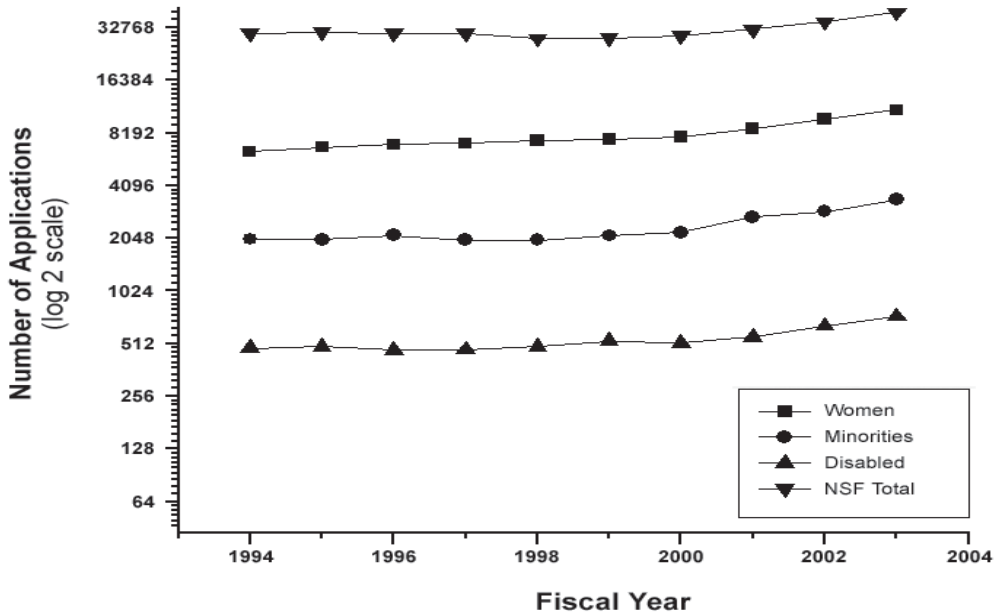
As the total number of applications received by NSF increased over the ten-year period, the number of applications from all of the underrepresented groups also increased. Applications received from women increased by 73%. Applications submitted by minority women increased by 54%. Minority women applicants accounted for 5% of all women applicants during the ten-year period. Applications submitted by all underrepresented minorities increased by 69%, and those submitted by disabled persons increased by 51%. The overall percentage of proposals submitted by minorities and disabled persons accounted for 5% or less of all proposals submitted for funding consideration.

As reflected by the trend lines in *Figure 2-1*, application submissions by all three underrepresented groups increased gradually between 1994 and 1999, but rose more rapidly as of FY 2000. For instance, the number of proposals from women increased 17.2% between 1994 and 1999, but between 2000 and 2003, it jumped by 42.5%. The percentage increase in proposal submissions for minorities went from 4.9% between 1994 and 1999 to 53.8% between 2000 and 2003. Similarly, the percentage increase in proposals from persons with disabilities changed from 9.5% between 1994 and 1999 to 41.9% between 2000 and 2003.

[1] *FY 2002 Report on the NSF Merit Review System and NSF Management and Performance Highlights.*

Figure 2-1

Grant Applications Submitted to NSF, by Underrepresented STEM Group, 1994-2003



This notable change in proposal submissions beginning in FY 2000 by members of all three underrepresented groups occurred at the same time and may have been the result of a confluence of three major factors. The first was NSF's embedded-diversity policy of 1999, which was a shift from programs specifically targeted to women, minorities, and persons with disabilities to embedding diversity in all of NSF's research and education grant programs. The second was a policy change in 2000 that enhanced enforcement of the reformulated merit-review procedure, which required that all proposals address both the intellectual and societal impact merits of the proposed activity. As of 2002, proposals that did not comply were returned without further consideration.[2] The third factor was that during the period 1994-2003, NSF initiated various outreach activities to increase the awareness of underrepresented persons about the Foundation's education and research grant opportunities. An example of these efforts included sending out "Dear Colleague letters" to inform academic institutions about the Foundation's diversity policies and programs, NSF visits to minority- and women-serving institutions, expanded use of the NSF web site to alert prospective applicants about the Foundation's general as well as targeted grant programs, workshops for underrepresented students and faculty, and special-topic conferences.

While the embedded-diversity and merit-review enforcement policies and enhanced outreach activities appear to have impacted the rising trend in proposals from women, minorities, and persons with disabilities, it is difficult to say without further research whether the increases in proposals were a direct result of these policy and outreach initiatives.

[2] See Chapter 1 for a review of the embedded-diversity policy and for the merit-review enforcement policy.

Proposal Submission Trends by Directorate

Table 2-1 provides a comparison of the numbers and percentages of proposals submitted to each of the Foundation's directorates and OPP in FY 2003, compared to FY 1996.[3] The results show that there were relative increases in the percentages of proposals submitted by women, minorities, and persons with disabilities to the directorates. There were two exceptions: minorities submitted the same number of proposals to OPP in 2003 as in 1996; and persons with disabilities submitted slightly fewer proposals to OPP and GEO in 2003 than in 1996.

Table 2-1
Proposal Applications Submitted to NSF Directorates and OPP, by Underrepresented Group for FY 1996 versus FY 2003

NSF	Total Proposals		Women		Minorities*		Disabled	
Directorate	1996	2003	1996	2003	1996	2003	1996	2003
OPP	478	526	**23.6%** (113)	**29.8%** (157)	**3.7%** (18)	**3.4%** (18)	**1.9%** (9)	**1.3%** (7)
MPS	4953	6436	**13.5%** (669)	**18.3%** (1179)	**5.7%** (286)	**7.5%** (482)	**1.1%** (55)	**1.5%** (101)
SBE	3436	3976	**28.8%** (991)	**42.3%** (1682)	**7.6%** (262)	**10.1%** (401)	**1.8%** (61)	**1.8%** (71)
CISE	1929	5433	**19.3%** (373	**23.8%** (1298)	**6.1%** (118)	**6.7%** (367)	**1.3%** (25)	**2.0%** (110)
GEO	3723	4061	**19.9%** (741)	**25.4%** (1033)	**6.4%** (239)	**6.5%** (263)	**2.4%** (88)	**1.6%** (67)
ENG	5953	8754	**11.9%** (712)	**18.5%** (1619)	**6.6%** (396)	**8.3%** (731)	**1.4%** (82)	**1.5%** (135)
BIO	5673	5394	**30.5%** (1732)	**35.6%** (1921)	**5.8%** (331)	**7.8%** (420)	**1.3%** (77)	**1.7%** (94)
EHR	3732	4073	**45.7%** (1707)	**53.5%** (2179)	**12.8%** (478)	**17.7%** (723)	**1.9%** (72)	**3.6%** (146)
Total	29877	38653	**23.5%** (7038)	**28.6%** (11068)	**7.1%** (2128)	**8.8%** (3405)	**1.5%** (469)	**1.9%** (731)

EHR = Education and Human Resources
BIO = Biological Sciences
ENG = Engineering
OPP = Office of Polar Programs
MPS = Mathematical and Physical Sciences
GEO = Geosciences
CISE = Computer and Information Science and Engineering
SBE = Social, Behavioral and Economic Sciences

*Underrepresented Minorities

[3] FY 1996 was used as the base year for comparison to FY 2003, because NSF's merit-review criteria were modified in 1995 and explicitly included NSF's focus on diversity in the grant review process. As such, proposal data dated prior to 1996 would have reflected a different policy setting.

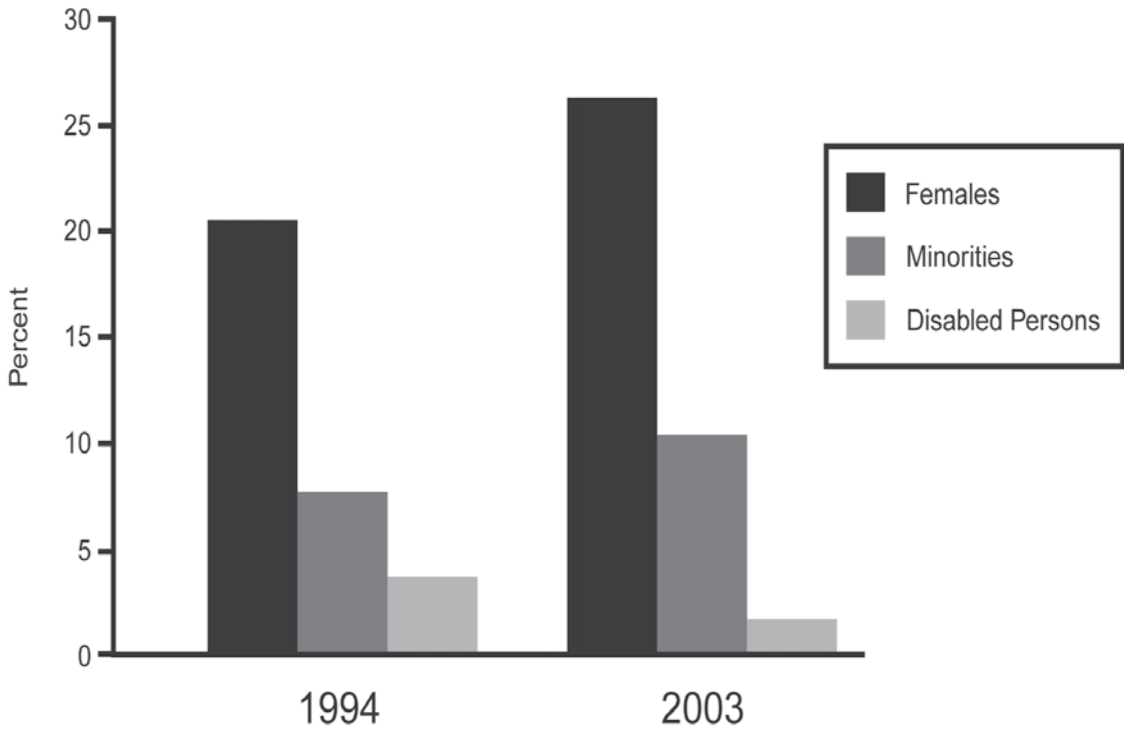
Reviewer Diversity and Compliance with Merit-Review Criteria

Chapter 1 reported that applicant compliance with NSF's new merit-review criteria policy increased to a near-perfect level by 2003. Diversity among the proposal reviewers also increased during this same ten-year period. Before presenting the findings on reviewers, the reader is cautioned that there are some limitations in the quality of the reviewer data. First, the gender and racial identity of the reviewers are underreported. Second, the data reported by reviewers on disabilities may be an underestimate because of confidentiality issues. Also, limited vision, hearing or other physical functions may not be considered by an individual to be a "disability," and would not be reported as such. These caveats on the reviewer data render the results tentative at best.

Albeit limited, the findings in Figure 2-2 reflect a change towards increased representation of women and minorities among NSF's proposal reviewers. Specifically, the data show an increase between 1994 and 2003 in the percentage of reviewers who are women or members of underrepresented minority groups. There was, however, a decrease in the percentage of reviewers reporting disabilities between 1994 and 2003. NSF has continued to request gender, race and disability information from the reviewers, in order to improve monitoring of diversity within the review panels.

Figure 2-2

Percentage of Underrepresented Persons among NSF Proposal Reviewers 1994 versus 2003. An Estimated Profile



Data source: NSF Office of Budget, Finance and Awards Management. Based on 5% and 14% of all the reviewers who reported their profiles in 1994 and 2003, respectively.

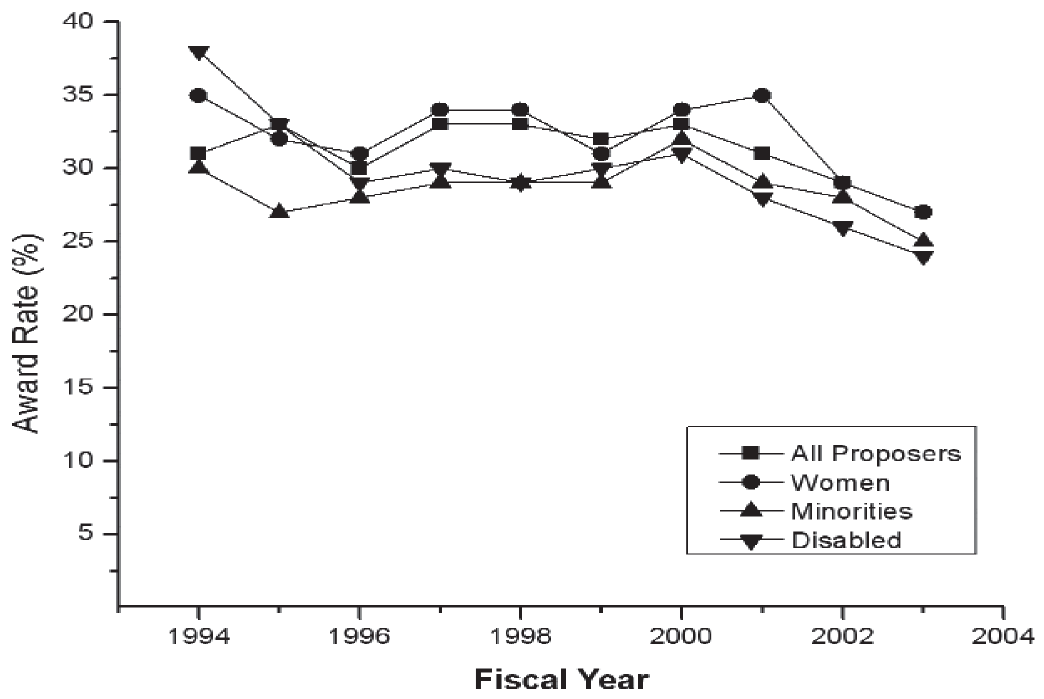
Proposal Award Rates

The annualized mean award rates during 1994-2003 were 32.2% for all women (31.9% for minority women), 28.6% for all underrepresented minorities, 29.6% for persons with disabilities, and 31.2% for all NSF proposals. In comparing individually the mean award rates for women, all minorities and persons with disabilities with NSF's overall annual mean award rates, the only statistically significant difference (5% level) was found between mean award rates for all non-Asian minorities and the overall annual rates. The mean for all minorities was lower (28.6% versus 31.2%). No significant differences were found between the mean awards rates for women or persons with disabilities and the overall annual mean rates.[4]

The proposal award rates for the underrepresented groups varied across the ten-year period of 1994 to 2003, as displayed in Figure 2-3. There were no consistent trends in the award rates for the groups, nor for proposers overall. The one notable observation was that the award rates for women were higher than those for minorities and disabled persons, as well as higher than the rates for all proposers. Rates for all groups began to show a decline between 2001 and 2002, as the number of submitted proposals rose faster than the budget.

Figure 2-3

NSF Proposal Award Rates for All Proposers and Underrepresented STEM Groups 1994 to 2003



[4] t-test results for women (t = 1.792, df = 9, n.s.); minorities (t = 4.993, df = 9, p =.05); and persons with disabilities (t= 1.390, df = 9, n.s.).

Directorate Award Rates

In general, the proposal award rates for the three underrepresented groups varied within each of the directorates and OPP (see Table 2-2). There were, however, no statistically significant differences found between the award rates for women, minorities, and persons with disabilities, and the total award rates for the directorates.[5] For example, the difference between the award rates for all three underrepresented groups in OPP did not significantly differ from the award rate for all proposals considered by the OPP. This finding was true for all the directorates.

Table 2-2
Mean Annualized Award Rates, by NSF Directorate and OPP, 1994 to 2003

NSF Directorate	Mean Award Rate for Women	Mean Award Rate for Minorities	Mean Award Rate for Persons with Disabilities	Mean Award Rate for All Proposers
OPP	41.4	32.3	37.9	39.2
MPS	36.6	33.3	34.7	36.0
SBE	32.0	32.4	33.6	34.9
CISE	33.7	27.3	28.2	29.8
GEO	33.5	27.2	32.9	36.2
ENG	27.9	24.5	21.7	24.4
BIO	28.1	28.6	29.9	27.2
EHR	33.7	30.0	31.5	31.2
Overall	32.2	28.6	29.6	31.2

Amount of Awards

On average, the amount of an award to women and minorities has tended to be lower than that for non-minority men. For instance, the average award amount in FY 2002 for females was $95,987, and for minorities, it was $88,763, compared to $108,825 for non-minority males.[6] Reasons for these differentials in funding were not clear from the available data, and require further investigation.

Support for Diversity and Participation Programs

The level of funding for diversity and participation programs is a critical indicator of the Foundation's commitment to increasing diversity in STEM. One of the major findings reported in Chapter 3 is that more program interventions are required to address the underrepresentation problem in science and

[5] Chi Square test results for the three groups were as follows: women (X^2 = 48.0, df = 49, p =.24); minorities (X^2 = 56.0, df = 49, p =.20); and disabled (X^2 = 58.0, df = 49, p =.24).

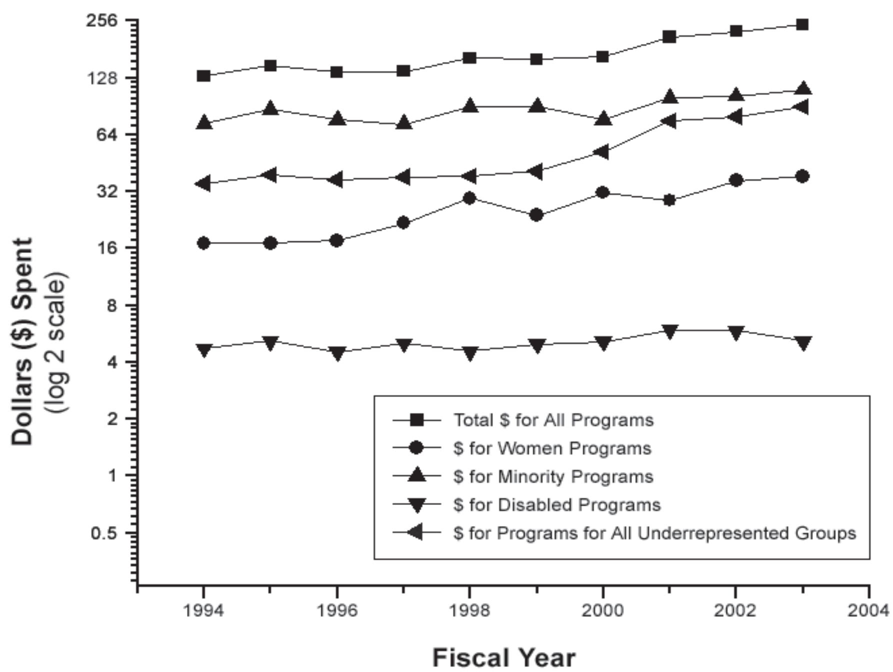
[6] Figures obtained from NSF Budget Operations and Systems Branch.

engineering. The question, therefore, posed by the present study was: How did the level of NSF investment in programs targeted towards increasing diversity in STEM vary over the last ten years?

Overall and as indicated in Chapter 1, the amount of NSF funds budgeted for targeted diversity and participation programs increased dramatically by 87.5% over the ten-year period from 1994 to 2003. In 1994, a total of $130.43 million was budgeted for these programs, and by 2003, the total grew to $244.60 million. The 2003 figure represented 21.9% of the total funds ($1.117 billion) spent on NSF investments in people.[7] Investment in people is one of the four strategic goal areas of NSF. The other investment areas are *ideas, tools, and organizational excellence*.

Funding for women- and minority-focused programs grew at a much higher rate than that for programs geared towards the needs of persons with disabilities. As Figure 2-4 shows, funding for disabled persons remained relatively flat and only increased by 9.8% over the 1994-2003 period, compared to an increase of 125.4% for women and 51.8% for minorities during this same period. Although the percent change in funding for women was greater than for the other two underrepresented groups, the dollar amount of funding for minority-focused programs was higher than for programs targeting women and persons with disabilities. For instance, in FY 2003, $111.11 million were allocated for minority-focused programs, compared to $38.54 million for women-focused programs, and $5.17 million for programs for persons with disabilities.[8]

Figure 2-4
NSF Investment in Targeted Diversity and Participation Programs, by Underrepresented Group (in Millions of Dollars), 1994 to 2003



[7] *National Science Foundation FY 2005 Summary of Budget to Congress,* page 13.

[8] Figures obtained from NSF Budget Operations and Systems Branch.

The changes in funding levels during this period reflected changes in program focus and strategies. For example, while women increased their numbers among holders of undergraduate and graduate degrees in science and engineering over the last two decades, limited opportunities for career advancement in academia and industry have persisted. In response, NSF shifted funding priorities to further enhance its efforts to increase participation of women at the professional and leadership levels of STEM. This was evidenced by the combined funding for the *ADVANCE* and *POWRE* programs that increased between 1997 and 2003 by 98.2% (i.e., from $8.67 million to $17.18 million).

For minorities, the shift in funding priorities has been from programs that focused on supporting minority individuals to those targeting minority institutions. Combined funding for the *LSAMP, Minority Institutions Infrastructure* and *Model Institutions for Excellence* programs, for example, increased 60.5% between 1994 and 2003 (i.e., from $28.19 million to $45.26 million).[9]

NSF Workforce

Diversity among the ranks of its employees is another indicator of NSF's commitment to increase the representation of women, minorities, and persons with disabilities within the STEM workforce. To facilitate the development of a diverse and competitive American workforce of scientists, engineers, and technologists is a major goal of the Foundation.[10] The study, therefore, posed the following question: To what extent has NSF succeeded in achieving diversity within its own STEM workforce?

In answering this question, three separate comparisons were made: (1) a comparison between the percentage of women, underrepresented minorities, and persons with disabilities in NSF's total workforce and those groups within NSF's STEM workforce, which consists of permanent and rotator scientists, technologists, engineers, and educators with at least a Master's Degree in science or engineering; (2) a comparison over time of the changes in the percentage of representation of women, underrepresented minorities, and disabled STEM staff within NSF; and (3) a comparison between the percentage of women, underrepresented minorities, and disabled STEM staff of NSF and those employed in STEM positions within the U.S. workforce who have at least a Master's Degree in science or engineering.

[9] Ibid.

[10] *National Science Foundation Strategic Plan: FY 2003-2008*, p. 14.

Total versus STEM Workforce of NSF[11]

Women, African Americans, and persons with disabilities have been particularly underrepresented in professional science and engineering positions at NSF, compared to their numbers in the Foundation's total workforce. For instance, in 1995, women made up 59.6% of all NSF staff, but 31.7% of the staff scientists and engineers. African Americans made up one-third of all NSF staff, but only 4.9% of the scientists and engineers employed by the Foundation (see Table 2-3). As noted in Chapter 1, women and African Americans had higher representation in program support and business operation positions.[12]

Table 2-3
Snapshot of Gender and Racial/Ethnic Composition of National Science Foundation Total versus STEM Workforce in 1995

Underrepresented Group	Percentage of NSF's Total Workforce	Percentage of NSF's STEM Workforce
Women	59.6	31.7
Native American	0.2	0.4
African American	33.2	4.9
Hispanic American	1.9	2.9
Asian American	3.5	4.9
White American	59.1	86.8
Persons with Disabilities	6.3	6.4

NSF Data for 1995 were obtained from NSF Office of Equal Opportunity Programs.

Directorate STEM Staff

The findings in Table 2-4 show that women were most represented among scientists and engineers within NSF's Biological Sciences, Social, Behavioral and Economic Sciences, and the Education and Human Resources Directorates. Women scientists and engineers were least represented in the Engineering directorate. Minority-group scientists were most represented in the Education and Human Resources Directorate and least represented in the Computer and Information Science and Engineering, and in the Geosciences Directorates. Scientists with disabilities were most represented in the Engineering directorate, barely represented in the Education and Human Resources Directorate, and not at all represented in the Computer and Information Sciences and Engineering Directorate.

[11] Employee data for 1994 were incomplete. The total number of NSF employees in 1995 was 1,300 and 1,331 in 2003. The number of staff scientists and engineers was 469 in 1995 and 468 in 2003.

[12] *Current NSF Profile.* NSF Office of Equal Opportunity Programs, January 2004.

Table 2-4
Percentage of Underrepresented Groups within NSF Directorate STEM Staff, FY 2002

Directorate	Total	Women	Minorities	Disabled
MPS	77	26.0	11.7	11.7
SBE	86	47.7	11.6	5.8
CISE	28	39.3	3.6	3.6
GEO	56	25.0	5.3	10.7
ENG	61	21.3	9.8	11.5
BIO	52	50.0	9.5	5.7
EHR	71	47.9	26.7	8.4

Data were obtained from NSF Office of Equal Opportunity Programs for FY 2002. Data not available for OPP.

Changes in Underrepresented Staff at NSF

Since 1995, the level of diversity among the ranks of NSF staff scientists and engineers has increased for women, African Americans, Hispanics, and persons with disabilities. The percentage of Native Americans has remained unchanged. In Table 2-5, the percentage of scientists and engineers employed at NSF from these target groups are compared for 1995 and 2003.

As can be seen, the percentage of women scientists and engineers grew from 31.7% to 39.5% between 1995 and 2003. African American and Hispanic staff scientists and engineers increased from 4.9% to 6.1% and from 2.9% to 3.5%, respectively. The percentage of disabled scientists and engineers at NSF grew from 6.4% to 9.1%.

Table 2-5

Changes in the Percentage of Gender and Racial/Ethnic Composition of NSF's Science and Engineering Workforce: 1995-2003 versus U.S. Science and Engineering Workforce: 2000

Underrepresented Group	NSF 1995	NSF 2003	U.S. 2000*
Women	31.7	39.5	25.4
Native American	0.4	0.4	0.3
African American	4.9	6.1	4.4
Hispanics	2.9	3.5	3.4
Asian American	4.9	6.5	14.0
White American	86.8	83.5	76.4
Persons with Disabilities	6.4	9.1	7.1

*Data obtained from *Women, Minorities, and Persons with Disabilities In Science and Engineering: 2004*. National Science Foundation, pages 176-177, Table H-1.These data are based on persons who are American-born and foreign-born, and were working within the U.S. science and engineering workforce in 2000.

Diversity of NSF's STEM Staff versus Total U.S. STEM Workforce

How did NSF's STEM workforce compare in the relative fractions of specific populations to the nation's overall STEM workforce? This is an important question, given NSF's leadership role in paving the way for increased participation and serving as an example for other institutions in the science and engineering community.

In comparing NSF's STEM staff in 1995 and 2003 with the country's total STEM workforce in 2000, Table 2-5 shows that a greater percentage of women scientists and engineers were employed at NSF than in the nation's overall STEM workforce. While the percentages of African Americans, Hispanics, Native Americans, and persons with disabilities were relatively low among NSF science and engineering staff, they were higher than the representation of these groups in the total U.S. workforce.

CONCLUSIONS

In assessing activities of the National Science Foundation during 1994-2003 to increase participation of underrepresented American talent within science and engineering, this study was driven by three major areas of concern: 1) NSF grant-giving to Americans who are underrepresented in STEM and the merit-review system used by the Foundation; (2) NSF support of programs and initiatives that help to increase access to education and employment opportunities for underrepresented groups; and (3) changes in diversity among NSF's science and engineering staff, as compared to the demographic diversity within the nation's total STEM workforce. The study analyzed several quantitative indicators related to these three areas of concern. Results of the analysis are summarized as follows:

In the area of grant-making, there was an increase in the number of grant applications submitted to NSF by women, underrepresented minorities, and persons with disabilities. This increase was greatest for women applicants during the ten-year period between 1994 and 2003. The percentage of proposals submitted by women rose by 73%, minorities by 69%, and by 51% for persons with disabilities. The mean annualized grant award rates for this same period was 32.2% for women, 28.6% for minorities and 29.6% for persons with disabilities. These award rates were comparable to the overall Foundation annualized award rate of 31.2%. The award rates varied from year to year and by directorate (or STEM area).

The reformulated merit-review policy that NSF introduced in 1997 was intended in part to encourage proposers to address broader-impact issues, including proposed activities to increase participation of underrepresented groups. However, as noted in Chapter 1, NSF has not put into place a mechanism for Foundation-wide monitoring and recording of the specific areas addressed by proposers under the broader-impacts criterion. It was, therefore, difficult to determine if the new policy has had an effect upon proposers in addressing the problem of underrepresentation of women, minorities, and persons with disabilities in STEM.

Over the ten-year period (1994-2003), NSF support for programs focused on women and minorities, however, grew far more than support for programs designed to assist persons with disabilities.

Diversity within the Foundation's STEM workforce was the third area investigated. The findings showed that NSF increased the percentage of women, African American, Hispanic, and disabled scientists and engineers among its staff between 1995 and 2003. The rate of growth for Native Americans remained flat at 0.4% during this same period. In comparison to the total U.S. workforce, NSF employed a greater percentage of women, minority, and disabled scientists and engineers. The percentage of minorities within NSF and the U.S. STEM workforce, however, still remains low, compared to non-minorities who make up more than three-quarters of the STEM workforce within NSF and within the nation's overall STEM workforce.

3 A Historical Review of CEOSE Findings and Recommendations to the National Science Foundation

Key Results

- The overarching problem faced by underrepresented groups during the period from 1980 to 2002 was the lack of access to education, training, and employment opportunities within the STEM fields.
- Virtually the same findings reported during the 1980-1992 period were repeated during the 1993-2002 period. Because of this, the Committee made the same major recommendations throughout the 23 years, namely, that greater and sustained attention needs to be paid to removing barriers faced by women, minorities, and persons with disabilities who want to enter the science and engineering professions.
- CEOSE's recommendations resulted in several changes in diversity-related NSF policy and programs, especially during the 1993 to 2002 period. Among these changes were initiation of new NSF policies to increase numbers of grant applicants from the underrepresented groups; revision of the merit-review system to encourage grant applicants to address issues of broader social impact, including diversity; and holding NSF directorates accountable for their initiatives to increase participation levels of underrepresented groups in NSF-supported programs.
- Between the early 1990s and 2001, both women and minorities increased their participation in science and engineering education. The percentage of women scientists and engineers in the STEM workforce increased significantly during this same period, but the percentage of minority-group scientists and engineers increased only marginally between the 1990s and 2001.
- New CEOSE-impelled NSF initiatives yielded steady, if slow, rate of change in numbers of women and underrepresented minorities receiving STEM degrees, particularly toward the end of the study period.

Since its inception in 1980, CEOSE has advised the National Science Foundation on matters of broadening the participation of women, underrepresented minorities, and persons with disabilities in science and engineering. This third chapter documents the actions of the Committee, by summarizing CEOSE's findings on the underparticipation of these groups and recommendations made to the Foundation between 1980 and 2002 to help increase the number and demographic diversity of the nation's scientists and engineers.

How The Chapter Is Organized

An overview of the approach used to review CEOSE's actions is first presented, which includes questions that steered the review, definitions of the terms "CEOSE Findings" and "CEOSE Recommendations," and the methodology employed to collect and verify the historical data.

Next, the purpose, organization, and operation of CEOSE are described, including the process by which the Committee makes its findings and recommendations to the National Science Foundation.

The historical data are then summarized within two major time periods: 1980-1992 and 1993-2002. Since the history of CEOSE has never been documented, the chapter includes the period from 1980 to 1992 in taking a retrospective look at CEOSE from its inception. Reporting on the second period (1993-2002) was specifically required by Congress.[1]

Under each of the time periods, CEOSE's findings and recommendations are first summarized. The findings cover many specific areas of concern, which vary by the individual underrepresented group (i.e., women, minorities, or persons with disabilities). To aid the reader, the findings and associated recommendations are, therefore, presented under the following sub-headings for each of the three underrepresented groups:

- Pre-college education
- Higher education, training, and grant opportunities
- The workforce
- Current interventions to broaden participation
- Notable external factors that affect participation and NSF programs
- CEOSE data needs to make findings and recommendations

The Compact Disc included with this report lists the Committee's individual findings, recommendations, and the sitting members of CEOSE for each of the biennial periods from 1980-1992 to 1993-2002 as Appendix D.

Finally, Chapter 3 ends with a summary of CEOSE's actions during the two time periods. We also take a look at the changes that have taken place in the broadening of participation of women and minorities in science and engineering education, and employment between 1993 and 2002.

[1] H.R. 4664 (2002).

Study Approach

The study's review of CEOSE was guided by the following questions:

- What was the nature of the CEOSE Findings and the Recommendations?
- Were there any significant changes in the findings, recommendations, and responses of NSF during the period under study?
- Were there any changes in the participation of the underrepresented groups within the science and engineering fields?

To answer these questions, data were collected from a variety of sources that included CEOSE biennial reports, CEOSE meeting minutes, NSF reports, and interviews with current and former members of CEOSE. All of the CEOSE findings and recommendations were verified for accuracy by cross checking the data from different source documents and asking NSF staff and current CEOSE members, who have a long association with the Foundation, to review the CEOSE Findings and Recommendations for accuracy.

Key Definitions

CEOSE Findings refer to research data and other information collected, observations made, and lessons learned by CEOSE in the course of reviewing and assessing NSF's equal opportunity policies and programs for women, minorities, and persons with disabilities. Significant portions of the findings were obtained from presentations made to CEOSE by NSF staff and outside STEM professionals.

CEOSE Recommendations are based on CEOSE's Findings and refer to policy and program suggestions or formally adopted Committee recommendations for action, which are communicated to the Director of NSF or heads of the Foundation's directorates. Recommendations are aimed at improving access to education, training, and employment opportunities, as well as increasing and sustaining participation of the underrepresented groups in the STEM professions.

Overview of CEOSE Purpose, Organization and Operation

Purpose

Pursuant to the Equal Opportunities in Science and Engineering Act of 1980, the purposes of the Committee are to (1) provide advice to the National Science Foundation concerning the implementation of policies and programs to increase participation of women, minorities, and persons with disabilities in science and engineering education, and employment opportunities; (2) provide advice on other policies and activities of the Foundation to encourage full participation of the underrepresented groups in scientific, engineering, and professional fields; (3) review and evaluate all Foundation matters relating to opportunities for participation in and advancement of the underrepresented groups in science and engineering education, training and research programs; and (4) prepare and transmit to Congress via the Foundation's Director a biennial report on its activities during the previous two years and proposed activities for the next two years. The Director is to submit this biennial report to Congress unchanged. However, the Director may attach a letter to the report to address any issues of concern.[2]

Founding Principle of CEOSE

CEOSE is committed to promoting the inclusion of all citizens, regardless of gender, race, ethnicity, or disability, in the nation's science, engineering, and technology workforce. Implicit in this principle is the vision of a nation in which every segment of the population is empowered and enabled to participate fully in America's STEM enterprise.

Organization

The Committee is composed of 15 men and women scientists and engineers, who are demographically diverse and come from different scientific disciplines within industry, academia, government, and the voluntary sector. Each member of the Committee is selected by CEOSE and appointed by the Director of the Foundation for a three-year term. Members may be appointed to serve a second three-year term. The Committee Chair serves for a one-year term as Vice Chair prior to assuming the Chairmanship. In addition to the 15 members, a NSF Executive Liaison serves as the CEOSE Executive Secretary. This person is also a scientist and assists CEOSE in organizing and implementing committee activities.

Operation

CEOSE convenes meetings three times a year, typically in the winter, spring and fall. The purposes of these meetings are to obtain, review and discuss information on specific problem areas and participation trends, and to deliberate on priority areas to focus its efforts. The Committee utilizes multiple NSF and non-NSF sources for data and other information upon which to base its recommendations. As previously noted, much of the information on problem areas is collected from presentations made

[2] 42 U.S.C. 1885c and 1885d.

by experts in the scientific and engineering fields. These presentations also provide the Committee with evaluation feedback on the effectiveness of NSF and other programs that are designed to encourage and support participation of women, minorities, and persons with disabilities in STEM. Furthermore, presenters are invited to give updates on legislative activity and budgetary decision-making of Congress that may impact the work of NSF and CEOSE. Invited presenters also provide updates on equal opportunity initiatives of other federal agencies, e.g., the Department of Defense, Department of Energy, Department of Education, Department of Labor, and National Institutes of Health.

The NSF Director and Deputy Director meet with CEOSE at each committee meeting, schedules permitting, to brief CEOSE about policies and trends in NSF and to respond to questions from committee members. Heads of the Foundation's directorates are also invited to the CEOSE meetings to brief the Committee on strategic plans and initiatives to improve diversity within NSF and the general STEM workforce.

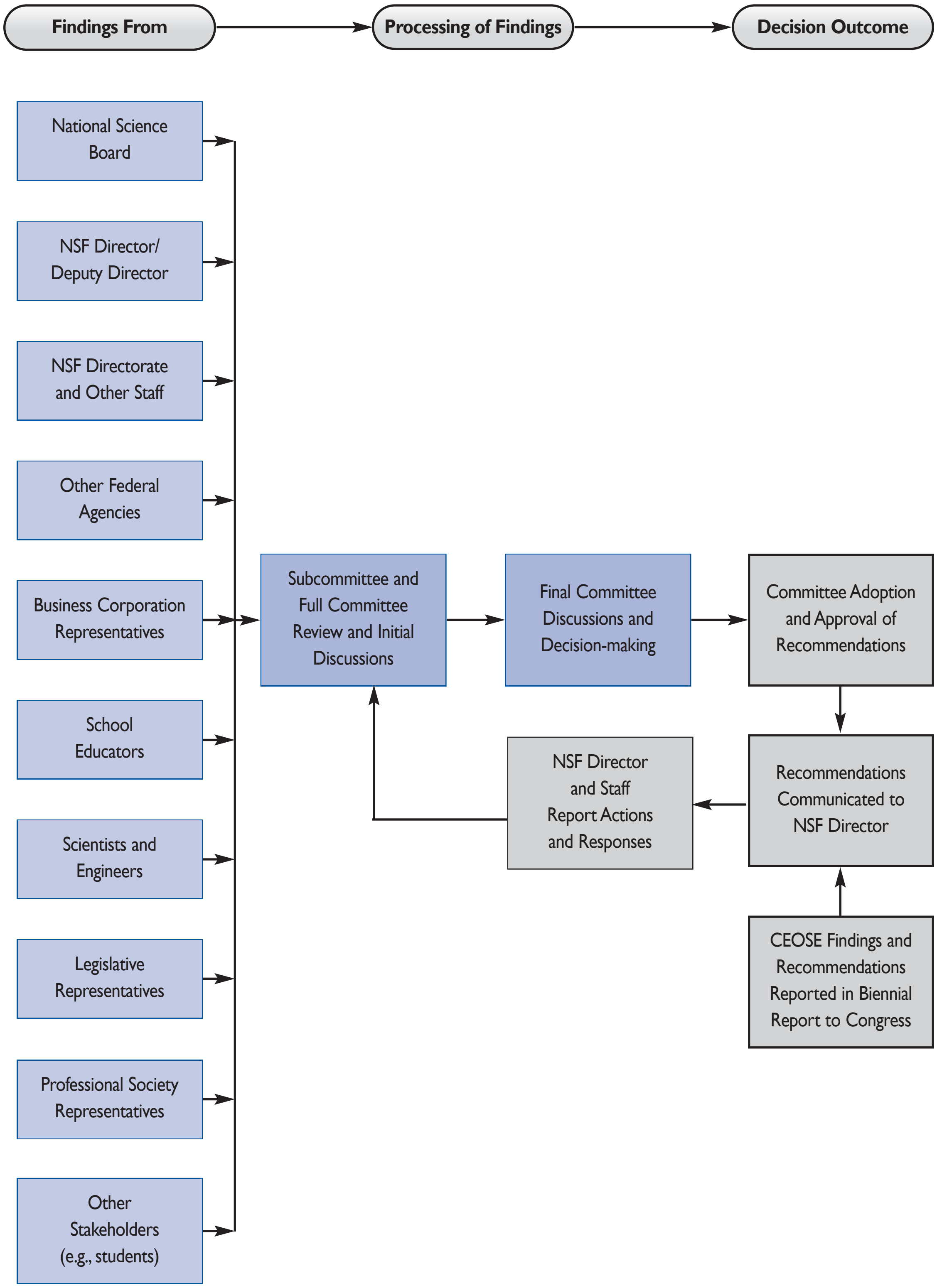
Members of CEOSE are assigned as liaisons to advisory committees of the various directorates. The liaisons advise the Directorate Advisory Committees on matters related to increasing access for women, minorities and persons with disabilities to directorate-grant programs. Members also serve on inter-agency equal opportunity committees, which allow them to share information on equal opportunity initiatives and to help promote a more government-wide focus on the need for increasing STEM education and employment opportunities.

Upon review and discussion of its findings, CEOSE uses its meetings to develop and approve specific recommendations for the Foundation to consider. The recommendations and supporting rationale are documented in the minutes of the meetings, and many of these recommendations are reported in the CEOSE biennial reports (see www.nsf.gov/od/oia/activities/ceose/index.jsp). Depicted in Figure 3-1 is the process by which CEOSE obtains and uses information to make its recommendations.

On May 27 and 28 of 1981, CEOSE held its first meeting to review the Committee's mission and charter.[3] Following an opening statement from the Director of NSF, Dr. John B. Slaughter, on the charge that Congress had given the Foundation, CEOSE began fact finding on ways to improve the participation of women, minorities, and persons with disabilities in the fields of science, technology, engineering, and mathematics.

[3] In the 1980 Act, the Committee was called the Committee on Equal Opportunities in Science and Engineering. During the initial years of its existence, the Committee's name was changed to the Committee on Equal Opportunities in Science and Technology (CEOST). The original name was reverted to subsequently.

Figure 3-1
Information-Gathering and Recommendation-Making Process of CEOSE



Historical Review of CEOSE: 1980-1992

Women

Table 3-1 summarizes the CEOSE Findings related to women in STEM for the 1980-1992 period.

Pre-College Findings: 1980-1992

Research data and the experiences and observations of expert educators who have provided input to CEOSE all point to gender bias as the major reason for girls and women not considering science as a "socially acceptable" career option. As a result, from K-12, females generally have shied away from pursuing a vocation in science or engineering. Their poorer retention rates in high school mathematics and science, as compared to males, reflect this differential treatment and perception of females.

Recommendations

NSF should support research to clarify issues involved in differential education of boys and girls in science and mathematics and support programs to reduce this differential. NSF should also promote increased participation of girls in research projects. Further, NSF and educational institutions should collaborate in disseminating information to women about career opportunities in STEM and the availability of financial aid.

Higher Education, Training, and Research Grant Opportunity Findings: 1980-1992

Gender bias apparently persists along the pre-college, undergraduate, and graduate school continuum. Women encounter far more barriers than men in accessing education opportunities, such as mentoring in science, mathematics and engineering, research grants, fellowships, or research assistantships offered by NSF. Minority and disabled women encounter even greater barriers because of their additional diversity characteristics. Women's colleges seem to be the only educational environments where women are intentionally encouraged and supported in their pursuit of a STEM career.

Recommendations

NSF should support research to assess barriers to women entering undergraduate STEM education programs, as well as practices that enable them to enter these programs. NSF and local education agencies should support comprehensive programs throughout the education system to motivate and mentor women pursuing STEM careers. Stipends, fellowships, and research assistantships for women in graduate school should be substantially increased. NSF should work to triple the number of women earning STEM doctorates. Moreover, NSF should fund the *Visiting Professorships for Women (VPW)* program that was begun in 1986. It grants awards to experienced women faculty to conduct research at top-rated academic institutions of their choice and to help motivate and mentor women undergraduates.

Table 3-1

CEOSE Findings Associated with Underrepresentation of Women in STEM as Stated during 1980-1992

Category	CEOSE Findings
Pre-college	Girls have higher dropout rates from primary/secondary level mathematics and science classes than boys. Societal attitudes discourage females from pursuing STEM careers.
Higher Education, Training, and Research Grant Opportunities	Women experience more barriers to higher education. Compared to men, far fewer women seek graduate education in STEM. Few are awarded doctorates. Women colleges prepare women for STEM better than co-educational colleges. The presence of women faculty helps attract women to STEM. Minority women and women with disabilities experience even greater barriers to STEM education and employment than other women.
Workforce	Women are currently underrepresented in STEM within and outside of NSF. Recruitment of women with potential or proven talent would help to fill the nation's need for STEM professionals. Women scientists and engineers earn less than their male peers. Women scientists have less access to promotion and advancement opportunities than their male peers. Women are twice as likely to have non-tenured faculty positions. Women tend to be in less visible STEM positions. Discriminatory employment practices in government, industry, and academia tend to impede women's participation and advancement.
Current Interventions	Existing intervention programs to increase the participation of women in STEM are either under-funded or not funded, e.g., Science *Career Facilitation* (re-entry) program was eliminated in the FY 1981 federal budget.
Notable External Factors	Retreat from affirmative action policies within the current political climate detracts from support of NSF initiatives to increase participation of women and minorities in STEM.
CEOSE Data Needs	NSF lacks sufficient data on women in the STEM pipeline and workforce, which limits the ability of CEOSE to advise NSF on increasing participation of women in STEM.

A program similar to the *Research Improvement in Minority Institutions (RIMI)* should be supported for women colleges. Launched in 1982, the *RIMI* program was designed to enhance the research infrastructure of colleges and universities with substantial minority student enrollment. Also, NSF should continue support of focused programs for minority and disabled women and enlist the support of organizations with model programs for these particular groups of women.

Workforce Findings: 1980-1992

Given the negative bias shown towards women in STEM education, it is not surprising that women are underrepresented in the STEM workforce. Not only are they underrepresented, but women scientists and engineers also earn lower salaries than their male peers and are provided with fewer opportunities for career advancement. The problem of access is not associated with a particular sector of the STEM workforce but is systemic throughout industry, academia, and government.

Recommendations

NSF should use its leverage to encourage grantee institutions to hire more women. NSF should establish gender awareness and sensitivity programs and hire more women for professional positions. NSF should also support programs, such as *Opportunities for Women Scientists and Engineers (OWSE)*, which focus on attracting women into STEM career tracks. Moreover, Congress should establish a committee with government-wide responsibility for equal opportunities for women in STEM.

Current Intervention Findings: 1980-1992

NSF-supported programs help to increase the number of women in STEM education and employment, e.g., previously mentioned *Visiting Professorships for Women* and the *Science Career Facilitation* (re-entry) programs. However, all of these programs have either received limited funding or were never funded. The *National Research Opportunity Grants*, for instance, was authorized in 1980 in the Science and Technology Equal Opportunity Act, but has not been implemented.[4] No programs have been created for high school, a crucial period for developing interest in science and mathematics. For a profile of these and other NSF diversity-focused programs, see Appendix B.

Recommendations

NSF should inform women about research grant program opportunities at NSF, increase the number of women on proposal review panels, collaborate with universities on addressing the issue of salary parity, set a goal for the number of tenured positions for women science and engineering faculty, and continue support of re-entry programs for women who temporarily leave their STEM professions for family reasons. Also, NSF should identify and replicate exemplary programs to increase participation of women in STEM. Further, Congress should solicit and enlist the help of all federal agencies in promoting STEM education and employment for women.

[4] U.S.C. 1885a.

Notable External Factor Findings: 1980-1992

Following the Bakke decision in 1978, the 1980s have been marked by a series of legal challenges to affirmative action policies and equal opportunity programs.[5] While this opposition to special group or set-aside programs is aimed at minorities specifically, programs for women are also vulnerable. The socio-political climate during the 1980s has created additional challenges for CEOSE.

Recommendations

NSF should bolster and protect affirmative action policies and initiatives for women as well as minorities.

CEOSE Data Need Findings: 1980-1992

In trying to assess the extent of underrepresentation of women in STEM education and employment, CEOSE often finds itself with insufficient gender data. The Committee has repeatedly urged NSF to improve the availability of data on women and provide disaggregated data on women sub-groups, e.g., African American, Hispanic, and Native American women.

Recommendations

NSF should revise its data collection system and provide CEOSE with disaggregated data on women sub-groups in the STEM pipeline and workforce, gather more data on education and employment barriers, and invest in providing CEOSE with a research capability to investigate certain issues on its own.

Underrepresented Minorities

A summary of CEOSE Findings related to underrepresented minorities in STEM for the 1980-1992 period is presented in Table 3-2.

Pre-College Findings: 1980-1992

CEOSE noted that minority urban and rural youth attend public schools that are woefully lacking in qualified science and mathematics teachers and other instructional resources. This was particularly true for African Americans, Native Americans, and certain Hispanic groups, such as Puerto Ricans and Mexican Americans. These minority youth tend to score lower on mathematics and science tests and have high dropout rates from science and mathematics courses. In general, they lack role models and mentors to encourage their pursuit of an education in these areas.

[5] *Committee on Equal Opportunities in Science and Engineering-2000 Biennial Report to The United States Congress.*

Recommendations

NSF, in collaboration with federal and local education departments, should form comprehensive strategies that support training and hiring of better qualified STEM teachers and a K-12 continuum of student motivational, mentoring, and remediation support. Also, NSF should encourage partnerships between colleges and high schools that prepare high school students for advanced science and mathematics instruction and provide them with research experiences.

Higher Education, Training, and Research Grant Opportunity Findings: 1980-1992

Due in part to the rising financial cost of higher education, more minorities tend to enroll in two-year colleges, where the science curricula are limited, than in four-year colleges, which offer a broader spectrum of science and mathematics courses. Comparatively fewer minority undergraduates major in the physical sciences. Far more major in the social sciences. As in the pre-college phase, minority undergraduates are rarely, if ever, exposed to minority scientists. Programs that focus on retention of minority students in STEM tracks are scarce and under-funded. Few minority college students go on to pursue a Doctoral Degree in a STEM field, and most are unaware of fellowships, research assistantships, or the postdoctoral research grant opportunities offered by NSF.

Recommendations

NSF should support programs that bridge the gap between high school and college and that focus on identifying, motivating, and mentoring minority students with an interest in science or mathematics. NSF should encourage and support partnerships between two- and four-year colleges to provide students in the former with greater access to physical, biological and engineering science courses. Also, NSF should fund Historically Black Colleges and Universities (HBCUs) and other minority higher education institutions to improve their infrastructure to better train graduate students and produce Ph.D.s in STEM fields.

Workforce Findings: 1980-1992

CEOSE noted that minorities are more underrepresented in the STEM workforce than women, within and outside of NSF. NSF and other STEM-related institutions lack adequate initiatives to promote staff awareness of talented minority scientists and the barriers they face in the STEM workplace. There are comparatively few tenured or untenured minority faculty in science or mathematics departments of universities. The problem of access to STEM employment and advancement opportunities is systemic and transcends the boundaries of government, industry, and academia.

Table 3-2
CEOSE Findings Associated with Underrepresentation of Minorities in STEM as Stated during 1980-1992*

Category	CEOSE Findings
Pre-college	Minorities are at risk in the public school system, and have high dropout rates from middle and high school mathematics and science classes. Native Americans lack sorely needed remediation programs. Insufficient national attention has been paid to pre-college needs of minority high school students. There is a shortage of qualified mathematics and science teachers in predominantly minority middle schools and high schools.
Higher Education, Training, and Research Grant Opportunities	Minorities are underrepresented in undergraduate and graduate school tracks for STEM. Retention programs are needed for undergraduate minority students. Most minority undergraduates, including highly talented ones, attend white majority schools with limited focused programs for their needs. Few minorities attain doctorates in STEM. Few minorities apply for NSF research grants. Generally, access to STEM educational opportunities is a formidable problem for minorities.
Workforce	Minorities constitute a growing portion of the overall workforce but are underrepresented in the STEM workforce within and outside of NSF. Minorities are relatively unaware of NSF grant opportunities. There are few tenured minority STEM faculty. Discriminatory employment practices against minorities are systemic. NSF cannot shoulder the entire burden of rectifying the inequalities encountered by minorities in STEM.
Current Interventions	Exemplary programs exist that increase minority participation in STEM education, e.g., *Resource Centers, Joins Hopkins Center for Advancement of Academically Talented Youth*. Great merit has been seen in programs that have been eliminated, e.g., *Minority Research Initiation* and the *Minority Graduate Fellowship* programs.
Notable External Factors	There is growing opposition to affirmative action and equal opportunity programs for minorities.
CEOSE Data Needs	NSF lacks sufficient disaggregated data on minority sub-groups in STEM for decision-making and programming. Disaggregated data are required for the different Hispanic ethnic groups and for Native American tribes.

*Minorities include African Americans, Hispanic Americans, and Native Americans. Asian Americans are not considered underrepresented in STEM.

Recommendations

NSF should undertake research to assess specific barriers encountered by minorities in pursuing STEM employment. NSF should begin by increasing staff awareness and sensitivity to diversity among its STEM professionals, and NSF should use its leverage to influence grantee organizations to adopt or expand similar initiatives to increase participation of minorities in STEM research, teaching, and management positions.

Current Intervention Findings: 1980-1992

Some exemplary programs sponsored by NSF aimed at increasing minority participation in STEM exist, e.g., *Resource Centers, Minority Research Initiation, and the Minority Graduate Fellowship* programs. The *Resource Center* program is designed to recruit and motivate students to participate in STEM education tracks. The other two programs were aimed at assisting graduate students in honing their research skills. Despite their promise, the *Minority Research Initiation* and *Minority Graduate Fellowship* programs have been eliminated. Funding is, however, continued for improving the research infrastructure of HBCUs.

Recommendations

Congress and NSF should restore funding for the *Minority Research Initiation* and *Minority Graduate Fellowship Programs,* and expand funding to establish additional *Resource Centers In Science and Engineering* to motivate, recruit, and retain minority students in STEM education programs.

Notable External Factor Findings: 1980-1992

As previously noted, legal challenges were increasing against the use of racial quotas in education and employment. Legal challenges to NSF programs focused on minorities and are further addressed later in this chapter.

Recommendations

Notwithstanding, CEOSE should strongly urge NSF to continue its support for equal opportunity initiatives that help to increase participation of minority groups in STEM.

CEOSE Data Need Findings: 1980-1992

NSF lacks sufficient disaggregated data on changes in minority group participation within the STEM pipeline and workforce. This is especially true for the various ethnic groups within the broad categories of Hispanics and Native Americans.

Recommendations

The Committee should continue to urge NSF to improve the collection and availability of disaggregated data on the various racial/ethnic groups underrepresented in STEM. The Foundation's Division of Science Resources Statistics was cognizant of the data needs of CEOSE, but at this time was unable to accommodate the Committee's request due to insufficient sample sizes of the various minority/gender sub-groups within the division's database (SESTAT) of scientists and engineers.

Persons with Disabilities

A summary of CEOSE findings related to persons with disabilities in STEM for the 1980-1992 period is presented in Table 3-3.

Pre-college Findings: 1980-1992

On a national level, there is little attention paid to high school students with disabilities who want to pursue mathematics or science as a career. Similar to the situation for minorities, there is a lack of qualified mathematics and science teachers who have a disability and can identify with disabled students in facilitating their learning process.

Recommendations

NSF should support a *Resource Center in Science and Engineering* program for high school and college students with a disability.

Higher Education, Training, and Research Grant Opportunity Findings: 1980-1992

Physical access to and use of educational facilities are major problems for persons with disabilities. Long-term investment of funds and other resources into educating STEM talent of persons with disabilities would help to contribute in reducing the current and future need for STEM professionals. Very few disabled persons are found in STEM faculty positions, and almost none are employed as scientists or engineers at NSF. Moreover, very few even apply for NSF research grants.

Recommendations

NSF should fund education programs for persons with disabilities to reduce access barriers. NSF should provide a grant program specifically designed for this underrepresented group. Also, NSF should support initiatives to develop more qualified science and mathematics teachers who have disabilities.

Table 3-3
CEOSE Findings Associated with Underrepresentation of Persons with Disabilities in STEM as Stated during 1980-1992*

Category	CEOSE Findings
Pre-college	National attention is needed for pre-college programs in STEM for persons with disabilities. There is a lack of qualified science and mathematics teachers for the disabled.
Higher Education, Training, and Research Grant Opportunities	Major investments in education of disabled scientists and engineers would help increase the STEM workforce. Limited access to educational opportunities is a major barrier for the disabled. Students with disabilities often have special needs that are unmet (e.g., travel and building access). Students with disabilities lack access to necessary equipment and materials to accommodate their disability, as well as lack of access to STEM teachers with disabilities. Very few persons with disabilities receive research grants from NSF.
Workforce	Few persons with disabilities are entering and advancing in STEM occupations and they are underrepresented within NSF. Accessibility to facilities and use of materials and technologies in the workplace are major barriers to employment in STEM.
Current Interventions	More interchange and collaboration are needed between agencies responsible for various concerns of the disabled. NSF lacks specific programs for persons with disabilities within the STEM pipeline and workforce.
Notable External Factors	Retreat from targeted group and quota-based affirmative action policies within the current political climate may detract from CEOSE and NSF initiatives to increase participation of persons with disabilities in STEM.
CEOSE Data Needs	NSF lacks sufficient data on persons with disabilities in STEM and their special needs.

*No findings were reported for persons with disabilities in 1980 and 1981.

Workforce Findings: 1980-1992

While many scientists and engineers may develop a disability during their careers, few disabled persons are represented among new entrants to the STEM workforce. Inaccessibility to work facilities, laboratories or research equipment present major obstacles to disabled persons seeking employment in the science and engineering fields.

Recommendations

NSF should place a high priority on programs for persons with disabilities to increase their participation in STEM.

Current Intervention Findings: 1980-1992

NSF lacks specific programs for persons with disabilities. As a matter of fact, the original 1980 Act (Public Law 96-516), which created CEOSE did not specify “persons with disabilities” as an underrepresented group. The disabled persons group was added to the legislation in 1997. Proposed programs for persons with disabilities were not included in the initial set of NSF proposals supported by CEOSE in 1981. Moreover CEOSE did not form in its beginning a subcommittee dedicated to the needs and concerns of the disabled, as it had done for women and minorities.

Recommendations

A science advocate with a disability should be hired to work in the Foundation’s Office of the Director to assist in developing programs for disabled persons with STEM talent. Also, NSF should make its facilities and meetings accessible for the disabled.

Notable External Factor Findings: 1980-1992

While persons with disabilities have not elicited the same type of legal challenge to affirmative action programs as is the case with minorities, there do exist *de facto* barriers to participation by persons with disabilities, as evidenced by the lack of access-friendly accommodations in many government, commercial and school facilities.

Recommendations

CEOSE should urge NSF to remain diligent in upholding affirmative action and equal opportunity policies in support of focused programs for persons with disabilities.

CEOSE Data Need Findings: 1980-1992

Issues of varying definitions of disability and confidentiality of medical information complicate the problem of obtaining data on persons with disabilities in STEM.

Recommendations

As with women and minorities, NSF should improve the collection of disaggregated data on persons with disabilities (i.e., by disability) and to work with other government agencies in the collection and sharing of these data.

Historical Review of CEOSE: 1993-2002

Women

A summary of CEOSE Findings related to women in STEM for the 1993-2002 period is presented in Table 3-4.

Pre-college Findings: 1993-2002

Although some progress has been made, the gap in gender achievement in science and mathematics still remains a problem, as well as lack of teacher quality. High school is where many girls and boys make career decisions about STEM, which represents an opportune point in early education to motivate and support female students to consider a vocation in the STEM fields.

Recommendations

NSF should continue to work towards reducing the achievement gaps in science and mathematics between boys and girls by one-half by the year 2010. NSF should continue efforts to improve teacher quality. Also, NSF should identify and fund best practices that create educational pathways from K-12 for females.

Higher Education, Training, and Research Grant Opportunity Findings: 1993-2002

There has been some increase in female enrollment in graduate STEM studies. NSF grant opportunities for women still need improvement. Grant applicant compliance with NSF's broader-impacts criterion needs to be better monitored and enforced to facilitate women's access to research grant opportunities. The broader-impacts criterion of NSF's merit-review process for grant applications requires the proposer to address how the proposal will impact broader issues, including the problem of underrepresented groups in STEM.

Recommendations

NSF should conduct research on education barriers encountered by women who are interested in pursuing a career in STEM. NSF should continue to increase partnerships between two- and four-year colleges to increase access to science and mathematics curricula and initiate additional programs and policies that establish linkages between academic tiers. NSF should strengthen the *Research Experience for Undergraduates* program and extend it to the high school level. Also, NSF needs to better enforce compliance to the broader-impacts criterion grant application requirement to promote grant applicant attention to diversity within proposed projects.

Table 3-4

CEOSE Findings Associated with Underrepresentation of Women in STEM as Stated during 1993-2002

Category	CEOSE Findings
Pre-college	Females tend to hold more negative attitudes towards careers in STEM than do males. Little change has taken place in mathematics and science test scores between girls and boys. Teacher quality in science and mathematics remains low for girls and other underrepresented groups. Students with potential for STEM tend to make career decisions in high school.
Higher Education, Training, and Research Grant Opportunities	Women scientists and engineers are underrepresented among principal investigators who receive NSF grants. Improvement is needed in grant applicant response to the broader-impacts criterion; enforcement across NSF directorates is not uniform. Research experience for women and other underrepresented groups is lacking and is key for retaining students in STEM pathways. In the 1990s, women increased enrollment in graduate schools for science; but only low numbers of them attained degrees in engineering. There is a paucity of women with doctorates in STEM.
Workforce	Women are still underrepresented in the STEM workforce. Women are less likely to hold faculty positions in STEM in high school or college than men. Women with doctorates in STEM are paid less and are granted tenure less than their male peers. The number of women in management positions is still low inside and outside of NSF.
Current Interventions	Focused programs, such as *Professional Opportunities for Women In Research and Education*, are proving effective.
External Factors	No CEOSE findings reported.
CEOSE Data Needs	Evaluation data on all women-focused programs are needed. Better metrics are needed to measure changes in participation levels in STEM. There are limited demographic data on NSF grant application reviewers and advisors. Disaggregated data for sub-groups of women by race/ethnicity are still needed.

Workforce Findings: 1993-2002

Women remain underrepresented in the STEM workforce. They also continue to be treated less favorably than men when it comes to pay and career advancement.

Recommendations

NSF should continue to ensure more diversity among its STEM staff and pool of reviewers and advisors through *embedded-diversity* efforts throughout the Foundation. Embedded-diversity refers to a shift in NSF policy from providing equal opportunity programs specifically targeted for women, minorities or persons with disabilities to embedding diversity in all foundation programs. Also, NSF should continue efforts to double by the year 2000 the number of women science and mathematics teachers and support programs, such as *ADVANCE*, to achieve parity for women faculty. NSF should establish grant award incentives for exemplary programs that promote diversity in the STEM workplace and forge partnerships between government and industry to increase employment opportunities for women.

Current Intervention Findings: 1993-2002

Focused programs for women are proving to be an effective means for supporting women in pursuit of STEM education and for increasing their presence in the STEM workforce, e.g., *Visiting Professorships for Women, Professional Opportunities for Women in Research and Education*, and *ADVANCE*. The first two programs were eventually incorporated into the *ADVANCE* program.

Recommendations

NSF should continue to support and replicate successful programs to increase participation and advancement of women scientists and engineers.

Notable External Factor Findings: 1993-2002

Following the Bakke decision in 1978, the 1980s were marked by a series of legal challenges to affirmative-action policies and equal-opportunity programs.[6] While this opposition to special group or set-aside programs was aimed at minorities, programs for women were also vulnerable.

Recommendations

NSF should bolster and protect affirmative-action policies and initiatives for women as well as minorities.

CEOSE Data Need Findings: 1993-2002

CEOSE continues to encounter difficulties in obtaining disaggregated data for sub-groups of women by race and ethnicity as well as metrics to better monitor changes in levels of participation of women in the STEM education pipeline and workplace. NSF's Division of Science Resources Statistics continues to consult with CEOSE on the latter's data needs and how best to satisfy those needs with the new SRS database system (SESTAT).

[6] The U.S. Supreme Court decided that use of quotas in affirmative action programs was not permissible in the case of Bakke v. Regents of the University of California in 1978.

Recommendations

CEOSE continues to recommend that NSF should improve its data collection system and availability of disaggregated data for women sub-groups. Starting in 1993, NSF did provide its Division of Science Resources Statistics (SRS) with funding to improve collection and reporting of disaggregated data for underrepresented groups.

Minorities

A summary of CEOSE findings related to underrepresented minorities in STEM for the 1993-2002 period is presented in Table 3-5.

Pre-college Findings: 1993-2002

While some narrowing of the achievement gap has occurred, more needs to be done in raising science and mathematics test scores of minorities at the high school level. Also, the problem of poor teacher quality in science and mathematics for predominantly minority high schools still persists.

Recommendations

NSF should continue curriculum and pedagogical efforts to reduce race-based achievement differentials. NSF should encourage and participate on the state level to work towards more comprehensive approaches for improving teaching quality standards and programs that target minority students. NSF should fund aggressive intervention efforts in high schools (and colleges) to increase student interest in engineering.

Higher Education, Training, and Research Grant Opportunity Findings: 1993-2002

Minorities continue to experience barriers in gaining access to advanced education in STEM and achieving doctorates. Limited opportunities for gaining research experience and receiving research grants constitute major problems in limiting the advancement of minorities in the pipeline and into the workforce.

Recommendations

NSF should support partnerships between two- and four-year colleges to expand the educational spectrum of STEM courses for minority students in 2-year colleges; conduct research to discern what barriers prevent minorities from entering graduate schools; and develop mentoring programs to retain minority students in graduate studies. Also, NSF should help to double by the year 2000 the number of STEM doctorates awarded to minorities. NSF needs to increase representation of Native Americans on CEOSE. This would help to provide the Committee with further insight and guidance in addressing cultural barriers that Native Americans students encounter in seeking a STEM education.

Workforce Findings: 1993-2002

Minorities remain underrepresented in the STEM workforce inside and outside of NSF. Efforts need to be continued within NSF to increase awareness of talents and capabilities of minority scientists, technologists, engineers, and mathematicians.

Recommendations

NSF should continue efforts to recruit and hire more minorities in professional STEM positions as well as minority reviewers and advisors; consider the "center" model for its proposed *Workforce Initiative*; award contractors for exemplary minority diversity programs; and examine policies and practices at universities to identify ways to increase faculty advancement opportunities for minority men and women.

Current Intervention Findings: 1993-2002

Evaluation feedback shows that a number of existing programs aimed at increasing participation of minorities in STEM are performing effectively.

Recommendations

NSF should continue to support effective programs targeted to minorities. NSF should also consider replicating these programs nationally for greater impact.

Notable External Factor Findings: 1993-2002

The Supreme Court ruled in the 1995 *Adarand Construction vs. Pena* case that federal affirmative-action programs using race or ethnicity criteria as a basis for decision-making are subject to the same standard of review, "strict scrutiny," previously applied to state and local affirmative action measures, rather than the less restrictive "intermediate scrutiny" standard previously applied to such federal programs. This decision led the U.S. Department of Justice to require all federal agencies to review their affirmative action programs for potential legal risks. The outcome at NSF was that some minority-focused programs were continued that could be justified under the "strict scrutiny" standard. Other NSF minority-focused programs were reconfigured, so that they did not exclude access by non-minorities, and some minority-focused programs were eliminated.

In 1998, NSF was challenged directly in a lawsuit on the constitutionality of the Foundation's *Minority Graduate Fellowship* program. After consultation with the Department of Justice, the program was eliminated. In a press statement (PS 98-12), NSF stated that the lawsuit did not impose any limitations on how NSF would structure its programs and that NSF would continue its commitment to diversity. Also, NSF would develop a single *Graduate Fellowship* program that would include an emphasis on outreach to underrepresented groups.

Recommendations

CEOSE recommended that NSF should continue its commitment to support greater diversity in the STEM workforce.

CEOSE Data Need Findings: 1993-2002

CEOSE continues to consult with SRS on ways to obtain disaggregated data for minority sub-groups as well as with the Education and Human Resources Directorate for systematic evaluation data on focused programs for underrepresented groups in STEM.

Recommendations

NSF should improve the capacity of SRS to collect demographic data on minority sub-groups within the STEM pipeline, workforce and those involved in NSF grant programs. Also, the Foundation should provide CEOSE with more evaluation data on programs for minorities as well as the other underrepresented groups.

Table 3-5
CEOSE Findings Associated with Underrepresentation of Minorities in STEM as Stated during 1993-2002

Category	CEOSE Findings
Pre-college	There has been limited improvement in reducing the gaps in science and mathematics test scores between minority and white high school students. Poor quality science and mathematics teachers are found more in minority-populated schools. African Americans and Hispanics make up low numbers of science and mathematics teachers.
Higher Education, Training, and Research Grant Opportunities	Large numbers of minority students attend two-year colleges with limited STEM educational tracks. Although some progress has been made in minority graduate enrollments, the numbers of African Americans, Hispanics and Native Americans, for instance, entering graduate school is disproportionately low. Low enrollment in Tribal colleges seems to be a cultural issue requiring research. The number of minorities receiving doctorates in science and engineering remains low. There are well-trained minority graduate students who lack mentoring and assistance to produce publications. Minority colleges and universities are in need of infrastructure improvements to encourage and retain STEM students. The funding rate for research proposals with minority principal investigators is below average for NSF.

continued

Category	CEOSE Findings
Workforce	The Census Bureau projects that in 2010, over two-thirds of the workforce pool will be minorities. Minorities continue to be underrepresented in the STEM workforce. NSF needs to be educated about STEM talents and capabilities of minorities, and the access barriers faced by these groups. The number of minorities entering the engineering field is low.
Current Interventions	*CREST* (the minority-targeted resource center program) has shown effectiveness in motivating and retaining minority students in STEM educational tracks. The *HBCU Undergraduate Program (HBCU-UP)* initiative proved successful in enrolling minorities in STEM courses and helping them to attain Bachelor's Degrees. A high percentage of students who participate in *Research Experience for Undergraduates (REU)* subsequently go into STEM careers. And industry-sponsored programs, such as Lucent Technologies' *Project GRAD*, are effective in providing research experience and employment for students.
Notable External Factors	Further legal challenges to affirmative action programs resulted in pressure on NSF to eliminate or reconfigure some of its minority-focused efforts.
CEOSE Data Needs	CEOSE continues to work with NSF's Division of Science Resources Statistics to obtain disaggregated data for minority sub-groups in STEM, as well as with the Education and Human Resources Directorate for evaluation data on focused programs.

Persons with Disabilities

A summary of CEOSE findings related to persons with disabilities in STEM for the 1993-2002 period is presented in Table 3-6.

Pre-college Findings: 1993-2002

High school is a critical point at which persons with disabilities make career decisions about STEM. NSF further commits itself to improving conditions for disabled persons, and has conducted a study on the barriers persons with disabilities encounter in STEM education.

Recommendation

NSF should continue its research on barriers and enablers for persons with disabilities.

Higher Education, Training, and Research Grant Opportunity Findings

In general, persons with disabilities are less likely to graduate from college, or pursue graduate studies in STEM areas. There are few disabled persons with a doctorate in science or engineering, and most became disabled after starting their careers. Few NSF grants are awarded to persons with disabilities.

Recommendations

NSF should increase staff/reviewer awareness and sensitivity to grant proposals from disabled persons. NSF needs to support a wide variety of changes in education to better accommodate and retain disabled persons in STEM pathways. Also, NSF should increase graduate student stipends to $25,000 per year for the disabled as well as other underrepresented groups.

Workforce Findings: 1993-2002

Talents of persons with disabilities are underutilized in the STEM workforce, within and outside of NSF. Many disabled scientists are over the age of 50.

Recommendations

NSF should ensure representation of persons with disabilities in the pool of grant reviewers as well as staff throughout the Foundation. Given the number of disabled scientists with long careers, NSF should use them as a resource to learn how to better accommodate and retain new disabled entrants to the STEM workplace.

Table 3-6
CEOSE Findings Associated with Underrepresentation of Persons with Disabilities in STEM as Stated during 1993-2002

Category	CEOSE Findings
Pre-college	Students with disabilities tend to make STEM career decisions in high school. Disabled persons are less likely to complete high school. The Education and Human Resource Directorate recently conducted research on barriers encountered by persons with disabilities who pursue science and mathematics education in high school.
Higher Education, Training, and Research Grant Opportunities	Disabled persons are less likely to enroll in and graduate from a four-year college. Graduate students with disabilities have special financial needs that can interfere with their educational opportunities. There are few disabled scientists and engineers with a doctorate. Only a few NSF grants are awarded to disabled scientists and engineers. There is greater emphasis on compliance with the intellectual-merit criterion than with the broader-impacts criterion.
Workforce	Persons with disabilities are underrepresented in the STEM workforce, inside and outside of NSF. There is a low percentage of STEM faculty with disabilities. Workplace facilities and technologies that are not disabled-friendly negatively impact on employment rates of persons with disabilities in STEM fields. A majority of disabled persons employed in STEM positions is over the age of 50, and for the most part became disabled after they began their STEM careers.
Current Interventions	*Program for Persons with Disabilities (PPD)* is effective in facilitating access to education and employment. NSF Mentoring Initiatives have proven effective. Budget constraints have been placed on programs for persons with disabilities.
Notable External Factors	Passage of the Americans with Disabilities Act may help to facilitate the installation of facility and assistive technologies for disabled persons in STEM.
CEOSE Data Needs	CEOSE has worked with SRS to gather data on disabled persons in STEM and has obtained some data on this group in STEM education. Additional data are still needed on members of this group within the STEM workforce.

Current Intervention Findings: 1993-2002

The *Program for Persons with Disabilities* is proving to be effective in helping to increase and retain disabled persons within STEM education and employment.

Recommendations

NSF should continue support of these programs and expand their capacity to accommodate even more disabled persons who are motivated to seek STEM education and employment.

CEOSE Data Need Findings: 1993-2002

CEOSE continues to be in need of evaluation data on programs aimed at persons with disabilities in STEM education and employment areas. While SRS has worked very hard to respond to the data needs of CEOSE, still further progress must be achieved to obtain sufficient disaggregated data on this underrepresented group.

Recommendations

Program initiatives for persons with disabilities in STEM should be assessed and findings made available to CEOSE. Also, NSF should improve its collection and reporting of disaggregated data on disabled persons involved in STEM.

Outcomes of CEOSE Recommendations Period from 1980 to 1992

CEOSE succeeded in fact-finding and made numerous recommendations to NSF to increase the diversity of the science and engineering workforce. NSF established a number of new programs to increase diversity in STEM.

During its first 13 years (1980-1992), CEOSE garnered and reviewed an extensive amount of information bearing on the many factors that contribute to the underutilization of women, racial/ethnic minorities and persons with disabilities within the STEM fields. Based on this information, and in consultation with NSF staff, CEOSE made numerous recommendations to the Foundation to improve education, training, employment, and career advancement opportunities for these underrepresented groups.

Partly in response to these recommendations, NSF began to increase its portfolio of diversity initiatives and programs during the 1980-1992 period. The programs reported in this section are only those which came about or were enhanced as a result of a CEOSE recommendation. These programs do not include all of NSF's programs.

Some specific examples of the impact of CEOSE's recommendations include the following: Based on its findings about the lack of opportunities for women faculty to engage in major research, CEOSE recommended that NSF provide support to encourage women science faculty to pursue research projects at major research institutions through the *Visiting Professorships for Women* program

(1986). CEOSE also urged the Foundation to support initiatives that increase access of women to mentorships and career information in science. This recommendation led NSF to establish the *Program for Women and Girls* (1992), which focuses on providing mentorship, internship and other career assistance for female high school and college students. For minority students, CEOSE recommended that NSF support efforts to bridge the gap between high school and college and focus on motivating minority students to pursue a STEM career. This recommendation helped spur the establishment of the *Louis Stokes Alliances for Minority Participation* (1991) grant program, which provides support for inter-institutional alliances to increase the number and academic performance of undergraduate minority students in science and engineering. In light of the large enrollment of minority students, particularly African Americans, at Historically Black Colleges and Universities, CEOSE prompted NSF to consider providing expanded grant support to improve the research infrastructure of HBCUs as a way to encourage more minority students to pursue an education in a STEM field. This strategy was also intended to enhance the research capabilities of HBCU faculty and graduate students. In 1987, NSF established the *Centers for Research Excellence in Science and Technology (CREST)*, which provides funds to upgrade the research capacity of minority-serving institutions.

NSF success with establishing and sustaining some women-focused programs was, however, mixed. Major programs that were undertaken prior to and during 1980s had proved to be cost effective in preparing women and minorities for STEM, but were either under-funded or eliminated. These programs included, for example, the *Women's Career Workshops, Science Career Facilitation, Women's Re-entry,* and *Visiting Professorships for Women* (all designed to motivate and encourage women to seek STEM careers). The *Career Workshop and Re-entry* programs were eliminated by 1982 because of budget constraints.[7]

NSF subsequently replaced or expanded upon the programs that were eliminated or downsized. These included the *Research Grant Opportunity* program to support women seeking STEM research grants from NSF. Minority women were given access to *Research Improvement in Minority Institutions* and the *Minority Research Initiation*, two new programs aimed at improving the research infrastructure of minority institutions and the research experience of minority graduate students.[8] Following the middle 1980s, NSF continued to support the Women's *Visiting Professorships* and *Research Grant Opportunity, Research Improvement in Minority Institutions* and *Minority Research Initiation* programs.[9]

Although CEOSE continued throughout the 1980s to push for program support for the disabled, its efforts resulted in only a few programs aimed at increasing the participation levels of persons with disabilities. Finally, in 1991 NSF created the *Program for Persons with Disabilities*, a demonstration project to fund initiatives that reduce structural barriers to education and employment facilities for persons with disabilities.

[7] *Annual Report of the National Science Foundation Committee on Equal Opportunities in Science and Engineering*, October 1982, p. 20.
[8] Ibid., p. 10.
[9] *Third Report of the National Science Foundation Committee on Equal Opportunities in Science and Engineering*, April 1986, p. 13.

Changes in STEM Participation

As NSF continued during the 1980s and early 1990s to initiate new programs and program changes to increase participation of underrepresented groups in STEM, the number of women and minorities entering the education pipeline and attaining undergraduate and graduate degrees in science and engineering increased.[10] However, little or no change in the demographics of the STEM workforce occurred for these groups, as reflected in statistics reported in NSF's annual report: *Women, Minorities, and Persons With Disabilities in Science and Engineering:* 2000. According to this report, many of the workplace conditions that existed in 1982 existed into the 1990s. For women, the same issues of lack of access to training and parity in employment that were underscored in the CEOSE findings of 1981 persisted and were underscored in the Committee's 1992 findings. CEOSE's recommendations to NSF also essentially remained the same throughout the 1980s and early 1990s.

For minorities, the lack of access to education and employment opportunities, as well as lack of disaggregated data for finer programming to meet the needs of minorities continued to top the list of CEOSE's findings in 1981 and 1992. Therefore, recommendations to improve the situation for minorities remained essentially unchanged throughout this period.

For persons with disabilities, the scenario was the same. The major findings in 1982 and 1992 were limited access to education and employment opportunities, lack of accessibility to facilities and technologies, and lack of data on the needs and achievements of disabled persons. Once again, the recommendations for corrective actions for this underrepresented group remained unchanged throughout the first 13 years of CEOSE.

It became increasingly clear to the members of CEOSE that although NSF had initiated a number of program interventions, significant changes in workforce participation levels for underutilized groups would require time. The very process of educating and training scientists and engineers is in itself time consuming. Given the re-occurrence of the same or similar findings and recommendations, CEOSE needed to adopt a long-term view and strategy for change. CEOSE's journey toward greater diversity in STEM, therefore, assumed a new plan of navigation. In 1992, CEOSE began to formulate its recommendations in terms of long range goals with measurable guideposts. For instance, instead of simply urging NSF to support efforts to increase employment and education opportunities in STEM, it recommended that NSF support efforts to triple the number of minority science and mathematics teachers by the year 2000; double the number of women science faculty by the year 2000; and, reduce the achievement gap in science and mathematics between males and females as well as between whites and racial minorities by one-half by the year 2010.[11] This approach was in keeping with the NSF's strategic planning and performance process, which was initiated the following year, pursuant to the Government Performance and Results Act of 1993 (GPRA).

[10] Science and Engineering Degrees: 1966-2001 (gender data); and *Women, Minorities, and Persons with Disabilities in Science and Engineering.* 1982 (race data). National Science Foundation.

[11] *Goals for The Coming Years: Committee on Equal Opportunities in Science and Engineering,* 1992, p. 6.

Period from 1993 to 2002

The second decade of CEOSE witnessed a continuation of the same concerns that were documented during the initial years of CEOSE.[12] Lack of or limited access to education, training and employment opportunities in science and engineering continued to be major concerns for women, minorities, and persons with disabilities. Throughout the 1993-2002 period, CEOSE continued to urge NSF to maintain its support of policies and programs that specifically address the performance goals established in 1992 to help increase the participation levels in STEM. In addition to programs specifically targeted to underrepresented groups, CEOSE also recommended that diversity efforts be embedded within all directorate programs of NSF in order to mainstream diversity within the Foundation. Evaluation of NSF's programs was also of major concern to the Committee. Without evaluation data, it was difficult for CEOSE to discern what was working and was not and where improvements should be made in the programs to maximize their impact.

In response to CEOSE's recommendations, NSF continued to expand its programs and policies to support equal opportunities in STEM. The Foundation funded several new programs recommended or endorsed by CEOSE. These programs included:

- *Urban Systemic Initiatives*, a pre-college program that targets high schools in 28 cities;
- *Louis Stokes Alliances for Minority Participation*, a multidisciplinary undergraduate program designed to help increase minority undergraduates in the sciences;
- *Research Experiences for Undergraduates*, a program for all groups that provides hands on training in research;
- *Program for Disabled Persons*, which provides an array of services to assist disabled students with training in research and other assistance;
- *Centers of Research Excellence in Science and Technology*, a program that supports improvements in research infrastructure in minority institutions;
- *Graduate Teaching Fellows in K-12 Education*, a program that partners graduate STEM students with K-12 teachers to improve teaching quality in science and mathematics in middle and high schools;
- *Professional Opportunities for Women in Research and Education*, a program that supports activities to promote the development of scholarly leaders in research;
- *Integrative Graduate Education and Research Traineeship*, a program that provides hands on experience in state-of the-art research methodologies and technologies; and
- *ADVANCE*, a program designed to help women prepare for leadership roles in STEM academia and business.

[12] The 1992 performance goals are listed in Appendix D of this report: Assessment of CEOSE Findings and Recommendations for 1991-1992.

Some of these program initiatives have demonstrated varying degrees of effectiveness. While CEOSE endorsed many of the programs based on their potential or available evaluation data, the Committee has requested that more systematic evaluation feedback be provided in order to further discern the effectiveness of these programs and their impact on participation rates.[13]

A major policy effort was initiated in 1997, when NSF introduced a change in the merit-review process for grant applications (broader-impacts criterion). As noted earlier in this report, the broader-impacts criterion requires that applicants specifically address the broad societal impact of their proposals, which includes how the proposed project would help increase participation of underrepresented groups in STEM. CEOSE recommended that diversity as a broad impact concern be included in the broader-impact criterion policy.

Initially, this merit-review policy met with some resistance and misunderstanding on the part of grantees. CEOSE's findings clearly showed that the compliance with the broader-impacts criterion needed to be better enforced. As a result of the Committee's urgings, the NSF Director issued in 2002 Important Notice 127, which requires grant applicants to respond to broader-impacts criterion in the Project Summary as well as in the Proposal Description sections of all grant applications, and that failure to do so would automatically disqualify the proposal from consideration.

In another policy change that was part of its GPRA strategic plan, NSF set specific goals to increase diversity throughout the Foundation. According to a 1999 report from NSF's Committee of Visitors, NSF generally met its internal organizational diversity goals.[14] Broader-impacts criterion and the new GPRA staffing goals are examples of NSF's policy enhancement actions.

Changes in STEM Participation

Participation in STEM education improved for women and underrepresented minorities between 1993 and 2001.

During the second decade of CEOSE, some improvements occurred in the level of participation of underrepresented groups in STEM education. As shown in Table 3-7, the percentage of Bachelor's Degrees in science and engineering awarded to American women increased significantly between 1993 and 2001 from 45.3% to 51.1%. The percentage of doctorates awarded to American women increased from 36.3% to 42.2%. During this same period, the percentage of Bachelor's Degrees awarded to underrepresented minorities also increased. African Americans awarded a bachelor's grew from 6.5% to 8.6%, Hispanics from 4.9% to 7.3%, and Native Americans, from 0.5% to 0.7%. The percentage of doctorates awarded to these minority groups also increased between 1993 and 2001. The increase for African Americans was from 3% to 4.3%, for Hispanics, from 3.2% to 4.1% and for Native Americans, from 0.2% to 0.5%. However, the percentage of African Americans, Hispanics, and Native Americans awarded a doctorate in STEM remained low, compared, for example, to white Americans who were awarded 82.7% of the STEM doctorates in 1993 and 78.1% in 2001.

[13] *Committee on Equal Opportunities in Science and Engineering-2000 Biennial Report to The United States Congress,* p. 37.
[14] Ibid., p. 38.

Finally, the employment data in Table 3-7 show that women and underrepresented minorities only marginally increased their presence in the science and engineering workforce between 1993 and 2001. The percentage of women in the STEM workforce increased from 22.9% to 25.4%, African Americans from 3.6% to 4.4%, Hispanics from 2.9% to 3.4%, and Native Americans/Alaskan Natives from 0.2% to 0.3%.

Table 3-7

Selected Indicators of Change in STEM Participation of Women and Underrepresented Minorities among U.S. Citizens and Permanent Residents: 1993 versus 2001

Indicator	Percent 1993	Percent 2001
Women awarded a Bachelor's Degree in S&E	45.3[1]	51.1[7]
Women awarded a doctorate in S&E	36.3[2]	42.2[8]
Women scientists and engineers employed in S&E workforce	22.9[3]	25.4[9]
Bachelor's Degree in S&E awarded to:		
- African Americans	6.5[4]	8.6[10]
- Hispanic Americans	4.9	7.3
- Native Americans/Alaskan Natives	0.5	0.7
Doctorate in S&E awarded to:		
- African Americans	3.0[5]	4.3[11]
- Hispanic Americans	3.2	4.1
- Native Americans/Alaskan Natives	0.2	0.5
Scientists and engineers employed in S&E workforce:		
- African Americans	3.6[6]	4.4[12]
- Hispanic Americans	2.9	3.4
- Native Americans/Alaskan Natives	0.2	0.3

[1] *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2002.* National Science Foundation, page 160-2, Table 3-15.
[2] Same source as Note1, page 227, Table 5-16.
[3] Same source as Note 1, page 249, Table 6-1. Percentage includes all women in U.S. S&E workforce, and may therefore be an over-estimate of women who are U.S. citizens and permanent residents.
[4] Same source as Note 1, pages 160-165, Tables 3-15 and 3-16.
[5] Same source as Note 1, page 227, Table 5-16.
[6] Same as Note 3.
[7] *Women, Minorities, and Persons With Disabilities in Science and Engineering: 2004*, page 56, Table C-13.
[8] Same as Note 5.
[9] Same source as Note 7, page 176, Table H-1. Data are for 2000.
[10] Same source as Note 5, pages 46-47, Table C-6.
[11] Same source as Note 5, pages 147-148, Table F-11.
[12] Same as Note 9.

CONCLUSIONS

To address the shortage of scientists and engineers and the underutilization of women, minorities, and persons with disabilities in the STEM workforce, Congress enacted the Science and Engineering Equal Opportunities Act in 1980. The law authorized the National Science Foundation to seek and support ways to improve the participation of these underutilized groups in science and engineering. The Foundation was also authorized to establish the Committee on Equal Opportunities in Science and Engineering (CEOSE). The specific purpose of CEOSE is to advise the Foundation based on its findings and recommendations.

The aim of the present study was to review and summarize the findings and recommendations of CEOSE during the period of 1993 and 2002, as well as the Committee's first 13 years of operation. Overall, CEOSE has succeeded over the last two decades in its mission to gather quality information about the underrepresented groups in science and engineering and to formulate recommendations for the Foundation to consider in its quest to help increase the size and diversity of the country's pool of scientists and engineers. Three major questions guided the study. The answers obtained to these questions are as follows:

What was the nature of the CEOSE findings and recommendations?

The overarching problem faced by the underrepresented groups has been the lack of access to education, training, and employment opportunities within the science, technology, engineering, and mathematics (STEM) fields. During both the periods from 1980 to 1992 and 1993 to 2002, CEOSE continued to collect a plethora of research data, statistics, and expert testimony on the extent of and reasons for the underrepresentation of women, minorities, and persons with disabilities within the STEM professions. These findings have not only broadened the Committee's understanding of the underrepresentation problem, but have also increased CEOSE's insights into the access barriers that hinder the utilization of scientific talent within America's diverse citizenry.

CEOSE's overall recommendations to the Foundation during the period under study were based on its findings that (1) unless underutilized groups of Americans are prepared as scientists and engineers, the country's scientific infrastructure, economic advancement, and national security will be in jeopardy; and (2) policy and program plans to improve the preparation and employment of the underrepresented groups should be further supported and evaluated.

Were there any significant changes in the response of NSF to CEOSE recommendations during the period under study?

Because of the relative sameness of CEOSE's findings, the Committee's recommendations also remained relatively unchanged during the last ten years under review. Actually, the Committee continued to make virtually the same major recommendations that it made during its beginning, namely, that greater and sustained attention needs to be paid to removing barriers faced by women, minorities, and disabled persons who want to enter the science and engineering professions.

CEOSE continued to urge the Foundation to provide the Committee with more and better data on the underrepresented groups, particularly persons with disabilities. While the Foundation has made significant progress in its data collection efforts, more disaggregated demographic data, especially on small populations, are needed to better focus the Committee's efforts.

Recommendations made by the Committee are reflected in several changes in diversity-related NSF policies and programs, especially during the 1993 to 2002 period. Some of these changes were (1) initiation of new NSF policies to increase numbers of grant applicants from the underrepresented groups; (2) revision of the merit-review system to encourage grant applicants to address issues of broader social impact, including diversity; (3) development of NSF staff awareness initiatives; and (4) holding NSF directorates accountable for their efforts to increase participation levels of underrepresented groups in NSF-supported programs.

The Foundation added many programs between the early 1990s and 2002 in areas of CEOSE concerns about program interventions. These programs targeted a wide spectrum of problem areas, e.g., lack of quality science and mathematics teachers in middle and high schools; unavailability of information in high schools and colleges about STEM careers; absence of mentors and role models for women, minority, and disabled science and mathematics students; low number of doctorates awarded to women, minorities, and persons with disabilities; deficiencies in the research infrastructure of minority-serving institutions; lack of accessibility for disabled persons to facilities and technologies; and lack of parity between women and men, as well as majority and minority faculty in the science and engineering departments of our universities.

Some of these programs were evaluated and found to be effective in realizing their particular objectives. Others are currently being evaluated. But, the question remains as to what impact these interventions have had on the participation rates for women, minorities, and persons with disabilities in the STEM pipeline and workforce. Further research is needed to answer this question.

Were there any changes in the participation of the underrepresented groups within the science and engineering fields?

Between the early 1990s and 2001, both women and minorities increased their participation in science and engineering education. (see Table 3-7). There were no reliable data to determine the change in the participation of persons with disabilities within STEM.

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

"We must recognize that when we make...choices we are giving priority to some values and not to others. We could choose other goals...a different mix of applied science vs. basic science, for example. Whatever our decisions, we are making value choices. Science, then, is not now, nor has it ever been, value-free. That is because science involves public policy choice...[S]ocial scientists teach us that collective decision-making processes are more likely to lead to outcomes that the whole community can support if decision-makers have had a chance to consider an array of diagnoses of 'the problem requiring action.' That argument alone is sufficient justification for broadening and diversifying the pool of those who do science in this country".

Mary Sue Coleman[1]

[1] Mary Sue Coleman, "And Miles to Go Before We Sleep: the Unfinished Journey of Women in Science," speech at the Women's Hall of Fame Induction, Friends of the Iowa Council on the Status of Women, University of Iowa, 1996.

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, of disabled persons, motivated Congress to enact the Science and Engineering Equal Opportunities Act of 1980, which created the Committee on Equal Opportunity in Science and Engineering (CEOSE). Subsequently, the National Science Foundation (NSF) and its grantee community have paid more attention to increasing these underrepresented groups in higher numbers and percentages in science, technology, engineering, and mathematics (STEM). Programs designed and funded by NSF and deliberations and actions of committees, such as CEOSE, have contributed to some increase in the participation of underrepresented groups in STEM disciplines (Figure 4-1).

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

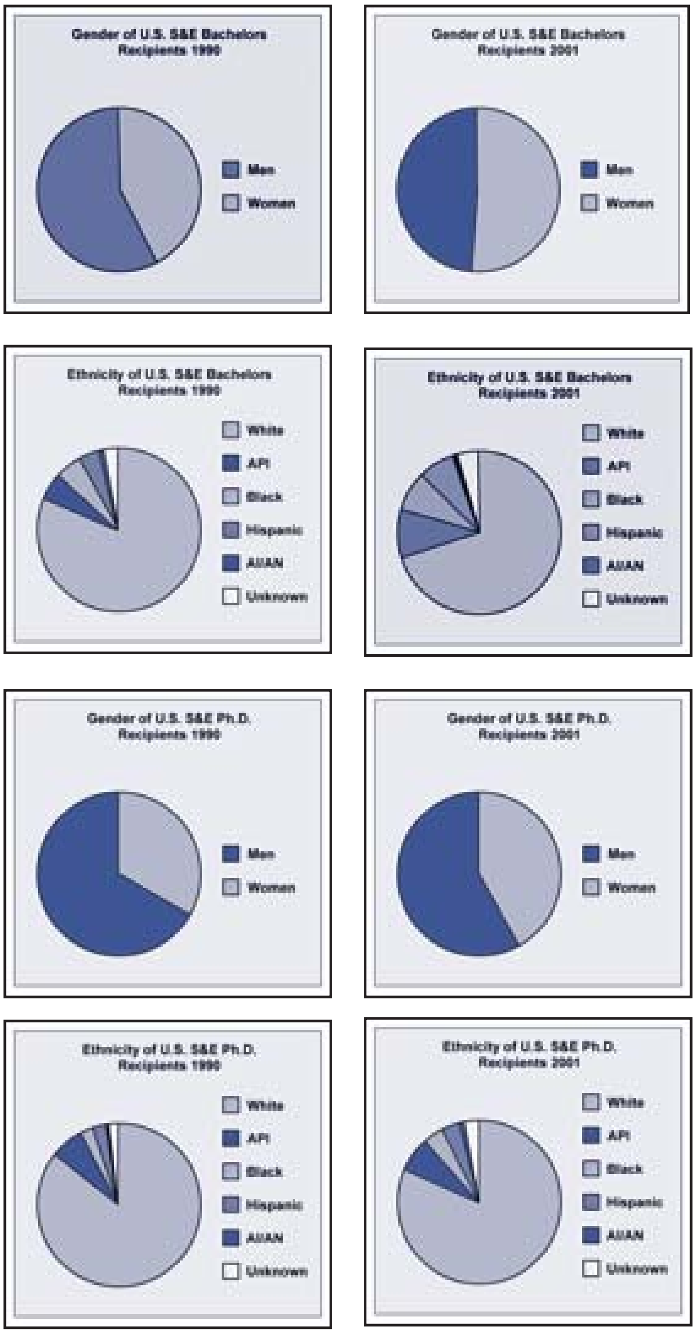
Previous chapters summarize the past and present NSF policies aimed at broadening participation; analyze the trends in participation during the past decade (1994-2003); and review CEOSE's findings and recommendations during its first 23 years (1980-2002). This chapter highlights and integrates conclusions and analyses from the previous chapters and interweaves them with insights, findings, and recommendations from CEOSE's deliberations in the past two years (2003-2004). Hence, this chapter is CEOSE's 2004 Biennial Report.

Historical Progress in Understanding the Problems of Underrepresentation

Research conducted over the past two decades has begun to reveal some critical insights into many aspects of underrepresentation in STEM disciplines. One rich source of statistical data is the series of NSF biennial reports, first published in 1982, on Women, Minorities, and Persons with Disabilities in Science and Engineering in the United States. The twelfth volume in this series was published in 2004, and is the source of much of the data presented in Chapter 2.

Figure 4-1

Share of STEM Bachelor's Degrees and Ph.D.s Earned by Women and Underrepresented Minorities in 1990 and 2001



Since 1990, there have been noticeable gains in the share of STEM Bachelor's Degrees and Ph.D.s earned by U.S. citizens and permanent residents. Total Bachelor's = 333,475 in 1990 and 384,492 in 2001 (Reference NSF03-312). Total Doctorates = 15,364 in 1990 and 16,262 in 2001 (Reference NSF04-317).

From Pipelines to Pathways

In her 1988 AAAS Presidential Lecture,[2] Sheila Widnall advanced the pipeline metaphor to describe the attrition of girls and women from science and engineering. The "leaky pipeline" and the reasons why girls do not choose the mathematics courses that enable their progression into STEM careers have been the subjects of numerous books and articles and formed a central theme of the deliberations of CEOSE through the late 1980s until the mid-1990s.

The "pipeline" metaphor is based on a statistical approach to examining the persistence of women, minorities and persons with disabilities in STEM disciplines. The approach 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. The "pipeline" metaphor is at best incomplete in that it assumes that the propelling forces for STEM access and advancement are only on the front end—a push—rather than recognizing that there may be plugs at the other end, and that there are multiple branches leading to premature exits. For example, one of the barriers to STEM participation by talented minority students has been shown to be the perceived lack of attractive science and engineering career opportunities. Several points of this lack of attractiveness have been discussed by Zumeta and Raveling[3] and formed part of the deliberations of CEOSE in 2003. Among the points discussed by the authors are: (1) expected long apprenticeship time (7 to 9 years for Ph.D. and postdoctoral training[4]); (2) inadequate compensation during these years, and (3) uncertain prospects for autonomous research positions at the end of the training period. In addition, lack of family "wealth" to support long periods of education, dearth of mentors, and a lack of support and encouragement to publish papers, were factors raised by CEOSE members. Projects funded by NSF programs such as *AGEP (Alliances for Graduate Education and the Professoriate)* do stress the necessity of early and continuing publications during graduate study as vital for launching a STEM career. CEOSE discussions also identified the need to provide students with information about diverse STEM careers outside academia.

The pipeline metaphor became a part of the common parlance in STEM education, and there was an unstated assumption that pipeline issues were the same or at least similar for all underrepresented populations - with attention paid primarily to women and minorities in the 1980s and early 1990s, extending also to persons with disabilities since about 1997. Thus, until recently, few studies of racial/ethnic minorities included any discussions on women; and few studies of women included any discussions of ethnic/racial minorities. Numerous scholars -Shirley Malcom, Shirley McBay, Cheryl Leggon, Daniel Solarzano, Beatriz Clewell, and Willie Pearson, Jr., among them—have long written and publicly called for the disaggregation of data to demonstrate variations within and across

[2] Sheila Widnall, "AAAS Presidential Lecture: Voices from the Pipeline," *Science*, 241, pp. 1740-1745, 1988.

[3] William Zumeta and Joyce Raveling, "Attracting the Best and the Brightest," *Issues in Science and Technology,* Winter 2002.

[4] *Doctorate Recipients from United States Universities: Summary Report 2003,* NORC at the University of Chicago (2004) measured the median elapsed time from baccalaureate to doctorate for students earning a research doctorate in 2003. For science/engineering doctorates, this period was seven years of registered time and under nine years of calendar time. For humanities doctorates, the median duration was nine years of registered time and over eleven years of calendar time, while for all non-STEM fields the median interval was just under nine years of registered time and over thirteen years of elapsed calendar time.

groups.[5] Yet, the recognition is just dawning in the general academic community that each underrepresented group is in itself diverse, and that it is important to be able to separate and understand the possibly different underlying factors related to the underrepresentation of the different groups and subgroups.

Today, many efforts to make science and engineering more inclusive are focusing attention on 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 to keep learning mathematics and science (retention), and what then leads students to graduate (persistence) and continue into STEM careers (attachment).

Detailed ethnographic studies, oral histories and some systematic social science research have led to the understanding that to address issues of retention, persistence, and attachment on the individual level, the diversity of "pathways in science" have to be recognized and understood. Among the earliest works on attrition at the college level is that by Tinto, who in 1975, identified the factors associated with attrition.[6] Among the factors he identified are (1) lack of preparation; (2) external commitments; (3) social isolation, (4) financial need; (5) interaction with faculty; and (6) academic failure. The importance of these factors is magnified for students from underrepresented populations pursuing STEM majors. The Wellesley Pathways project[7] on a longitudinal study of students' entry and persistence and Elaine Seymour's studies of students who are "leavers" and "stayers" among science majors,[8] made educators increasingly aware of the different routes to STEM careers and the need for allowing and even encouraging a rich variety of pathways.

[5] Anne J. MacLachlan, "The Lives and Careers of Minority Women Scientists," http://cshe.berkeley.edu/projects/minority/livesandcareers.htm, Minority Ph.D. Project, Center for Studies in Higher Education, University of California, Berkeley. Anne MacLachlan, "Research on Addressing Institutional Challenges in Science and Engineering to Increase Faculty of Color," "Keeping Our Faculties: Addressing the recruitment and retention of faculty of color," The University of Minnesota, Nov. 18, 2004.
http://www.oma.umn.edu/kof/conference.html and http://www.vanderbilt.edu/csma/newsletter/KOF_bib.pdf
Sandra Harding, editor (1993). *The Racial Economy of Science: Toward a Democratic Future.* Bloomington: Indiana U. Press. Shirley Malcom, Paula Hall, and Janet Brown, *The Double Bind: The Price of Being a Minority Woman in Science.* Washington, DC: AAAS, 1976. Beatriz Clewell and Angela Ginorio (1996), "Examining Women's Progress in the Sciences from the Perspective of Diversity," in Cinda Sue Davis, et al., *The Equity Equation, Fostering the Advancement of Women in the Sciences, Mathematics, and Engineering*. San Francisco: Jossey-Bass. D. G. Solarzano (1994), "The baccalaureate origins of Chicana and Chicano scientists in the physical, life, and engineering sciences: 1980-1990." *J. of Women and Minorities in Science and Engineering.* 1:253-272. Maricel Quintana-Baker (2002), "A Profile of Mexican American, Puerto Rican and other Hispanic STEM Doctorates: 1983 to 1997." *J. of Women and Minorities in Science and Engineering*, 8:99-121. Cheryl B. Leggon (1987), "Minority Underrepresentation in Science and Engineering Graduate Education and Careers." In L. S. Dix, editor, *Minorities: Their Underrepresentation Career Differentials in Science and Engineering*. Washington, DC: National Academy Press.

[6] Tinto, V. (1975). "Dropout from higher education: a theoretical synthesis of recent research," *Review of Educational Research,* 45, 89-125; Tinto, V. (1987 and 1993). *Leaving College: Rethinking the Causes and Cures of Student Attrition.* (1st and 2nd ed.). Chicago: University of Chicago Press.

[7] Paula Rayman, Belle Brett (1993). *Pathways for Women in the Sciences: The Wellesley Report, Part I;* and Janet T. Civian, Paula Rayman, and Belle Brett (1997) *Pathways for Women in the Sciences, The Wellesley Report, Part II.*

[8] Elaine Seymour and Nancy Hewitt (1997), *Talking About Leaving: Why Undergraduates Leave the Sciences*. Boulder, CO: Westview Press.

The early deliberations of CEOSE and NSF identified several factors for the early attrition of females and minorities from a STEM pathway: lack of qualified mathematics and science teachers, discouragement by guidance counselors, the perceived irrelevance of science and mathematics to their daily lives, a lack of public understanding of science, and peer pressure. In combination, these factors led students to opt out of "science and math" tracks as early as middle and high school. Thus, many programs designed by NSF and other agencies to broaden participation addressed these issues. Teacher professional development, standards and frameworks for teaching mathematics and science, and programs to motivate young children by making science and mathematics more inviting were parts of the multi-faceted response to the problem of early attrition from STEM education.

CEOSE has come to realize that broadening participation will require addressing a variety of pathways issues, such as the broad range of "ways of knowing,"[9] , factors that hamper access or progress, gatekeepers and gate-openers, and the development of a rich variety of paths to invite and guide many persons from underrepresented groups to reach STEM careers. The standard preparation for a STEM career traditionally pursued by a relatively homogeneous group of people who acquired competencies one after the other successfully to reach the heights of the career, has effectively excluded those not following this path.

From Individual Support to Institutional Transformation

Social science research and ethnographic studies over the past two decades have revealed some of the factors that influence women and minorities in STEM disciplines. This information is guiding the design and articulation of a handful of programs in higher education to focus on institutional transformation, in addition to assistance to individuals. Whereas support and encouragement for individuals are necessary, it has become clear that they are insufficient to attract, retain, and advance women, minorities, and persons with disabilities in STEM fields. As Bernice Sanders articulated in the 1980s, specific aspects of the environment at institutions engaged in science and engineering create a "chilly climate"[10] for members of traditionally underrepresented groups. Nonetheless, the approach to broadening participation through most of 1990s focused predominantly on recruiting, encouraging, and supporting individuals.

Today, attention is increasingly paid to those aspects of the nature of STEM institutions that have led to the near-exclusion of women, minorities, and disabled persons. More emphasis is beginning to be placed on changes that must occur in the ways of doing and teaching science and engineering and in the environment for STEM within higher education and other institutions. Since the 1980s, several researchers have chronicled the discrimination faced by women and minorities in the STEM

[9] Mary Belenky, Blythe Clinchy, Nancy Goldberger, Jill Tarule (1986), *Women's Ways of Knowing: The Development of Self, Voice and Mind.* New York: Basic Books. Reissued 1997.

[10] Roberta M. Hall and Bernice R. Sandler (1985), "A Chilly Climate in the Classroom," in Aloce Sargent (ed.) *Beyond Sex Roles,* 2nd edition. 503-510; see http://bernicesandler.com/.

workforce. It was not until 1999, however, that Nancy Hopkins' study of the environment for women faculty at MIT[11] brought the issue of the pervasiveness and subtlety of institutional discrimination to public attention. Despite systematic increases in the numbers and percentages of STEM Ph.D.s earned by women and underrepresented racial and ethnic minority group members, the demographic profile of STEM faculty at research-intensive educational institutions remains markedly homogeneous.[12,13]

While the individual-based programs tend to emphasize attraction, retention, and financial support, anecdotal evidence suggests that successful institutional transformation emphasizes factors affecting persistence and attachment of students and professionals. These factors include curriculum, teaching approaches, mentoring, career opportunities, role models, decision-making, reward structure, resource allocation, ways of collaborating, and overcoming low societal expectations 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 limited both by inertia in each institution's system and by a dearth of knowledge about specific factors and their effects. Institutional change is also hampered by an inability or unwillingness to identify and create appropriate incentives to the faculty members, who are the gatekeepers for both the institution and the discipline. It is essential that institutions develop the capacity and expertise to identify and enable people who will champion and catalyze change. Clearly, more social science research is needed before all factors can be understood and addressed.

Several anecdotal examples, some not very well known, show that curricular design, climate, and mentoring can make a significant difference in broadening participation. For example, the late Henry C. McBay of Morehouse College, devised a chemistry curriculum that led more than 45 African American students to earn chemistry Ph.D.s from the nation's most selective institutions. Isiah Warner has led the change in climate and priority at Louisiana State University that made its Department of Chemistry one of the top producers of African American Ph.D. recipients in chemistry.[14] In the 1980s, the late Anna Harrison's reforms of the science curriculum at Mount Holyoke College increased retention of women students.[15] At Spelman College, the faculty transformed the

[11] "Study on the Status of Women Faculty in Science at MIT," MIT March 1999; http://web.mit.edu/fnl/women/women.pdf. Hopkins and colleagues analyzed data and interviews that showed that female faculty were marginalized through inequities in allocation of resources and exclusion from decision-making.

[12] Helen S. Astin and Christine M. Cress (2002), "A National Profile of Academic Women in Research Universities," in Lilli Hornig (ed), *Equal Rites, Unequal Outcomes: Women in America.* New York: Kluwer Academic/Plenum Publishers.

[13] Cheryl B. Leggon, (1987), "Minority Underrepresentation in Science and Engineering Graduate Education and Careers," in L. S. Dix (ed), *Minorities: Their Underrepresentaion Career Differentials in Science and Engineering.* Washington, DC: National Academy Press.

[14] *Minorities in the Chemical Workforce: Diversity Models that Work*, a Workshop Report to the Chemical Sciences Roundtable. (2003). Washington, DC: National Academy Press.

[15] Anna Harrison, "*An Exploration of the Nature and Quality of Undergraduate Education in Science, Mathematics and Engineering;"* 1989 Wingspread report resulting from a conference sponsored by the NSF and the Johnson Foundation and published by Sigma Xi, is still considered a seminal document in education reform circles.

curriculum to produce "science-savvy citizens."[16] More than a third of Spelman's students major in STEM disciplines. Bryn Mawr College is well known for its numbers and percentages of women graduates who continue their education through the Ph.D. in many fields of science. Some recent projects have designed and assessed learning in "female-friendly" curricula at the college level notably by Sue Rosser in Biology and Allan Fisher in Computer Science.[17] These examples suggest that curricula that recognize and take advantage of the broad range of student motivation and learning patterns result in increased learning and motivation. These types of programs or activities are not widespread, but could provide models for elements of a larger movement toward institutional transformation initiatives.

From the standpoint of providing underrepresented role models for students and early-career staff members, roles models are important for attachment and persistence of students and early-career faculty and staff. An institution with faculty, senior scientists, engineers, managers, and administrators in STEM areas from underrepresented groups provides an image of the profession as one that is diverse and a climate that is inclusive. CEOSE has become convinced that the common complaint from institutions and search committees that they are not able to find "qualified candidates" from underrepresented populations may be a "supply-side myth," that attempts to explain or excuse a university's inability to diversify. The fact is that Ph.D. production of underrepresented racial and ethnic minority group members has been increasing systematically, though modestly. Increasing numbers of minority Ph.D.s are finding employment in non-academic STEM positions. Why not also in academe, where students with increasingly diverse demographics could see these role models and identify with their professional examples?

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 transition from focusing primarily on individuals to enabling institutional change was driven, in part, by legal challenges and the realization that the encouraged and well-prepared individuals from

[16] Sylvia Bozeman, "General Science Education Courses at a Four-Year Institution," *Project Kaleidoscope 10th Anniversary: Celebrating and Anticipating a Decade of Reform.* College Park, Maryland, October 22-23, 1999.

[17] Sue Rosser (1990), "Female-Friendly Science: Applying Women's Studies Methods and Theories to Attract Students,*" Athene Series in Women's Studies. New York:* Teachers College Press;. also, Sue Rosser (1997), *Re-Engineering Female-Friendly Science. New York:* Teachers College Press. Allan Fisher and Jane Margolis (2000), *Unlocking the Clubhouse.* Cambridge, MA: MIT Press.

underrepresented groups faced subtle and often unconscious institutional barriers that hindered their career progress. Institutional transformation is always slow, but many factors exacerbate this problem in the STEM disciplines. These factors include: lack of access to proper foundational education, to mentoring, and to role models; perception that the required long periods of preparation do not lead to attractive careers in the sciences; and "hidden" cultural factors in the institutions of higher learning and research. Several of these factors have been the focus of CEOSE deliberations and are discussed throughout this report.

NSF's DMR-supported *Partnership for Research and Education in Materials (PREM)* for MSIs.

The challenge of designing and implementing institutional transformation that will promote and sustain inclusion is hampered by inertia in each institution, a dearth of knowledge about specific institutional factors and their effects, and numerous hidden biases. Trans-forming institutions without eliminating or at least substantially reducing bias is unlikely to yield lasting improvements for underrepresented groups. Tenured faculty at major research universities play a central gatekeeping role in defining what is and what is not "good science" and who is "qualified." In addition, informal networks of advisors and mentors are critical for referring a qualified candidate for a faculty opening. These aspects of the academy underscore the need for a strong mentoring system that will give underrepresented students access to the established networks. This situation makes it critical that all groups be represented equitably on the faculty, if change is to be institutionalized.

Additional systematic social science research needs to be conducted, and the existing research on systemic biases needs to be understood by decision-makers—particularly administrators at the leading research universities—to help them chart and then follow a course toward equity, opportunity, and access. Fortunately, several efforts are underway that can assist, at least, in recruiting. For example, the University of South Carolina, the Council of Graduate Schools and the Educational Testing Service are collaborating to establish a portal for a database that will contain information on underrepresented minorities in all disciplines and at all levels.[18]

Although institutional transformation is a slow and hard process, still in only its early stages, it will be essential to sustain improvement. For example, despite the increased proportion of Ph.D.s being earned by women and minorities at prestigious departments in a broad range of science and engineering fields (see Figure 4-1 in this Chapter), the demographic profile of the faculty at these leading institutions remains virtually unchanged.[19] Some of the key research findings on institutional factors are:

[18] http://www.cgsnet.org/.

- Mentoring,
- The role of policy levers properly implemented, and
- The role of minority-serving institutions, and community colleges in providing access to STEM careers, especially for underrepresented racial and ethnic minorities.

These factors have long been of interest to CEOSE, which commends NSF for recognizing their importance and configuring programs to drive institutional transformation in STEM. Additional discussion of these factors is highlighted in the section on CEOSE's 2003-2004 activities.

A National Imperative

One consequence of the global war on terror and heightened concerns about national security is that currently it is more difficult for foreign nationals to enter the U.S. to pursue graduate study and for employment. Since foreign nationals have recently composed a significant fraction of our STEM graduate students, postdoctoral fellows, and high-tech workforce, the entry restrictions and lengthy visa delays are leading to projections of shortages of foreign scientists and engineers. Many of these foreign nationals support the science and technology infrastructure of the U.S., and contribute to its competitiveness. These students are now choosing to conduct graduate study elsewhere.[20] These new concerns add urgency to the need to expand America's home-grown STEM talent pool. Thus, homeland and national security interests reiterate the vital importance of ensuring that all U.S. citizens have access and opportunities to engage in STEM careers, and further underscore the value of NSF's programs that work to broaden participation and invite talented Americans from all backgrounds and regions into STEM.

NSF Responses and Achievements to Broaden Participation

Chapter 1 focuses on the policies and programs implemented by NSF for broadening and increasing participation in STEM at all levels. The earliest such programs at NSF have existed since 1976, aiming to facilitate careers and graduate study in STEM. Among these are the *Science Career Workshops (SCW)* and *Minority Graduate Fellowships (MGF)*. Appendix B provides a timeline of NSF's major programs to broaden participation and reveals some of the trends outlined above. As understanding and data collection have progressed, NSF has modified its programs, taking advantage of the new knowledge. By pursuing a range and variety of programs, policies, and approaches, NSF has been generally successful in anticipating and addressing the needs of <u>all</u> people to be attracted to and supported in the STEM disciplines:

-- embedding diversity in its own hiring by ensuring that appointees are drawn from the entire pool of qualified scientists and engineers;

[19] Helen S. Astin and Christine M. Cress (2002), "A National Profile of Academic Women in Research Universities," in Lilli Hornig (ed), *Equal Rites, Unequal Outcomes: Women in America.* New York: Kluwer Academic/Plenum Publishers.

[20] Paul Mooney and Shailaja Neelakantan, "No Longer Dreaming of America," *Chronicle of Higher Education*, October 8, 2004.

-- programs for individual support such as scholarships and career facilitation projects;

-- programs that address groups of students early in their career preparation such as the highly successful *Research Experience for Undergraduates (REU)*;

-- policies such as merit-review criteria, which require proposals to document the anticipated broader impacts of the project;

-- support for experimental infrastructure for all institutions through the scientific research programs and through the Course, *Curriculum and Laboratory Improvement (CCLI)* programs, and specifically for supporting and linking minority institutions with research universities through the *Historically Black Colleges and Universities-Undergraduate Program (HBCU-UP)* and the *Tribal Colleges and Universities Program (TCUP), Research Improvement in Minority Institutions (RIMI) and Centers for Research Excellence in Science and Technology (CREST);*

-- programs, such as the *Louis Stokes Alliances for Minority Participation (LSAMP), the Alliances for Graduate Education and the Professoriate (AGEP)* and the *Bridges to the Doctorate*, which strengthen participants' sense of belonging to a "community of science" and address transition points with significant attrition.

-- programs that seek to advance the frontier of interdisciplinary research through collaboration, such as the *Engineering Research Centers (ERCs)*, Science and *Technology Centers (STCs)*, and Integrative Graduate *Education and Research Traineeship (IGERT).*

-- programs that work towards institutional transformation to make the climate of STEM disciplines inclusive and welcoming, such as *ADVANCE (Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers)* which is aimed at improving the institutional climate, especially for women and enabling them to advance to the ranks of leadership.

Appendix B shows that 1991 was a key year when NSF initiated several programs that addressed underrepresentation. The *LSAMP, RIMI and Program for Persons with Disabilities (PPD)* all came into being this year. The addition of a program to address the specific needs of persons with disabilities was an important new step in 1991. The period of 1999-2002 was another period of significant program initiation, representing an attempt to address institutional transformation at various levels. *IGERT, AGEP, HBCU-UP and TCUP* were all initiated during this 3-year period. While *IGERT* was not solely concerned with broadening participation, it had an underlying premise that interdisciplinary, socially relevant, research would attract and retain more of the young people with strong preparation in STEM.

In parallel, NSF went beyond special programs aimed specifically at broadening participation to embedding diversity explicitly throughout the Foundation—in the programs of all Directorates. In addition, the requirements for major interdisciplinary centers, such as *Engineering Research Centers (ERCs)* and Science and *Technology Centers (STCs)*, now explicitly include broadening participation, among other goals, along with mechanisms for accountability. Several other programs strongly encourage partnerships between major research universities and minority-serving institutions or community colleges.

In its efforts to model inclusiveness, NSF has increased the diversity of its STEM and support workforce. As Chapter 2 shows, NSF's science and engineering staff now includes a slightly higher representation of persons from traditionally underrepresented groups than does the U.S. STEM workforce overall. In addition, it appears that women, minorities, and persons with disabilities are participating in greater numbers and percentages as reviewers, panelists, and advisory committee members, though only a small fraction of these individuals have voluntarily provided this demographic information.

CEOSE Activities in 2003-2004

In addition to the preparation of this retrospective report, CEOSE engaged in wide-ranging discussions and updates,[21] focusing significant effort in six directions.

(1) <u>Research and Data:</u> Discussion of research needs; data sources, importance, and challenges; and possible uses of data for broadening participation;

(2) <u>Mentoring:</u> 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) <u>Policy Levers and Merit-Review Criteria:</u> Examination of the merit-review criterion related to broader impacts as a policy lever to broaden participation;

(4) <u>Role of Research Universities, NSF Grantee Institutions, and Centers in Broadening Participation:</u> Discussions of the role in broadening participation of the institutions that set the ethos of the STEM enterprise;

(5) <u>Tribal Colleges</u>: Firsthand examination of two tribal colleges to gain a deeper appreciation of the particular needs of this particular group of institutions; and

(6) <u>Community Colleges:</u> Discussion of the role of community colleges in broadening participation.

[21] Presentations from key NSF program officers and staff related to its work and presentations on related national initiatives are a principal feature of CEOSE meetings and inform its deliberations and activities. Major presentations, their dates, and the primary points highlighted in the presentations are listed in the two boxes in Appendix C, one summarizing presentations made by NSF staff, and the other by guest presenters. A large fraction of the information used in this chapter with regard to conclusions and recommendations arose from these presentations and subsequent discussions. Details are available in the minutes recorded at http://www.nsf.gov/od/oia/activities/ceose/.

Research and Data

The need for reliable data and rigorous social science research is obvious for informing and shaping policy and programmatic decisions. Despite significant efforts, the research base remains limited (especially on racial and ethnic minorities and persons with disabilities), and there are several challenges to obtaining reliable data. For example, there is a serious problem in matching disaggregated data along and across the STEM pathways, because the databases and surveys sampling different stages often classify or define groups differently. For some points along the pathways, the data combine both native-born and foreign-born individuals. At other points, it is not possible to isolate permanent residents among the foreign born. Clarity and specificity in these and other classifications are important in understanding the details of the domestic supply of STEM talent and in designing and evaluating the impact of policies. There are several unanswered or poorly answered research questions related to the factors and effects that promote or discourage participation in STEM by members of the various underrepresented groups, which have to be answered with disaggregated data.

With respect to demographic data on who is participating in STEM and in what roles, NSF's Division of Science Resources Statistics (SRS) is responsible for data and analyses on the entire U.S. science and engineering enterprise. SRS staff made several excellent presentations to CEOSE, to provide information and answer questions.

Several surveys are critical in maintaining the SRS database, SESTAT (Scientists and Engineers Statistical Data System), and producing the important biennial Report on Women, Minorities, and Persons with Disabilities in Science and Engineering. Among them are the:

- National Survey of Recent College Graduates (NSRCG), administered to individuals who received a Bachelor's or a Master's Degree in science or engineering (S&E) from a U.S. institution;
- National Survey of College Graduates (NSCG), administered to individuals who hold a degree in any field, based on a sample of individuals from the decennial census.
- Survey of Doctoral Recipients (SDR), administered to individuals who hold a doctorate in S&E from a U.S. institution, consisting of a sample of those who have responded to the Survey of Earned Doctorates (an annual census and survey of new recipients of research doctorates in all fields from U.S. institutions) over the years.

There are many policy concerns about correct measurement of the foreign-born component of the STEM supply. One is related to concerns about the dependence of the U.S. STEM enterprise on international sources that could be shut off or substantially reduced for any number of reasons in the future. For example, tightened visa restrictions since 9/11 have adversely affected the ability of many graduate schools to recruit top students from other nations. Another concern is related to correctly measuring progress toward improving the participation of U.S.-born racial and ethnic minority group members, who are often viewed interchangeably in some data sets with foreign-born, permanent residents of the same ethnicity. This confusion inflates the perception of "progress" toward improved representation.

Challenges to the usefulness and reliability of the databases, especially with regard to underrepresented populations include: poor survey response rates; classification errors with different surveys providing ambiguous data on factors such as citizenship or other demographics; the need to oversample some underrepresented populations and at the same time protect privacy; and severely constrained resources. With planning, revisions and redesign, the SRS is working to provide a reliable 2003 database despite these challenges.

The SRS data on women, underrepresented minorities, and persons with disabilities in STEM are a useful resource for policy studies and analysis. For example, the Committee on Women in Science and Engineering (CWSE) of the National Research Council (NRC) analyzed data collected by NSF and found, as discussed by many others and by CEOSE in particular, that the top research institutions (Research I, Carnegie Classification 1995) have the lowest percentage of women in their faculty.[22] This finding led to the current focus of CWSE on gender differences at research-intensive universities aimed at producing two reports: a guide that describes actions actually taken by research universities with stellar reputations, in order to improve the situation for women; and a congressionally-mandated study to examine gender differences in careers of science, engineering and mathematics faculty, focusing on Research I institutions of higher education.[23]

Two examples are provided in the accompanying insets to illustrate the importance of reliable disaggregated data in elucidating the issues of underrepresentation. The first examines the pipeline problem and the corresponding supply-side arguments specifically with respect to faculty candidates. The second is an example presented by a CEOSE member in 2003. It shows how data can be used in a scenario analysis of the rate of production of minority Ph.D.s needed to achieve parity or representation proportionate to population.

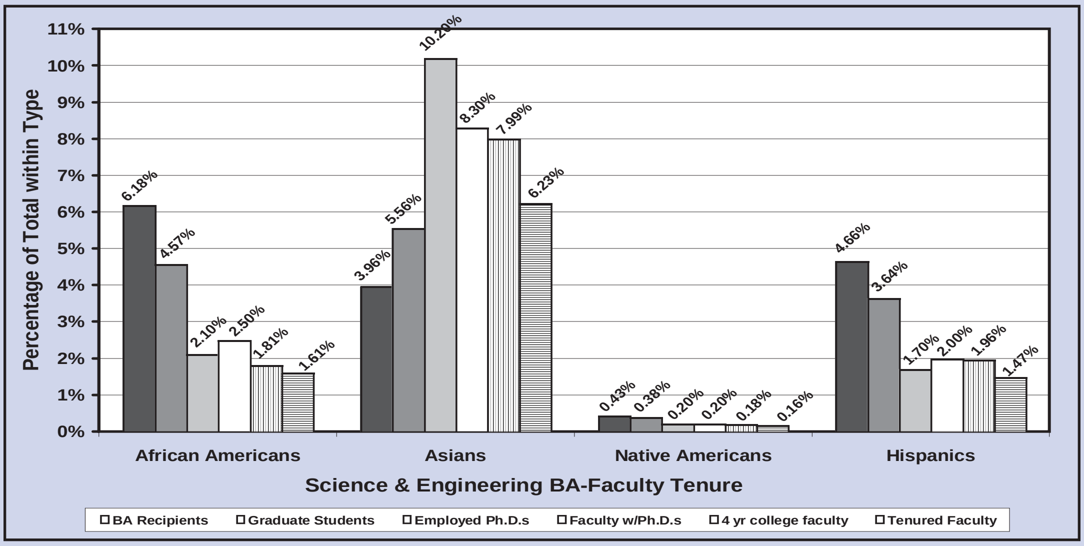
[22] *From Scarcity to Visibility: Gender Differences in the Careers of Doctoral Scientists and Engineers*. Washington, DC: Committee on Women in Science and Engineering, National Research Council, 2001.

[23] *"WOMEN IN HIGHER EDUCATION: Where the Elite Teach, It's Still A Man's World," Chronicle of Higher Education, December 3, 2004.*

Pipeline and Availability of Minority Candidates for Faculty Positions

Turner and Myers examined the pipeline from undergraduate degree recipients to tenured faculty in science and engineering fields.[24] Using 1991 data for U.S. citizens, they show that the pipeline differs among racial and ethnic groups. At every point along the pipeline there was substantial underrepresentation of African Americans, Native Americans, and Hispanics in the science and engineering fields. For these three groups, there was a slight decline in representation from the baccalaureate stage to the graduate student stage and then a steep decline in representation from the graduate student stage to faculty stage. The low representation of African Americans, Latinos, and Native Americans among tenured faculty mirrored the low representation of these groups among science and engineering Ph.D.s.

Figure 4-2. Pipeline from B.A. Recipiency to Tenure by Race and Ethnicity, U.S. Citizens, 1991 (Turner and Myers, 2000).



Among Asians, however, representation among science and engineering faculty was higher than it was among baccalaureate recipients or graduate students. Even among Asians, though, there was a steep drop-off between those with Ph.D.s and those who were tenured faculty.

Given the substantial underrepresentation among African Americans, Native Americans, and Hispanics from the undergraduate degree to the faculty ranks, it is understandable that some authors assume that the undersupply of minority Ph.D.s is the underlying factor explaining the undersupply of minority faculty. Turner and Myers test this supply-side hypothesis using 1990 census data. Although the analysis focuses on all faculty and not just science and technology faculty, they conclude that Ph.D. production has only a minor impact on minority faculty representation. Instead, they find that market factors, such as the attractiveness of non-academic employment influence faculty supply even more. The authors replicate the findings using 2000 data and confirm that the impacts of increased Ph.D. production on faculty representation are small. In one model which assumes that only African American Ph.D. production increases (i.e., all other Ph.D. recipiency rates by other races remains unchanged) a one percent increase in black Ph.D. recipiency rates will only increase black faculty representation by 20 percent.[25] In short, the undersupply of minority Ph.D.s is only a small part of the larger problem of the underrepresentation of minority faculty.

[24] Caroline S.V. Turner and Samuel L. Myers, Jr. (2000), *Faculty of Color in Academe: Bittersweet Success.* Needham, MA: Allyn and Bacon, p. 183.

[25] Samuel L. Myers, Jr. and Caroline S. Turner, The Effects of Ph.D. Supply on Minority Faculty Representation, *American Economic Review,* May 2004, Vol. 94, No. 2, p., 300.

Broadening Participation to Achieve Parity: An Exploratory Analysis

One CEOSE member described to CEOSE a scenario analysis of the rate of production of Ph.D.s among underrepresented minorities (URMs), and explored projections of the production rate that would be needed to reach parity with the presence of URMs in the population at large.[26]

The authors use SESTAT data to project the number of natural science and engineering (NS&E)[27] Bachelor's Degrees to be earned by URMs and majority individuals over the next 20 years, given the number of people in each group who would be about the right age for holding such a degree. In addition, they compare the number of NS&E Ph.D.s awarded to URMs and majority individuals per 100 NS&E Bachelor's Degrees earned currently, and make projections for the future. They also look separately at the situation for men and women in each group. This analysis is not adjusted for the decreasing rate at which the majority population is entering natural science and engineering fields.

The results put into context the slowness of the rate at which URM Ph.D. production is growing, despite the national effort. The authors find that despite dramatic increases in the number of degrees awarded to URMs between 1985 and 2000, in proportion to their population URMs still earn fewer than half as many NS&E Bachelor's Degrees as do whites. Looking at the fraction of NS&E bachelor's recipients who continue their education through the Ph.D., the authors note that URMs are only 68% as likely to do so as whites. This "parity ratio" of 0.68, being below 1.00, indicates that the STEM pipeline is leakier for URMs than for whites—a situation that has changed little over the years.

For women overall, representation in NS&E fields has increased steadily during the past decade. Interestingly, URM women earn a larger share of URM NS&E degrees than majority women earn of majority NS&E degrees. In 2000, URM women received 49% of URM NS&E Bachelor's Degrees and 41% of URM NS&E Ph.D.s, while majority women received only 39% of NS&E Bachelor's degrees among the majority and 29% of Ph.D.s. Research to understand the comparative success of URM women in NS&E may yield insights about factors that encourage or hinder URMs and women in NS&E.

This type of analysis has potential policy value; as such a statistical approach could be used to set reasonable goals for the graduate education of URMs. Figure 4-3 shows five future scenarios for the parity ratio, depending upon the number of NS&E URM doctoral degrees added each year. If the current level of 750 URM Ph.D.s per year is constant (0 in the figure) then the parity ratio would drop to 27% by 2025. This decline is due to the anticipated growth in production of URM Bachelor's Degrees, driven by the increasing URM population in the United States. To keep the URM parity ratio at today's level of 68%, 52 additional URM Ph.D.s would need to be added each year to the previous year's total. Note that between 1992 and 1998—the period of fastest URM Ph.D. growth—there was an average growth of only 47 URM Ph.D.s per year. In other words, if the production of URM Ph.D.s does not increase faster than it has historically, the racial composition of professors and Ph.D. research scientists will fall rapidly further behind the increasingly diverse population of undergraduates in NS&E.

[26] Thomas L. Windham, Barbara E. Kraus and Mark R. Petersen, "*Striving Towards Equity: Diversity Goal-Setting for Doctoral Education in the Natural Sciences and Engineering,*" presented to CEOSE in 2003; paper revised in 2004; Poster presentation, *"Diversity Goal-Setting for Doctoral Education in the Natural Sciences and Engineering,"* at AAAS Annual Meeting, 17-25 February, 2005.

[27] NS&E includes all of the physical and biological science disciplines and engineering, but not the social sciences.

It would not be unreasonable to strive for a future in which NS&E URMs continue from Bachelors' Degrees to Ph.D.s at the same rate as the majority population—a parity ratio of 1.00. To achieve this ratio by 2015 would require, for example:

> Increasing the number of Ph.D.s awarded to URMs by 100 each year (constant slope scenario), or
>
> Increasing the number of Ph.D.s awarded to URMs by 8.2% each year (constant percentage growth scenario).

The addition of only 95 URM Ph.D.s per year would delay parity to 2020. With 90 additional URM Ph.D.s per year (or a 5.9% per year increase in URM Ph.D. production), parity could be reached in 2025. These predictions are not hard and fast, but can be used as a guide to help set goals for increasing the number of URMs that earn Ph.D.s. The data and projections provide useful guidance for understanding probable futures based upon defined goals.

This work provides an insight into educational disparity, and underscores the need for good data. It points to the fact that to maintain global leadership in science and technology, we must find ways to increase the participation of groups traditionally underrepresented in NS&E fields, particularly at the doctoral level. In the coming decades, URMs will compose a growing fraction of the population. If URM representation within science and engineering does not increase, the total number of U.S. NS&E Ph.D.s will decline substantially relative to the overall U.S. population.

Figure 4-3.

Extrapolation of parity ratio against time. Numbers on legend show the number of URM doctoral degrees added each year. The number of URM NS&E Bachelor's Degrees is assumed to grow by the numbers indicated each year. [Note that these parity ratio calculations do not correct for the observation that currently, the rate of majority men entering NS&E is showing a downward trend.]

Mentoring

Mentoring has been widely recognized as an important factor in the careers of many successful scientists and engineers and as a critical enabler in broadening participation. Generally, mentoring is a career-oriented, caring relationship in which the mentor, a more experienced person, provides guidance, encouragement, inspiration, and a sounding board to a less experienced person. Mentoring is often cited as a component of successful programs that have increased participation from groups traditionally underrepresented in STEM fields. There is no general agreement on what exactly mentoring entails. In addition, there are those who feel that good mentoring requires training and experience on the part of the mentor. To date, there has been little investment or effort in training scientists or engineers in how to be good mentors to women or underrepresented racial and ethnic minorities. Because of the widespread belief in the importance of mentoring in academic and industrial STEM communities, the White House established the *Presidential Awards for Excellence in Science, Mathematics, and Engineering Mentoring (PAESMEM)* program in 1996. "The program, administered on behalf of the White House by the NSF, seeks to identify outstanding mentoring efforts or programs designed to enhance the participation of groups underrepresented in STEM. The awardees serve as exemplars to their colleagues and are leaders in the national effort to more fully develop the Nation's human resources in science, technology, engineering, and mathematics".[28]

CEOSE discussed a systematic approach to mentoring and created a Subcommittee on Mentoring during its deliberations in 2001-2002. As a result, CEOSE co-sponsored in October 2003 a workshop on mentoring. Funding for the workshop was provided by the *Alliances for the Graduate Education and the Professoriate (AGEP)* program of the Division of Education and Human Resources. The preparation for the workshop included a review of the literature on mentoring, specifically in the STEM disciplines.[29] This two-day workshop was conducted by the American Association for the Advancement of Science (AAAS).

Among other items, the workshop identified research questions needing attention:

- What is successful STEM mentoring and how do we measure it? What happens when mentoring goes wrong?
- Are there significant differences in various mentoring strategies, including one-to-one, network mentoring, peer mentoring, cascade mentoring, and informal mentoring?
- What external variables influence effective mentoring at different educational levels, including the K-12 years, the undergraduate years, the graduate years, and the early career years?

[28] PAESMEM CALL FOR NOMINATIONS: Presidential Awards for Excellence in Science, Mathematics and Engineering Mentoring (PAESMEM), Program Solicitation NSF 04-525 http://www.nsf.gov/pubs/2004/nsf04525/nsf04525.htm.

[29] Yolanda S. George and David Neale, "*Report on a Study Group Meeting to Develop a Research and Agenda for Action on STEM Career and Workforce Mentoring*," prepared by the American Association for the Advancement of Science, Directorate for Education and Human Resources Programs, October 24, 2004.

- What are the interpersonal dynamics and related variables that characterize "successful" mentoring?
- How do different types of institutions recognize or reward mentoring, particularly in the STEM area?

Two of the primary challenges in tackling research questions on STEM Career and Workforce Mentoring are (1) developing an operational definition and framework for STEM career and workforce mentoring; and (2) deciding how to unpack the variables related to STEM mentoring in order to answer the research questions that are being posed.

A useful way to understand what constitutes effective mentoring programs is to look at several programs, bearing in mind that effectiveness also depends on the institution in which the program is embedded, and on the people who champion and nurture such programs. All three of the following programs were significantly supported by the NSF, have continued to exist over a number of years, have undergone extensive evaluation, have a demonstrated track record of success, and were recognized with PAESMEM awards. They have features that appear to have wide applicability.

Examples of Successful Mentoring Programs

Significant Opportunities in Atmospheric Research and Science (SOARS) creates a model mentoring community. Each entering student (protégé) has a mentoring team that includes four mentors (research, writing, community, and peer) to: 1) facilitate their integration of learning and research, 2) foster their development as successful members (junior researchers) of the University Corporation for Atmospheric Research (UCAR) research community, and 3) guide them to become attractive graduate school candidates. UCAR established SOARS in 1995 in partnership with NSF and with additional support from the Department of Energy, the National Aeronautic and Space Administration, and the National Oceanic and Atmospheric Administration. The SOARS program goal is to broaden participation in science and engineering by increasing the number of African American, Native American, and Hispanic American students enrolled in and graduating from Masters and Doctoral Degree programs in an atmospheric or related science. Undergraduate students interested in pursuing careers in these sciences can participate for up to four years. SOARS includes a 10-week summer program at the National Center for Atmospheric Research (NCAR) and other national laboratories. SOARS has achieved a high retention rate. Eighty percent of its protégés return for two or more years. To date, no protégé has left college without completing an undergraduate degree in a STEM field. Sixty-four of the 90 participants completed their Bachelor's Degrees with fifty-two having enrolled in graduate programs. Of these 52, fourteen entered the workforce with Master's Degrees, 36 are pursuing Master's Degrees, six are Ph.D. candidates and one has already earned a Ph.D.. In 2001, SOARS was awarded a PAESMEM. www.fin.ucar.edu/soars.

MentorNet (www.MentorNet.net) is the leading e-mentoring network that pairs women students and early career faculty from the world's colleges and universities with engineering and science professionals from both industry and academia for e-mail based mentoring relationships. In existence since 1998, MentorNet has matched over 12,000 protégé/mentor pairs, including individuals from 170 universities and 2,000 companies. The key to MentorNet's success is not only its ability to pair up protégés and professionals with complementary interests and objectives, but to coach these relationships with a structured program of useful and appropriate topics for their conversations. As a result of the MentorNet program, protégés consistently report increased confidence in their success and an increased desire to pursue studies and careers in science and engineering; mentors report not only great satisfaction in being able to bring along the next generation of engineers and scientists, but also increased skills, self-awareness, and renewed energy and interest in their own professional work. MentorNet received a PAESMEM award in 2001.

The Computing Research Association's Committee on the Status of Women in Computing Research (CRA-W) runs a number of successful mentoring programs that span numerous educational levels. Two programs target the undergraduate level: the *Distributed Mentoring Program (DMP)* and *Collaborative Research Experiences for Undergraduates (CREU)*. Since 1994, the *DMP* has matched almost 300 outstanding undergraduate women with female faculty mentors for a summer of research at the mentor's institution. *DMP* students participate in a research project, observe graduate life, and benefit from a close mentoring relationship with their advisors. An independent evaluation found the program to be very effective: 51% of participants who had graduated had gone on to graduate school. *CREU* also aims to increase the number of women who enter graduate school but targets a broader group of students. To date, more than 200 CREU students have worked in collaborative teams with a faculty adviser at their home institution for an academic year. An evaluation found *CREU* to have served as a vehicle that promoted skill-building, knowledge-building, mentoring relationships, role modeling, and enhanced student career aspirations; 32% of its students continued on to graduate school. In 2004, *CREU* was extended to include minority teams. In recognition of the success of these (and other) programs, *CRA-W* received the 2004 *Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring (PAESMEM)* for "significant achievements in mentoring women across educational levels".

Policy Levers and Merit-Review Criteria

As described in Chapter 1, NSF has used policy levers to focus attention on broadening participation. Notably, in 1997, NSF re-crafted its general merit-review criteria and specific review criteria for individual proposals into a two-criterion system that addresses the intellectual merit of a project, and explicitly encourages proposers to build into their projects activities that will broaden participation or have other societal benefits. The "broader-impacts criterion" of the Proposal Merit-Review process and its recently strengthened enforcement provide an example of a policy lever that has helped NSF to promote broadening participation in STEM. To increase compliance with the policy, the requirement was reshaped in 2002 as "Important Notice 127" which announced that NSF would return proposals without review, if the one-page Project Summary did not specifically address the proposal's broader impacts. Beginning in FY 2003, NSF returned 276 or 0.7% of all proposals submitted for funding consideration, because their summaries lacked a broader-impact statement. In that same year, over 90% of reviewer evaluations of proposals addressed both the scientific merit and the broader-impact merits of the proposed projects—compared to 84% in FY 2002 and 69% in FY 2001. This example suggests a model where reshaping an existing policy and making it more specific and enforceable serves as an effective means to enable the desired impact of the policy.

A second model is exemplified by NSF's recent, explicit emphasis on engaging major interdisciplinary centers in broadening participation. In the latest version of the program announcements for *Engineering Research Centers (ERCs)* and *Science and Technology Centers (STCs)*, the Foundation has built into the review process and renewal criteria a requirement that each Center make significant contributions to broadening participation. The funding mechanism for an STC or *ERC* is a formal cooperative agreement between NSF and the center's host institution (often a major research university), which commits the institution to certain specific requirements and holds it accountable for results.

Role of Research Universities and NSF Grantee Institutions in Broadening Participation

In view of the central role of institutions of higher education in shaping the ethos of STEM, and the changes occurring in the demographics of the pool of candidates for faculty positions, graduate study and postdoctoral training, it is imperative that universities work systematically to broaden participation. Strategies are needed to ensure that increased numbers of American students find it attractive and possible to participate in the education and training process in STEM fields. Promotion of and outreach to potential students in STEM is necessary and particularly must include underrepresented minority groups, women, and persons with disabilities.

Several discussions of CEOSE revolved around faculty diversity at STEM departments as an important indicator of, and a potential agent for, change in the very nature of the STEM enterprise. Diversity at the undergraduate level at most universities has become fairly common. However, the low diversity among the faculty and NSF grantees (where better data are also needed) demonstrates a key barrier to fully broadening participation. Measurable change can best be effected if the institutions themselves have a comprehensive university diversity plan with specific goals and implemented strategies. The need is for thoughtful self-examination and the design of changes tailored to the culture of the institution, not simply setting quotas or other numerical measures. CEOSE encourages NSF to continue to configure its policy levers and incentives for maximum impact, with one goal being to stimulate this type of sustainable institutional change.

Tribal Colleges

Tribal Colleges are located on reservations and managed by tribal governments. Most provide higher education only through the Associate Degree level, and emphasize courses and degrees that will contribute to life on the reservation. Their student population is overwhelmingly dominated by Native Americans. Because of the importance of Tribal Colleges to the education of Native Americans, who are scarce in STEM, CEOSE held its spring 2004 meeting in Montana at Little Big Horn College and Chief Dull Knife College, respectively on the Crow and Cheyenne Reservations.

CEOSE heard from dedicated administrators, science faculty and students, and toured the limited facilities. The Committee was impressed with what these colleges accomplish with minimal resources in very remote locations. CEOSE learned firsthand how important NSF's *TCUP* grants, distance learning, and partnerships with universities have been to the colleges' science and mathematics curricula and research opportunities for their faculty and students. To improve the ability of these institutions to attract Native Americans to STEM and provide them with motivation and a strong foundation to continue their education through the bachelor's and graduate level, CEOSE strongly endorses *TCUP* and encourages innovative distance-learning initiatives, assistance with proposal writing, and linkages including faculty exchanges with other institutions of higher learning.

Community Colleges

Toward the end of the current biennium, CEOSE began to focus attention on community colleges. Community colleges provide an important pathway into STEM careers for a large number of students, especially underrepresented populations. SRS has conducted a study of the role of community colleges as pathways to Baccalaureates and Masters' degrees. The report of this study describes the prominent role of community colleges in the education of STEM graduates.[30] Students attend community college for financial and other reasons, including as a preparation for a four-year college. The report states that "From 1990 to 2000…enrollment of underrepresented minorities at two-year colleges increased 65 percent." As many as 49% of minority students take their first college-level science course at a community college.

Only recently have community colleges become a focus for NSF funding. NSF has only one program, the *Advanced Technological Education (ATE)* that is directed at improving STEM education at community colleges. The *ATE* program was established by Public Law 102-476 in October 1992 pursuant to the Scientific and Advanced Technology Act of 1992. The act was "to establish a national advanced technician program, utilizing the resources of the Nation's two-year Associate-Degree-granting colleges, to expand the pool of skilled technicians in strategic advanced technology fields, to increase the productivity of the Nation's industries, and to improve the competitiveness of the United States in international trade, and for other purposes."[31]

[30] John Tsapogas, "The Role of Community Colleges in the Education of Recent Science and Engineering Graduates," *InfoBrief NSF 04-315*, May 2004. http://www.nsf.gov/sbe/srs/infbrief/nsf04315/start.htm.

[31] http://www.wmich.edu/evalctr/ate/ate.html.

The program has been evaluated systematically and the results are impressive.[32] Since its inception 13 years ago, the program has had a large impact on broadening representation. Over 46,000 students have taken one or more STEM-related courses either developed or improved through support of the *ATE* program. This number represents only those courses offered at institutions receiving *ATE* grants. In all likelihood, an even larger number of students is benefiting from the implementation of *ATE*-sponsored course curricula or materials at other institutions. During the next two years, CEOSE will focus additional attention on community colleges and how to enable them to contribute optimally to broadening participation of underrepresented groups in STEM disciplines.

Recommendations and Future Directions for CEOSE

The Need for Better Data and Research on Participation in Science and Engineering

A common theme throughout CEOSE's history has been its call for: (1) more and higher-quality data about the science and engineering workforce, (2) research to advance our understanding of the factors and effects, (3) more mechanisms requiring accountability for outcomes, and (4) definitive evaluations of programs and policies with respect to their impact on broadening participation.

As noted earlier, NSF's Division of Science Resources Statistics (SRS) has met with CEOSE throughout the Committee's history. In addition to providing a central clearinghouse for the collection, interpretation, and analysis of data on scientific and engineering personnel and resources, SRS fulfills NSF's legislative mandate to provide a source of information for policy formation by other agencies of the Federal Government.[33] Personnel from SRS meet with CEOSE before revising and issuing the major regular surveys of science and engineering degree recipients and workers described in the previous section. These surveys provide the most complete and accurate information available about the overall science and engineering workforce in the United States.

Through its interaction with CEOSE, SRS has obtained input on the types of questions and data needs pertinent to educational and workforce demographics in science and engineering. SRS surveys and sampling techniques have evolved over the years to improve the extent to which data sets can be disaggregated to answer questions about the participation of each of the underrepresented populations separately, despite very small numbers, in many cases. That said, correlation does not mean causality: there remains room to continue to improve data gathering and availability, and missing data or data that cannot be cross compared continue to be among the continuing frustrations that hamper understanding and progress in broadening participation. The research and knowledge-base does not yet exist to intentionally design and create an environment that allows people to "become all they can be" and fully develop their potential in STEM or other areas.

[32] See http://www.wmich.edu/evalctr/ate/evalproducts.htm for evaluation reports.

[33] NSF Organization Act. National Science Foundation Act (1950), Public Law 507, 81st Congress. See also http://www.nsf.gov/statistics/about.cfm.

Though the overall impact of NSF's programs has been positive, evaluation of NSF programs with respect to their success in broadening participation is uneven. From Chapter 2, it is clear that definitive information about the impact of programs is available in comparatively few cases. Evidence is also sparse about the specific features of programs that cause them to be more or less effective. Moreover, only in a few cases, such as the programs sponsoring major, multiyear, interdisciplinary centers (*ERCs* and *STCs,* for example), is there clear institutional accountability for broadening participation.

1. Recommendation to NSF on 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. Recommendation to NSF on 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. Recommendation to NSF on Policy Levers. NSF should continue to design and employ 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.

Tribal Colleges

These institutions introduce large numbers of Native American students to higher education and to STEM careers. Their facilities for research are limited to non-existent, and their faculty has very high teaching loads. Yet these institutions are increasingly recognized as an important pathway into STEM for talented individuals. Increasingly, leading research institutions are seeking to partner with such institutions, in part to meet requirements specified in NSF program solicitations, but also recognizing the potential that many of these institutions and their students display. CEOSE observes that the most successful partnerships are between entities who respect each other as equals in the partnership, and urges major institutions to ensure that partnership arrangements with MSIs address the needs of the MSI as well as their own.

4. Recommendation to NSF on 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.

CEOSE Priorities and Future Directions in the 2005-2006 Biennium

The retrospective study and CEOSE deliberations reported here highlight the progress along with concerns and pressing problems associated with broadening participation in science, technology, engineering, and mathematics disciplines. Some points emerge clearly and can be used to articulate and set directions for the next biennium of deliberations and work by CEOSE.

Widening Pathways into STEM

Most STEM research and most NSF funding tend to be centered in research-intensive universities, where the environment for underrepresented persons in STEM has been improving only slowly. Most women, minorities, and persons with disabilities, however, start their higher education at other types of institutions, and are taught by pre-college teachers who were educated at other types of institutions. A large and growing number of Americans, in fact, are entering community colleges or other two-year institutions, where there is currently little NSF investment and highly variable infrastructure for STEM. Other than programs targeted at MSIs (which many community colleges are), the only program investing in strengthening STEM education in community colleges is the *ATE* program. *ATE* has done a remarkable job in initiating excellent training and facilities at several community colleges.[34] Yet, the role of community colleges in furthering the diversity goals of NSF and contributing to the mission of CEOSE remains not as well developed as the role of other institutions. Developing these

[34] *ATE* Evaluation report: http://www.wmich.edu/evalctr/ate/evalproducts.htm

goals and articulating the nature of programs that will enhance the quality of education at community colleges can be a fruitful direction for the deliberations and actions of CEOSE in the near-term. It is time to initiate a focus on the role of community colleges and other two-year institutions as a vital pathway for access, and to strengthen their ability to provide competitive, high- quality education to the many students they serve.

1. Recommendation to CEOSE on 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. Recommendation to CEOSE on 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.

Evaluation

Systematic formative and summative evaluation of key programs and projects with respect to their impact on broadening participation continues to be needed, to understand what works, what does not work, and why.[35] For many years, evaluation of educational programs has typically been non-existent or primarily anecdotal. This situation has started to change. Moving forward, it will become useful to consider evaluation plans concurrent with program design, and valuable to include in each evaluation plan elements that address issues, causes and remedies for underrepresentation in STEM. Benefits can emerge if CEOSE focuses some of its energies on evaluation in the near-term, in parallel to the increase in NSF attention to research, assessment and accountability, recommended above.

3. Recommendation to CEOSE on 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.

The Role of CEOSE

Since its inception over 20 years ago, CEOSE has been composed of individual volunteer scientists, engineers, and educators, deeply committed to improving the inclusiveness and reach of science and

[35] *S*ee Building Engineering and Science Talent (*BEST*). A Bridge For All: Higher Education Design Principles to Broaden Participation in Science, Technology, and Engineering and Mathematics. San Diego: BEST. February 2004.

engineering and willing to spend a three-year term advising NSF on this important topic. Many CEOSE members are themselves members of groups underrepresented in science and engineering, as well as practicing scientists, engineers, or research administrators. All bring to CEOSE valuable knowledge and experience gained from their professional and personal lives, along with typically a track record of innovation and success in broadening participation in STEM with respect to at least one of the underrepresented groups in some specific area(s) of science and engineering. Despite their commitment to and years of engagement in broadening participation, a significant number of CEOSE members report that they were unaware of the existence of CEOSE before being recruited to become members. It is hard to imagine that CEOSE's effectiveness and impact could have been maximized, since it is largely unknown, even among people active in its mission area.

Because CEOSE is a body of volunteer professionals with full-time research and other responsibilities, its role is necessarily advisory and catalytic. Moreover, CEOSE can serve as a champion, an advocate, and an objective critic. It can stimulate networking by providing a forum for learning about and sharing effective practices and programs. However, it is important to emphasize that CEOSE does not set policy, implement programs, or do research.

When considering the challenge of broadening participation throughout science and engineering in the United States, it must be acknowledged that the Federal government provides only 30% of the funding for research and development, and NSF provides less than 4% of the Federal total. Are the other agencies and industry putting a similar emphasis on broadening participation? If not, why not, and should this be changed? Looking only at the Federal portion, how can we garner similar attention paid at the other major science and engineering agencies, such as the Department of Defense, the National Institutes of Health, the National Aeronautics and Space Administration, the Department of Energy, the Department of Homeland Security, and the Department of Agriculture? Would an advisory group, similar to CEOSE, be valuable for some of these other agencies?

As described above, collaborating towards possible system-wide synergy in efforts to broaden representation across governmental agencies and other sectors is vital. The first step in this process could begin with wide dissemination and discussion of this report initiated by CEOSE with the help of the Congress, NSF, and offices such as the Office of Science and Technology Policy (OSTP). CEOSE acknowledges gratefully OSTP convening a meeting of the CEOSE Chair and Vice Chair with representatives from a large number of agencies to disseminate the findings of the last biennial report.

4. Recommendation for CEOSE on 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.

The Important Role of NSF

NSF is one of about twenty federal agencies that invest significant taxpayer funds in science and engineering research. However, it is the only agency responsible for advancing science and engineering across a broad frontier, and it has specific mandates to promote science and engineering education, as well as to provide a central clearinghouse for data on scientific and engineering resources. NSF plays a special and key role in supporting fundamental research, education and science, and engineering infrastructure at colleges and universities throughout the United States. For the most part, NSF neither does research itself nor operates scientific facilities. Instead, it invests federal funds in the best projects and programs proposed by researchers and educators throughout the country, as judged by competitive review that assesses proposals against two criteria: scientific and engineering merit and broader societal impacts.

As stated in the preface to the National Science Foundation Strategic Plan, FY 2003-FY 2008:

Although NSF represents less than four percent of the total federal funding for research and development (R&D), it accounts for approximately 13 percent of all federal support for basic research and 40 percent of non-life-science basic research at U.S. academic institutions. NSF's broad support for basic research, particularly at U.S. academic institutions, provides not only a key source of funds for discovery in many fields, but also unique stewardship in developing the next generation of scientists and engineers. NSF is also the principal federal agency charged with promoting science and engineering education at all levels and in all settings, from pre-kindergarten through career development. This helps ensure that the United States has world-class scientists, mathematicians and engineers, and well-prepared citizens.

Throughout CEOSE's history and even earlier, the NSF has paid significant attention to broadening participation of underrepresented groups in science and engineering. With its investments in science and engineering research projects, education, and data collection and analysis about the scientific and engineering enterprise in the United States, NSF has some influence on factors that encourage or exclude participation.

CEOSE commends NSF on its admirable achievement in diversifying its own staff, thereby setting a positive example for the larger STEM community. By broadening participation in its own STEM workforce and on review panels, designing programs, tailoring program solicitations, defining review criteria and holding proposers accountable for addressing them, supporting topical workshops with broadened participation, and encouraging first-time principal investigators, NSF has likely helped drive the positive trends in participation (though the definitive evidence to prove this claim is lacking) observed over the past 24 years. There is anecdotal evidence that NSF's policies are impacting the promotion and reward policies at individual universities to give some credit to efforts to broaden participation.

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.

APPENDIX A

CEOSE Membership List as of October 2004

Dr. Indira Nair, CEOSE Chair
Vice Provost for Education
Professor, Engineering and Public Policy
Carnegie Mellon University, Pittsburgh, PA

Dr. Robert L. Lichter, CEOSE Vice Chair
Principal, Merrimack Consultants, LLC
Atlanta, GA

Dr. Beverly Karplus Hartline, Report Chair
Special Assistant to the President
Heritage University, Toppenish, WA

Prof. Ashok Agrawal, Professor & Chair
Engineering and Technology
St. Louis Community College, St. Louis, MO

Dr. David R. Burgess, Professor of Biology
Boston College, Boston, MA

Dr. Luis Echegoyen, Chair and Professor
Department of Chemistry
Clemson University, Clemson, SC

Dr. Wesley L. Harris, Department Head
Department of Aeronautics & Astronautics
Massachusetts Institute of Technology
Cambridge, MA

Dr. J. K. Haynes
David Packard Professor and Dean
Division of Science and Mathematics
Morehouse College, Atlanta, GA

Dr. Joyce Bennett Justus
Special Assistant to the Chancellor
for Intersegmental Relations
University of California at Santa Cruz
Santa Cruz, CA

Dr. Samuel L. Myers, Jr.
Roy Wilkins Professor of Human Relations and
Social Justice, Humphrey Institute of Public Affairs
University of Minnesota, UMN Twin Cities Campus
Minneapolis, MN

Dr. Willie Pearson, Jr., Professor and Chair
School of History, Technology and Society
Georgia Institute of Technology, Atlanta, GA

Dr. Carol Halpert Schwartz
Professor of Economics, School of Management
New York Institute of Technology
Old Westbury, NY

Dr. Telle Whitney, President and CEO
Anita Borg Institute for Women and Technology
Palo Alto, CA

Dr. Lilian Shiao-Yen Wu, Program Executive
University Relations, IBM Corporation
Yorktown Heights, NY

Ms. Sara Young, Director
American Indian Research Opportunities
Montana State University
Bozeman, MT

CEOSE MEMBERS DURING
2002-2004

Dr. Thomas Windham, Director, SOARS
University Corporation for
Atmospheric Research, Boulder, CO

Dr. Gustavo Roig, Director, Center for
Advancement of Engineering Pre-College
Education, College of Engineering
Florida International University
Miami, FL

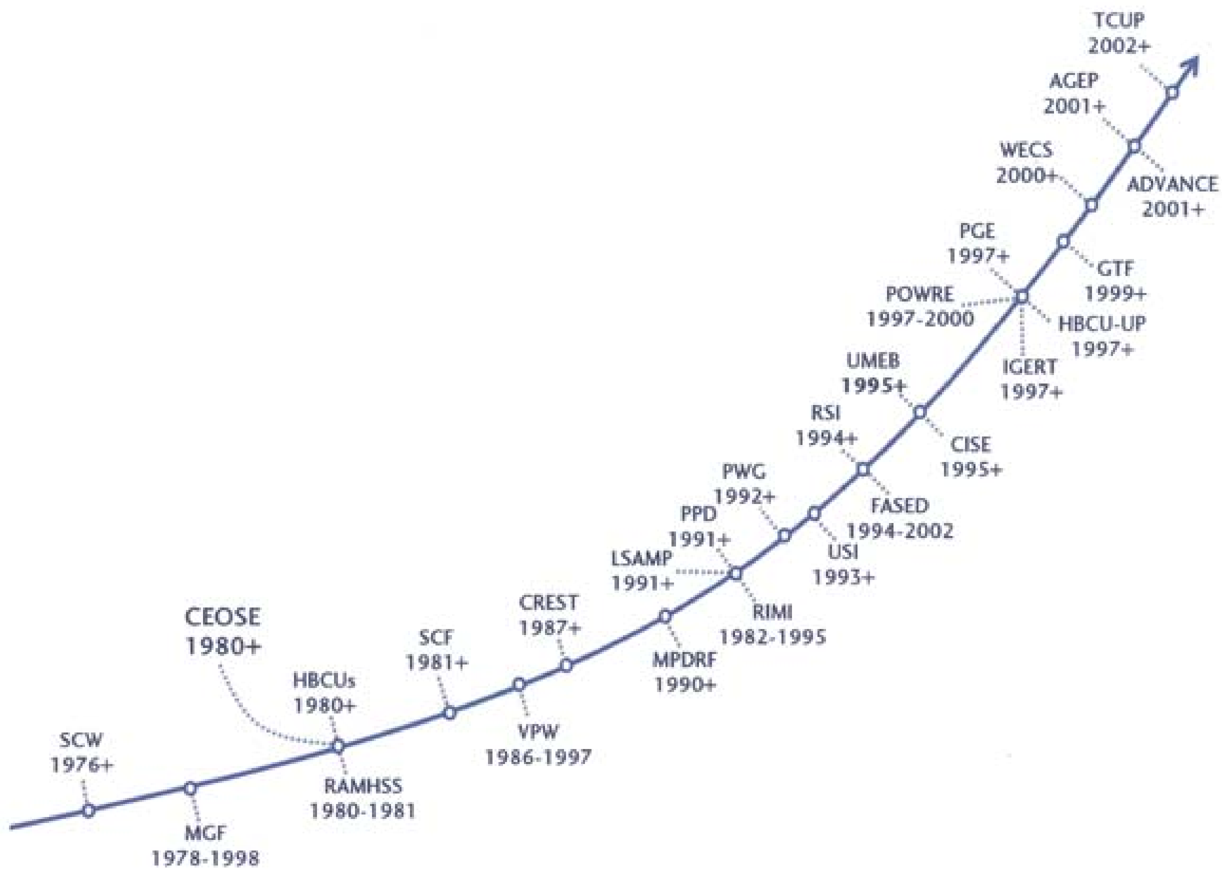
Dr. Marian Johnson-Thompson
Director of Education and Biomedical
Research Development,
National Institutes of Health
Research Triangle Park, NC

NSF EXECUTIVE LIAISON TO CEOSE

Dr. Margaret E. M. Tolbert, Senior Advisor
Office of Integrative Activities
National Science Foundation
Arlington, VA

APPENDIX B

Timeline of Illustrative NSF Diversity Programs from 1976 to 2002



Program List

Science Career Workshops (SCW):
provides 1-2 day career information and motivation conferences for women.

Science Career Facilitation Project (SCF):
provided grant assistance to women resuming their education in science or re-entering their professional careers, after family or other leave.

Minority Graduate Fellowship (MGF):
provided stipend support to promising STEM graduate students.

Experimental Program to Stimulate Competitive Research (EPSCoR):
a partnership program between NSF and U.S. States to assist states to improve their research infrastructure by helping researchers and institutions to obtain Federal R&D grants.

Research Apprenticeships for Minority High School Students (RAMHSS):
encouraged the involvement of high school minority students in research and provided funding supplements to principal investigators supported by NSF for minority high school student research assistants.

Historical Black Colleges and Universities (HBCUs):
provides grant support to enhance the quality of STEM instructional and outreach programs.

Research Improvement in Minority Institutions (RIMI):
provided for improved research capabilities of institutions with significant minority student enrollment.

Congressionally mandated NSF report on **Women, Minorities, and Persons with Disabilities in Science and Engineering** - A Biennial Report of the Division of Science Resources Statistics.

Visiting Professorships for Women (VPW):
provided research grants for experienced female faculty to conduct research at top-rated universities and to mentor female students.

Centers for Research Excellence in Science and Technology (CREST):
provides substantial resources to upgrade research capacity of research-productive, minority-serving institutions for students and faculty.

Minority Postdoctoral Research Fellowship (MPDRF):
provides grants to increase the quality of STEM scientists by providing opportunities for postdoctoral training and starter research.

Passage of the Federal **Americans with Disabilities Act** (Public Law 101-336) that prohibits discrimination and ensures equal opportunity for persons with disabilities in employment.

Program List

Louis Stokes Alliances for Minority Participation (LSAMP):
provides support for alliances among institutions to increase the number and quality of students seeking Baccalaureate Degrees in STEM fields.

Program for Persons with Disabilities (PPD):
demonstration project to reduce barriers to access and availability of STEM education, retention and career advancement.

Program for Women and Girls (PWG):
supports educational, mentoring, internships and other activities to increase participation of girls and women in STEM fields.

Urban Systemic Initiatives (USI):
support system-wide reform efforts to improve science, mathematics and technology education for urban economically disadvantaged students in 28 targeted cities.

Facilitation Awards for Scientists and Engineers with Disabilities (FASED):
provided support to encourage the disabled, and grant support for special equipment and assistance.

Rural Systemic Initiatives (RSI):
support system-wide reform in science, mathematics and technology education for rural and economically disadvantaged primary and secondary school students.

Undergraduate Mentoring in Environmental Biology (UMEB):
supports institutions to create innovative programs that encourage undergraduate students, especially women and minorities, to pursue a career in environmental biology.

CISE Minority Institutional Infrastructure Program:
supports projects to increase minority participation in academic research in computer science, by improving infrastructure at minority-serving institutions.

Research Experiences for Undergraduates (REU):
supports active research participation by undergraduate students in science and engineering.

Professional Opportunities for Women in Research and Education (POWRE):
combined previously established NSF career-focused programs (e.g., VPW), and provided support for women principal investigators.

Integrative Graduate Education and Research Traineeship (IGERT):
supports innovative programs that integrate education and research to increase knowledge base, research skills and diversity of Ph.D. scientists in STEM fields.

Program List

Historically Black Colleges and Universities - Undergraduate Program (HBCU-UP):
provides expanded funding opportunities for African American higher education institutions to plan for and implement long-term programs to increase outreach and retention of undergraduates in the STEM areas.

Program for Gender Equity in STEM (PGE):
supports research and information-dissemination activities to improve gender related educational policies.

Presidential Awards for Excellence in Science, Mathematics and Engineering Mentoring (PAESMEM):
awards outstanding mentors who serve as role models for underrepresented groups in science and engineering.

Alliances for Graduate Education and the Professoriate (AGEP):
provides program support to increase number of students who receive a doctorate in STEM, with a special emphasis on underrepresented groups and mentorship.

Graduate Teaching Fellows (GTF):
funds partnerships between graduate STEM students and K-12 teachers to improve teaching quality in science and mathematics in middle and high schools.

Women in Engineering and Computer Science Program (WECS):
is included in the Graduate Research Fellowship Program (GRFP), and provides fellowships to women in engineering and computer science.

ADVANCE:
provides support to U.S. academic institutions to improve climate for women and to advance women to highest ranks of leadership

Tribal Colleges and Universities Program (TCUP):
provides awards to enhance quality of STEM instructional and outreach programs, with an emphasis on leveraged use of technologies at Tribal institutions.

APPENDIX C

Activities and Deliberations of CEOSE in 2003-2004

CEOSE accomplishments and areas of focus from CEOSE meetings during the 2003-2004 biennium are threaded through the previous parts of Chapter 4. Among the topics most frequently discussed were: data issues, underrepresentation and strategies to broaden representation at Research Universities, and the potential implications on broadening participation of the Supreme Court decision related to admissions at the University of Michigan and of the post-9/11 visa restrictions on foreign nationals. This section presents major activities in some detail to give an overview of the work. The deliberations of CEOSE occur primarily at three yearly meetings, in February, June and October. This was also the case in this period, with one exception. The June 2004 meeting was replaced by an April meeting to enable CEOSE to visit two Tribal colleges to learn firsthand the situation in these colleges, which provide higher education to significant numbers of Native Americans. At the start of this biennium, a Senior Advisor from NSF's Office of Integrative Activities was appointed as the new Executive Secretary and Liaison to CEOSE. Her efficiency, thoroughness, and counsel helped bring continuity and coherence to CEOSE deliberations and were a significant positive factor in enabling and expediting the production of this report with the assistance of an able and responsive contractor. Additionally an Orientation for new CEOSE members was instituted in 2003 and is expected to recur at suitable intervals. The preparation of the 23-year retrospective report was a central activity for CEOSE, especially during calendar year 2004. Other regular features continued vigorously, including a discussion with the Foundation's Director and/or Deputy Director at every meeting. In these meetings, the Foundation's leadership updated CEOSE with NSF news, especially actions on, and progress in broadening participation. They heard and responded to CEOSE concerns and were consistently supportive of CEOSE efforts. Intense discussions and generation of ideas and action items followed these sessions and the several presentations by NSF staff, guest speakers and reports by CEOSE members. CEOSE also regularly received reports from its members on the Advisory Committee meetings to which they were CEOSE liaisons. A Mentoring Workshop recommended by CEOSE in 2001-2002 was conducted by AAAS in October 2003, jointly sponsored by CEOSE and the Human Resources Division of the EHR Directorate. It was well attended by a large group, including several CEOSE members. Some major lessons learned were presented earlier in Chapter 4 in the section on Mentoring.

Perhaps the most formative experience for CEOSE during this period was moving one of its regular meetings into the field, to two Tribal Colleges in rural Montana. This meeting was powerfully effective in educating CEOSE deeply about one of the populations of concern, the Native Americans, and is detailed in Box 4. CEOSE learned that hearing from these colleges firsthand is vital in order to be able to address relevant issues with the proper understanding of these institutions. The visit was arranged by CEOSE's Sara Young, who is a member of the Crow Nation and the Director of the PAESMEM-Award-winning Native American Research Opportunities (AIRO) Program at Montana State University.

Presentations and Updates to CEOSE during 2003-2004

Presentations from key NSF program officers and staff related to its work and to national initiatives are a principal feature of CEOSE meetings. These inform its deliberations and activities. Major presentations, their dates, and the primary points highlighted in the presentations are listed in the three boxes below, one on presentations made by NSF staff, one by guest presenters, and the third by CEOSE members. Much of the information that led to the conclusions and recommendations in Chapter 4 arose from these presentations and subsequent discussions. The boxes summarize the topics and the ensuing CEOSE discussion very briefly. Full details can be found in the meeting minutes, available at http://www.nsf.gov/od/oia/activities/ceose/minutes/2003-06.html.

Box 1
Highlights from Presentations by NSF Staff Members to CEOSE in 2003-2004 Meetings and Key Points of Ensuing CEOSE Discussions[1]

Math Science Partnerships (MSP) - Focus on student achievement, teacher workforce and evidence-based outcomes. Many of these programs are still in the early stages. The MSP program hopes, over time, to increase industry participation. CEOSE response: The program is innovative and well-funded. CEOSE members would like to be informed about MSP workshops being held around the country to stimulate interest. CEOSE was pleased that the proposal review panels and the awardees are diverse by discipline, gender, race, and research communities. More could be done in increasing the diversity of the teacher workforce. (February 2003) Science Resources Statistics.

Science Resources Statistics (SRS) – SRS collects the data for and produces the congressionally mandated biennial Report, Women, Minorities, and Persons with Disabilities in Science and Engineering. Keeping informed about the details of these data and the definitions is vital to the work of CEOSE, and so the Committee asks for and receives frequent updates and responses from SRS staff. The SRS plan for the 2004 report includes an implementation of continually updated data on the Web, in addition to a hard copy volume with data summary cards and a CD. These presentations continue to be an essential means for keeping CEOSE informed about trends and methods. Members of SRS staff have been most cooperative and immensely helpful in responding to CEOSE concerns about the survey designs and data and in addressing numerous issues, such as sampling of small populations, data disaggregation, and the validity of various data sets. (February 2003, June 2003, October 2004)

Cross Boundary Activities at the National Science Foundation: Emerging science thrives through both disciplinary and interdisciplinary research. While it is important to support core research in disciplines, cross boundary activities also warrant investment. NSF is fostering activities that cross research with education and cross private and applied partnerships with basic and core research. CEOSE can advise NSF on how to guide an enterprise that deals with 22,000 institutions that hold the next generation of researchers and educators. (February 2003)

[1] See CEOSE minutes at http://www.nsf.gov/od/oia/activities/ceose/index.jsp for details.

The NSF Graduate Research Fellowship Program–A program since 1952, GRFP assumed responsibility for minority applications in 1998 with the elimination of the Graduate Minority Research Fellowship Program (GMRFP). Initially, the number of GRFP awards to minorities decreased compared to the prior level. In 2002 there was an encouraging increase in the number of awards to minorities, most likely due to the implementation of innovations in the program. (June 2003)

Profile of the NSF Workforce: The profile of NSF's workforce is 42% scientific and engineering, 36% business operations staff, and 22% program support staff. The total NSF workforce size is 1,409, including permanent, temporary, and intermediate staff members. (June 2003)

NSF Programs and Activities for Persons with Disabilities: The history of the Program for Persons with Disabilities (PPD) goes back to 1991 when a series of task forces came to the realization that persons with disabilities are underrepresented in science and that NSF needed to do something about it. The PPD officially debuted in FY 1994. It had been co-funded through smaller projects from 1991 until 1994. Initially, it was funded at $2.2 million. The amount increased from 1995 until 2001, and has been level at $4.9 million ever since. The program has made about nine awards per year for the last decade. For more information, see http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5482. Note: the PPD has been incorporated into RDE (Research in Disabilities Education). CEOSE expressed interest in learning more about the program so that it can identify how to best assist in the inclusion of Persons with Disabilities. (October 2003)

Box 2
Guest Presentations Made to CEOSE in 2003-2004[2]

Director, Center for the Advancement of Scholarship on Engineering Education (CASEE) of the National Academy of Engineering: The ultimate objective of this newly established center is to enhance the quality and number of engineers in the workforce by increasing the efficiency and effectiveness of engineering education (http://www.nae.edu/nae/caseecomnew.nsf?OpenDatabase). (February 2003)

Senior Pofessional Staff Member of the U.S. Senate Committee on Commerce, Science and Transportation: This Senate Committee covers NSF along with other agencies such as NASA, the Technology Administration at Commerce, the Earthquake Research Program and the U.S. Department of Homeland Security. This Senate Committee has noted that while NSF funding for STEM education at minority-serving institutions (MSIs) is 15% to 16%, funding from the research directorates to MSIs is significantly lower (1.5% -1.6%). It has requested NSF to develop a plan to improve the percentages of funding. The speaker remarked that the expectation is that CEOSE will be a part of that plan formulation. The speaker also informed CEOSE about a bill on possible funding for digital and wireless infrastructure for minority-serving institutions that would fit within the NSF authorization. (February 2003)

[2] See CEOSE minutes at http://www.nsf.gov/od/oia/activities/ceose/index.jsp for details.

Associate Director for Science, Office of Science and Technology Policy (OSTP) in the Executive Office of the President, met with CEOSE to discuss ongoing activities to address issues of the STEM workforce including the National Science and Technology Council (NSTC) Committee on Science and the President's Council of Advisors on Science and Technology (PCAST). (June 2003)

Senior Policy Analyst/National Science Board: A draft of the new NSB report on the National Workforce Policy for Science and Engineering, prepared by the Task Force on the National Workforce Policies for Science and Engineering, was made available for review by CEOSE members. Recommendations included in the draft report are in five areas: Undergraduate education in S&E; advanced education; pre-college teaching workforce for mathematics, science , and technology; U.S. engagement in the international science and engineering workforce; and knowledge-base in S&E workforces. (June 2003)

General Counsel for NSF and Vice President and General Counsel for Carnegie Mellon University: The "Supreme Court decision on affirmative action," commonly termed the "Michigan decision," is a salient topic for CEOSE and so two presentations were arranged. Implications for Minority Federal Programs and Initiatives were addressed by the NSF General Counsel and the General Counsel from Carnegie Mellon. NSF has a specific Congressional mandate to increase the number of women, minorities, and persons with disabilities entering the science and engineering enterprise. However, NSF, like academic institutions, must do this in a constitutionally permissible way. NSF's programs are currently structured to withstand judicial scrutiny, with standards that existed before and after the Michigan case. However, this does not mean that NSF will not be subject to legal action. As NSF moves forward with plans for the workforce of the 21st century, NSF will continue to support the goals and ambitions set forth.

The decision is largely favorable to universities and to the goals of universities and NSF in providing a diverse and educated workforce. Universities are reacting to and dealing with the Supreme Court decision in their strategies to address diversity. Private universities collaborated in filing amicus (Friend of the Court) briefs, which support the concept that diversity is a compelling interest that should permit the consideration of race as one factor in admissions. Universities have to be prepared to present arguments as to how educational benefits flow from diversity at their particular institution.

The President of African American Images, Inc. in Chicago, Illinois, spoke on "The Crisis of African American Males." He emphasized that young Black males are in crisis by pointing to numerous examples and stressed the need for early interventions. He discussed the effectiveness of several projects (e.g., KIPP Academy Experiment, Robert Moses Project, and the Meyerhoff Program at the University of Maryland at Baltimore County) along with success stories of Black males who succeeded against all odds. CEOSE discussed afterwards that, while some of the speaker's perspectives are controversial, the issue is important. (February 2004)

Box 3

Presentations Made by CEOSE Members to CEOSE or at an External Meeting in 2003-2004 and Summary of Follow-up Discussion[3]

Working paper on "Striving Toward Equity": discussed on page 93, addressed the challenge posed to CEOSE a year ago of increasing the number of underrepresented minorities receiving Ph.D.s in STEM by 100 per year. Dr. Windham's approach to the question was to develop several scenarios that indicated what number of Ph.D.s would need to be earned in order for there to be parity with whites. CEOSE discussed the need for minority students to be motivated to complete STEM degree work, strategies needed to open doors for them to complete their education, and the subsequent monitoring of those students' educational and career progress. The Committee agreed that the objective should be defined first and then numerical goals established based on that objective. The LSAMP Program is producing over 22,000 underrepresented minorities with Bachelor's Degrees per year and should be a significant pipeline into the academy. Where are they going to go once they have completed their degree work? Are they being hired by Research 1 Institutions? Longitudinal tracking of these program participants is becoming increasingly important. (February 2003)

The International Conference on Women in Physics of the International Union of Pure and Applied Physics. The purpose of the conference was to understand the severe underrepresentation of women in physics around the world, and to develop strategies to increase their participation.
http://www.iupap.org (June 2003)

Presentation of the 2002 CEOSE Biennial Report to Congress, convened by the White House Office of Science and Technology Policy. Officials from approximately 20 federal agencies and organizations participated in the meeting, listening to the presentations, providing insights on their programs with relevance to the CEOSE mandate, and sharing ideas on various programs. Meeting participants discussed their programs for broadening participation. Examples include: the loan repayment program, local area training systems, opportunities at DOD schools, various science and engineering curricula, federal employment, the need for more women and underrepresented minorities in the workforce, fellowships, community colleges, internships, innovative recruitment strategies, museum science and engineering programs, and mentoring programs. At the meeting, it was suggested that CEOSE get on the road and do more outreach.

CEOSE discussion: The meeting emphasized the fact that there is a great deal of interest in the work of CEOSE. CEOSE members recognized the need to identify critical issues that require input from other agencies, develop strategies for addressing these issues, and request the assistance of OSTP as needed. It would be useful for professional societies to be involved in the meetings. There needs to be a wide dissemination of the next CEOSE report as well, through presentations by CEOSE members in addition to distributing the report. It would be useful to produce a standard set of slides for such presentations. (October 2003)

[3] Ibid.

NSB Workshop-Broadening Participation in Science and Engineering Research and Education: This well-attended workshop focused on national needs for human resources and especially for a diverse workforce in science and technology. Suggestions on workforce needs were made for government, academia, and the private sector to use. The Workshop accomplished the goal of bringing greater attention to Research 1 Institutions and strategies to provide incentives to them to broaden representation. There was discussion of how minority and women (but not women of color) students complete their degree work at Research 1 Institutions and are unable to obtain positions at these institutions. (October 2003)

Small Populations: Information on small populations has been a continuing concern of CEOSE. This presentation emphasized the difficulties in and the need for collecting statistical information on the Native American populations. It included information on the Indian people, health disparities, reservations, education, needs, the workforce, efforts to increase participation in STEM, Tribal and Tribally-Controlled Colleges, students, attainment of degrees, and faculty. CEOSE discussion: Problems are encountered in the implementation of ancestry information surveys because of definitions of population categories, and in the way persons who indicate multiple races are placed in the census data (see OMB Circular 0002). (February 2004)

Box 4
CEOSE Visit to Tribal Colleges, April 2004[4]

CEOSE held a meeting on April 19-20, 2004 at two Tribal Colleges in Montana--Little Big Horn College in Crow Agency and Chief Dull Knife College in Lame Deer. This was the first off-site meeting in the history of CEOSE. Both College presidents gave an account of the histories of their peoples and of their institutions. It was noted by CEOSE members that there are unique issues in recruitment and retention of Indian students to STEM and require the involvement of families. The family is extremely important, and the culture takes precedence over all else. Science, technology, engineering, and mathematics are integral parts of the Indian culture. The spirit and hard work of the students were evident. They showed determination, resourcefulness, and commitment to complete their formal education.

Little Big Horn College, located on the 2.25 million acre Crow Indian Reservation in Crow Agency, Montana, was established in 1980 and accredited in 1990. The 1978 Tribal Colleges Act paved the way for the establishment of the college. Prior to the establishment of Little Big Horn College, students had to leave the reservation in order to attend college. The student body is comprised of Crow tribal members (90%), members of Native American tribes from around the Intermountain west (8%), and residents of the Big Horn County area (2%).[5]

[4] Ibid.
[5] http://www.lbhc.cc.mt.us/ for details about Little Big Horn College.

Chief Dull Knife College was originally chartered in September, 1975, by Tribal Ordinance as the Northern Cheyenne Indian Action Program, Incorporated, and granted funding by the Indian Technical Assistance Center of the Bureau of Indian Affairs.[6] Starting as a vocational school for training students for jobs in the developing mining enterprises in communities near the reservation, a broader vocational and post-secondary education was instituted. The first academic courses were offered at Dull Knife during Winter Quarter of 1978.

NSF Programs and Initiatives: 1) Rural Systemic Initiatives, which focus on K-9 levels; 2) course offerings, such as the new forestry track; 3) Louis Stokes Alliances for Minority Participation (Successes: Developed new Forestry Degree Program, Held Summer and Natural Research Camps and Developing an Agricultural Degree Program); 4) Experimental Program to Simulate Competitive Research (Success: Held a Summer Undergraduate Research Program); 5) Course Curriculum and Laboratory Improvement Program (Success: Introductory Biology Curriculum Development); and 6) Tribal Colleges and Universities Program (Success: Held a Career Fair).

Needs Articulated and Observations Salient to the Work of CEOSE:

Workload of the Faculty: A dedicated faculty teach several courses each semester, in addition to working on various projects. CEOSE could see the difficulty the faculty would have to come away from the colleges in order to serve on panels, etc.

Mutual Partnerships: Partnerships, including industrial linkages would help. It is possible to have mutually beneficial partnerships when the Indian partners are treated as equals. Housing is a problem when considering Visiting Faculty.

Needs Enumerated were: equipment to use for teaching and training purposes, more diverse course curricula, programs to maintain the tribal culture, and recruitment and retention of additional well-qualified faculty members. In terms of courses, enrollment in environmental science courses is increasing, while that for computer science is decreasing at Little Big Horn.

Some distance learning courses are being planned in both places.

Needs Expressed by Students: 1) knowledgeable tutoring and more advanced courses; 2) career planning; 3) orientation to four-year colleges; 4) funds for educational and personal support purposes; 5) more internships, scholarships, and fellowships; 6) appropriate study environment in their homes; 7) greater access to computers and calculators; 8) convenient child care services while students are in college, 9) evening classes; and 10) more laboratory equipment and facilities.

[6] http://www.cdkc.edu/ for details about Chief Dull Knife College.

Recommendations from the Visit:

- NSF should continue to support TCUP and LSAMP, and get mainstream universities to work with the colleges (i.e., through REU Programs).
- Establish at NSF a student scholarship/fellowship program focused on Indian students and programs at Tribal Colleges that will enable the students to remain in their home nations while conducting research or participating in educational programs. Students are more likely to complete their degree work if they have the opportunity to remain near their families.
- Provide support for K-12 curriculum development and teacher enhancement programs and initiatives as well as course and curriculum development. Distance education opportunities may be a way to overcome some of the issues with shortage of faculty.

APPENDIX D

CEOSE Findings and Recommendations 1980-2002

The detailed findings and recommendations for this period are contained in the CD attached to this report.

APPENDIX E

LIST OF ACRONYMS

AAAS	American Association for the Advancement of Science
ADVANCE	Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers
AGEP	Alliances for Graduate Education and the Professoriate
ATE	Advanced Technological Education Program for Community Colleges
ATY	Academically Talented Youth
CEOSE	Committee on Equal Opportunities in Science and Engineering
COV	Committee of Visitors
CRA-W	The Computing Research Association's Committee on the Status of Women in Computing Research
CREST	Centers for Research Excellence in Science and Technology
CWSE	Committee on Women in Science and Engineering
CREU	Colloborative Research Experience for Undergraduates
EPSCoR	Experimental Program to Stimulate Competitive Research
FASED	Facilitation Awards for Scientists and Engineers with Disabilities
GPRA	Government Performance and Results Act
GRFP	Graduate Research Fellowship Program
GTF	Graduate Teaching Fellows
HBCU	Historically Black Colleges and Universities
HBCU-UP	Historically Black Colleges and Universities-Undergraduate Program
HRD	Human Resource Development
IGERT	Integrative Graduate Education and Research Traineeship
K-12	Kindergarten to Twelfth Grade
LSAMP	Louis Stokes Alliances for Minority Participation
MFP	Minority Fellowships Program
MGF	Minority Graduate Fellowship

MPDRF	Minority Postdoctoral Research Fellowship
MSI	Minority-Serving Institutions
NAEP	National Assessment of Educational Progress
NSF	National Science Foundation
OWSE	Opportunities for Women Scientists and Engineers
PAESMEM	Presidential Awards for Excellence in Science, Mathematics, and Engineering Mentoring
PGE	Program for Gender Equity
PI	Principal Investigator
POWRE	Professional Opportunities for Women in Research and Education
PPD	Program for Persons with Disabilities
PWG	Program for Women and Girls
RAMHSS	Research Apprenticeships for Minority High School Students
REU	Research Experiences for Undergraduates
RIMI	Research Improvement in Minority Institutions
ROW	Research Opportunities for Women
RSI	Rural Systemic Initiatives
S&E	Science and Engineering
SAT-M	Scholastic Aptitude Test in Mathematics
SCF	Science Career Facilitation Project
SCW	Science Career Workshop
SRS	NSF's Divison of Science Resources Statistics
STEM	Science, Technology, Engineering and, Mathematics (Includes Social, Behavorial and Economic Sciences)
TCUP	Tribal Colleges and Universities Program
UMEB	Undergraduate Mentoring in Environmental Biology
URM	Underrepresented Minorities
USI	Urban Systemic Initiatives
VPW	Visiting Professorships for Women

APPENDIX F

PHOTO CAPTIONS AND CREDITS

Chapter 1

Page 8: At the Georgia Tech/Emory Center (GTEC) for the Engineering of Living Tissues—an NSF *Engineering Research Center*—a graduate student uses flow cytometry to characterize smooth muscle cells that will be used in cardiovascular tissue engineering devices. Photo Credit: NSF Multimedia Gallery, http://www.nsf.gov/news/mmg/mmg_disp.cfm?med_id=51720&from=mmg

Page 17: The Smithsonian Institution's National Museum of Natural History operates a Research Training Program for scholars in the *Louis Stokes Alliances for Minority Participation (LSAMP)* program. In this photograph, *LSAMP* Smithsonian Ichthyologist, Dr. Susan Jewett, discusses the Coelacanth—a "living fossil"—with participants in the NSF-sponsored LSAMP Scholars Winter Workshop. The Coelacanth is a prehistoric fish once thought to be extinct until found living in modern times. Credit: Smithsonian Institution. Photo Credit: NSF Multimedia Gallery, http://www.nsf.gov/news/mmg/mmg_disp.cfm?med_id=51634&from=mmg.

Page. 18: The Rural Alaska Honors Institute (RAHI) includes among its activities geoscience field trips. One of its projects, The Alaskan Natives in Geosciences Project, is co-funded by the NSF directorates of Geosciences and the Office of Polar Programs. This project is an integrated, intergenerational approach designed to attract young Alaskan Natives to the geosciences as a career and to encourage declared Alaskan Native geoscience majors to continue their studies. A college-level, field-intensive, introductory geoscience course is designed specifically for the high school juniors and seniors enrolled at RAHI. This is followed by a community-based, one-week field course open to RAHI graduates as well as other Alaskan Native geoscience students.

Page 21: With NSF sponsorship, a ubiquitous computing environment (iLearn-System) was designed to assist blind students in their educational endeavors. NSF Grant Number ITR-0326544. Photo Credit: NSF (Arizona State University).

Page 22: A graduate student in marine science takes mid-river samples in the Neuse River in North Carolina. Credit: Photo by Hans Paerl; courtesy University of North Carolina's Endeavors magazine. NSF multimedia gallery *http://www.nsf.gov/news/mmg/mmg_disp.cfm?med_id=51623&from=mmg*.

Page 23: A student gets a microscopic view while participating in the FIRST (Female Involvement in Real Science and Technology) program at the John Swett School in Oakland, CA. Credit: Photo by Nick Lammers. NSF Multimedia Gallery: http://www.nsf.gov/news/mmg/mmg_disp.cfm?med_id=51866&from=mmg.

Page 24: Biology undergraduate student, NSF target investigator and major professor collaborate on a project that explores the induction of transposition in mammals by environmental contaminants. This work was supported by National Science Foundation grant OSR 93-50539. Credit: Idaho *EPSCoR* Program. NSF Multimedia Gallery, http://www.nsf.gov/news/mmg/mmg_disp.cfm?med_id=51673&from=mmg.

Chapter 4

Page 86: The objective of the *Partnership for Research and Education in Materials (PREM)* is to enhance diversity in materials research and education by stimulating the development of formal, long-term, collaborative research and education partnerships between minority-serving institutions(MSIs) and the NSF Division of Materials Research-supported groups, centers, and facilities. Photo Credit: NSF Division of Materials Research (Professor Selke's lab at California State University, Los Angeles).

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