National Science Board

The Science and Engineering Workforce
Realizing America's Potential

National Science Foundation

August 14, 2003

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NATIONAL SCIENCE BOARD

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TASK FORCE ON NATIONAL WORKFORCE POLICIES FOR SCIENCE AND ENGINEERING

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PREFACE

The National Science Board began its study of long-term trends and policies for the science and engineering (S&E) workforce in 2000, at the end of the longest peacetime economic expansion in US history. As the study draws to a close, we are cognizant of growing unemployment for scientists and engineers in some fields, reflecting the current downturn in the business cycle. Existing forecasting models and data for policy and planning do not support surgical interventions in the workforce responsive to short-term fluctuations in supply and demand. These tools should be improved, but that task is beyond the scope of this report.

Even with improved methodological tools, Federal policy cannot react primarily to short-term skill shortages or surpluses, but rather to the long-term opportunities and needs for the Nation. The necessity for sophisticated, costly facilities for science and engineering education, well-qualified faculty, and the long lead-time required to attain a baccalaureate, much less an advanced degree in science or engineering, precludes a "just-in-time" delivery approach to policies to sustain and strengthen the S&E workforce.

Current data are sufficient to identify several significant trends for the global and domestic science and engineering talent pools. These trends compel a forward-looking Federal response based on national needs. The President's Council of Advisors for Science and Technology (PCAST), the House of Representatives in its National Science Policy Study, *Unlocking Our Future*, the Council on Competitiveness, and The United States Commission on National Security/21st Century among others have argued for a strengthened Federal focus and action on national needs for science and engineering research and education.

The Federal Government is uniquely qualified to establish S&E workforce policies that transcend national boundaries or are addressed to national-level needs for the S&E workforce—such as overall skill mix and mix of participating demographic groups. We as a nation have a long-term challenge to sustain US global advantages in science and technology that rely on the capabilities of our workforce. Federal agencies working with other participants in and beneficiaries of US science and engineering must take up this challenge.

Warren M. Washington
Chair, National Science Board

ACKNOWLEDGMENTS

We wish to thank the many members of the science and engineering and policy communities for the generous contribution of their time and intellect to the Board's study. Those who participated as speakers and panelists in special meetings of the Task Force on National Workforce Policies for Science and Engineering are listed in the agendas for those meetings, included in the appendices to this report. Also provided in Appendix VI are the names of organizations and individuals who commented on the draft released by the Board for public comment at its May 22, 2003 meeting. The contributions from the various stakeholder communities have been critical in shaping our thinking and recommendations on national policies.

We are grateful to the many National Science Foundation staff members who have provided support throughout this study. In particular we want to call out the valuable assistance of the staff of the Division of Science Resources Statistics. Others who were critical to the success of this study include NSF Deputy Director, Dr. Joseph Bordogna and NSF Assistant Director for Education and Human Resources, Dr. Judith Ramaley.

We want to express our appreciation to the National Science Board Office staff for their many contributions to this effort. Those deserving special note include former Executive Officer Dr. Marta Cehelsky, who guided all aspects of the Board's effort during the initiation phase of our study; NSB Senior Policy Officer, Dr. Daryl Chubin, who served as the first Executive Secretary to the Task Force until his departure; Ms. Jean Pomeroy, Senior Policy Analyst, who contributed to the drafting and revisions of the report; and former Acting Executive Officer, Mr. Gerard Glaser.

Finally, we wish to acknowledge the special contribution of former NSB Chair Eamon Kelly, who launched this activity and provided his energy and guidance during its initial phases.

EXECUTIVE SUMMARY

INTRODUCTION

Science and technology have been and will continue to be engines of US economic growth and national security. Excellence in discovery and innovation in science and engineering (S&E) derive from an ample and well-educated workforce – skilled practitioners with two- and four-year degrees and beyond, researchers and educators with advanced degrees, and precollege teachers of mathematics and science. The future strength of the US S&E workforce is imperiled by two long-term trends:

- 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;

- The number of native-born S&E graduates entering the workforce is likely to decline unless the Nation intervenes to improve success in educating S&E students from all demographic groups, especially those that have been underrepresented in S&E careers.

The National Science Board has examined these issues and finds that national-level action is needed to ensure our country's capacity in S&E in an increasingly competitive and changing global labor market. The Federal Government has primary responsibility to lead the Nation in a coordinated response to meet our long-term needs for science and engineering skills in the US workforce.

The scale and nature of the ongoing revolution in science and technology, and what this implies for the quality of human capital in the 21st century, pose critical national security challenges for the United States. Second only to a weapon of mass destruction detonating in an American city, we can think of nothing more dangerous than a failure to manage properly science, technology, and education for the common good over the next quarter century.

U.S. Commission on National Security/21st Century (2001)

RECOMMENDED NATIONAL POLICY IMPERATIVE

The Federal Government and its agencies must step forward to ensure the adequacy of the US science and engineering workforce. All stakeholders must mobilize and initiate efforts that increase the number of US citizens pursuing science and engineering studies and careers.

The National Science Board findings and recommendations to achieve this imperative through broad-based efforts with other stakeholders follow.

FINDINGS AND RECOMMENDATIONS

Undergraduate Education in Science and Engineering

RECOMMENDATION:

The Federal Government must direct substantial new support to students and institutions in order to improve success in S&E study by American undergraduates from all demographic groups.

The Federal Government should:

- Ensure that scholarships and other forms of financial assistance are available to well-qualified students who otherwise would be unable to attend school full time to pursue an S&E major;
- Provide incentives to institutions to expand and improve the quality of their S&E programs in areas in which degree attainment nationwide is insufficient;
- Provide financial support to community colleges to increase the success of high-ability students in transferring to four-year S&E programs in colleges and universities; and
- Expand funding for programs that best succeed in graduating underrepresented minorities and women in S&E.

Advanced Education in Science and Engineering

RECOMMENDATION:

Federal support for research and graduate and postdoctoral education should respond to the real economic needs of students and promote a wider range of educational options responsive to national skill needs.

Federal strategies should:

- Ensure that Federal stipends for graduate and postdoctoral students provide benefits[1] and are competitive with opportunities in other venues;

- Invest in innovative approaches to doctoral and masters education that prepare students for a broad range of disciplinary and cross-disciplinary careers in academia, government, and industry; and

- Provide consistent, long-term support for high-quality disciplinary and interdisciplinary doctoral training programs in S&E.

KNOWLEDGE BASE ON THE SCIENCE AND ENGINEERING WORKFORCE

RECOMMENDATION:

To support development of effective S&E workforce policies and strategies, the Federal Government must:

- **Substantially raise its investment in research that advances the state of knowledge on international S&E workforce dynamics;**

- **Lead a national effort to build a base of information on:**
  1. **The current status of the S&E workforce,**
  2. **National S&E skill needs and utilization and**
  3. **Strategies that attract high-ability students and professionals to S&E careers.**

PRECOLLEGE TEACHING WORKFORCE FOR MATHEMATICS, SCIENCE AND TECHNOLOGY

RECOMMENDATION:

In partnership with other stakeholders, the Federal Government should act now to attract and retain an adequate cadre of well-qualified precollege teachers of mathematics, science and technology.

To make precollege teaching more competitive with other career opportunities, resources must be provided to:

- Compensate teachers of mathematics, science and technology comparably to similarly trained S&E professionals in other sectors;

- Reinforce the profession of teaching as an important and rewarding career and include teachers as an integral part of the scientific and engineering professions;

[1] Fringe benefits, especially for health care.

- Support classroom training and expedite teacher certification of scientists and engineers from professions other than teaching;

- Support in-service training to enhance classroom skills and subject matter expertise; and

- Support programs in teacher preparation at institutions that succeed in integrating faculty and curricula of schools of engineering and science with schools of education.

To improve effectiveness of precollege teaching, stakeholders must collaborate to:

- Support outreach efforts to K-12 by science and engineering professionals to motivate high-quality curricular standards and expand content knowledge for classroom teachers; and

- Support research on learning that better informs K-12 mathematics and science curricula and pedagogy development.

US Engagement in the International Science and Engineering Workforce

RECOMMENDATION:

During the current reexamination of visa and other policies concerning the mobility of scientists and engineers, it is essential that future US policies:

- **Strengthen the capacity of US research universities to sustain their leadership role in increasingly competitive international S&E education;**

- **Strongly support opportunities for American students and faculty to participate in international S&E education and research; and**

- **While enhancing our homeland and national security, maintain the ability of the United States to attract internationally competitive researchers, faculty and students.**

Process for Producing the Report

The National Science Board Task Force on National Workforce Policies for Science and Engineering, reporting through the Committee on Education and Human Resources, was established in October 2000. Its charge was to assess long-term national workforce trends and needs in science and engineering and their relationship to existing Federal policies and to recommend policy directions that address long-term S&E workforce needs. In response to the charge and to better inform recommendations, the task force initiated an extensive examination of existing data, policy documents, and expert opinion.

A data briefing, held on January 30, 2001 (see agenda, Appendix II), provided expert testimony from the following:

- Bureau of Labor Statistics covering databases on occupations and employment maintained by the various surveys of the bureau;
- NSF Division of Science Resources Statistics on the three surveys that constitute NSF's Scientists and Engineers Statistical Data System;
- US Department of Education's Office of Educational Research and Improvement concerning the information technology workforce and certification programs;
- Institute for the Study of International Migration at Georgetown University on information sources concerning migration of S&E students and workers to the US; and
- The University of Phoenix, Council of Graduate Schools, and Alfred P. Sloan Foundation concerning university perspectives on approaches to degree programs, skills certification, and response to market demand.

In order to better understand policy issues concerning the flow of foreign S&E workers to the United States, the task force commissioned a report, "State of Knowledge on the Flow of Foreign Science and Technology Workers to the United States," by Dr. B. Lindsay Lowell of the Institute for the Study of International Migration at Georgetown University (see Executive Summary of his report, Appendix V).

Task force meetings featured expert testimony from NSF staff on teacher preparation and professional development, national data on teachers, and NSF data on mid-career training and education of S&E professionals. For information on issues at the State level, the task force was briefed on the critical path analysis of California's S&E education system by the Executive Director of the California Council on Science and Technology.

The task force held a workshop in March 2002 on national policies addressing the US education system and approaches to achieve increased numbers of well-prepared associate and baccalaureate degree recipients (see agenda, Appendix III). Presentations and discussion by leaders in the field focused on policy options in the following areas:

The transition from precollege to undergraduate study;
Multiple pathways to the workforce and mobility of students among various educational offerings;
The system for teacher preparation and certification and the interplay with other career options;
State-level policies on science and technology education;
Incentives to increase the supply of college graduates;

Diversity and student development;
Institutional strategies and their impacts on undergraduate students.

The task force held a workshop in June 2002 concerning the interplay between the international character of the advanced science and engineering workforce and national needs (see agenda in Appendix IV). Dr. John Marburger, Director, Office of Science and Technology Policy, Executive Office of the President, addressed the workshop. Experts from industry, government, academia, and professional societies explored needs and policies across the following areas:

Employment serving the US government;
US corporations and their workforce needs;
The impact of security policies on the S&E workforce;
Policies and approaches in other countries;
US policies and regulations affecting international graduate students and postdoctoral researchers;
Factors affecting the choice of domestic students to attend graduate school.

The task force contracted with SRI International for a comprehensive literature review that identified and summarized studies with policy recommendations relevant to the S&E workforce (see bibliography, Appendix VII).

The National Science Board approved a draft report of the Task Force on National Workforce Policies for Science and Engineering for public comment at its May 22, 2003 meeting. The report was posted on the NSB web page on May 30, with a request for comments by July 1, 2003. An outreach effort was undertaken to encourage comment. All comments were reviewed by the task force and the Committee on Education and Human Resources. A revised draft reflecting comments was considered by the full Board and approved for publication at the August 14 NSB meeting. Names of those submitting written comments are listed in Appendix VI, unless anonymity was requested.

Box A:
Defining the Science and Engineering Workforce

There are a number of definitions for the science and engineering workforce. The most common is to count those in occupations classified as science and engineering positions. However, this approach fails to identify those with skills in science and engineering used in non-S&E occupations—for example, in technical management. The task force has focused on the availability of skills, in view of the fluid nature of the science and engineering workforce—with members capable of employment in a number of kinds of occupations over the course of their careers. In this definition, a precollege teacher with a baccalaureate or the equivalent in a field of science, mathematics or engineering is a member of the science and engineering workforce. Also included are practitioners with two-year degrees and certificates in science, engineering and technology fields. Further, doctoral level scientists in postdoctoral positions form a vital and growing component of the US S&E workforce in some fields of research, notably nowadays in biomedicine.

This approach appears to be more in keeping with how degree holders view themselves. For those with science and engineering baccalaureates or higher-level degrees in the workforce in 1999, 67 percent in occupations not formally classified as S&E jobs stated that their jobs were at least somewhat related to their highest S&E degree field. In 1999 there were 10.5 million S&E degree holders at the baccalaureate level or above in the workforce. For the purposes of this study, this group along with those with associate degrees in science and engineering are considered the qualified pool of scientists and engineers. (See SEI-2002, "Who is a Scientist or Engineer?" 3-5)

CHAPTER ONE

INTRODUCTION

THE CHALLENGE FOR US SCIENCE AND ENGINEERING

Science and technology have been and will continue to be engines of US economic growth and national security.[2] Excellence in discovery and innovation in science and engineering (S&E) derive from an ample and well-educated workforce – skilled practitioners with two- and four-year degrees and beyond, researchers and educators with advanced degrees, and the precollege teachers of mathematics and science. Historically, the US has benefited from both an abundant supply of indigenous talent and the contributions of scientists, engineers, and graduate students from other countries. This blend of domestic and international talent has advanced the frontiers of knowledge and propelled the US to a position of global leadership in S&E. Analyses of current trends, however, indicate serious problems lie ahead that may threaten our long-term prosperity and national security. These include:

- Flat or reduced domestic student interest in critical areas, such as engineering and the physical, and mathematical sciences, as shown by data for bachelors degrees; (see Figure 1);
- Large increases in retirements from the S&E workforce projected over the next two decades[3];
- Projected rapid growth in S&E occupations over the next decade, at three times the rate of all occupations[4];
- Anticipated growth in the need for American citizens with S&E skills in jobs related to national security, following September 11, 2001; and
- Severe pressure on State and local budgets for education of the future S&E workforce.

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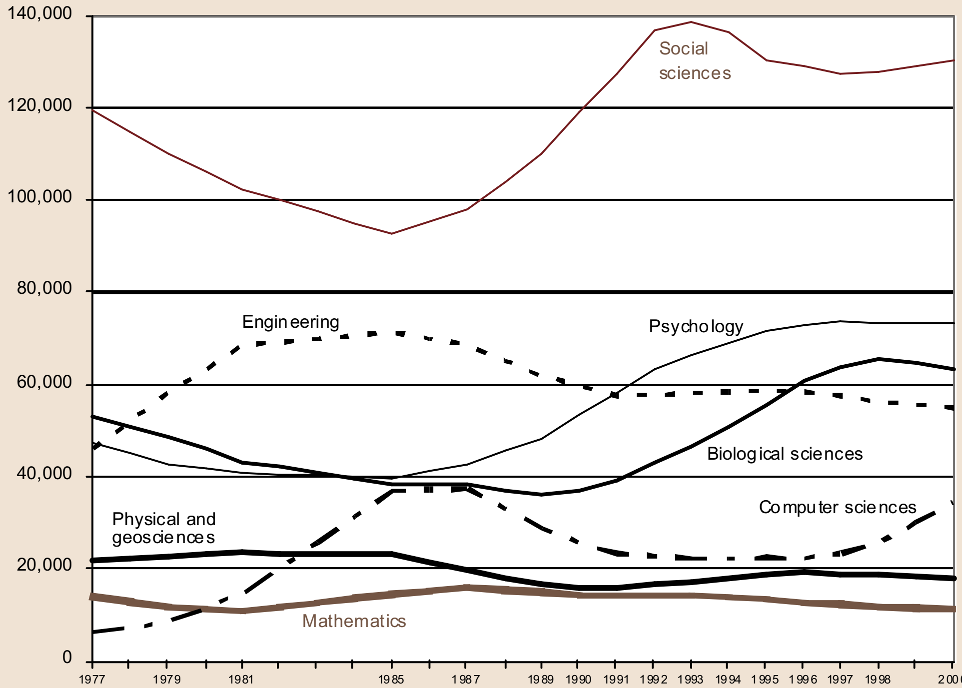
[2] The United States Commission on National Security/21st Century, chapter 2.

[3] *Science & Engineering Indicators—2002* (SEI-2002) reports that "total retirements of S&E degreed workers will increase dramatically over the next 20 years, barring large changes in retirement rates. More than half of S&E degreed workers are age 40 or older, and the 40-44 age group is nearly 4 times as large as the 60-64 age group," 3-3.

[4] SEI-2002: 3-27 & text table 3-23. The long-term growth in S&E occupations far exceeds that of the workforce in general—with more than four times the annual growth rate of occupations in general since 1980, 3-3.

FIGURE 1

BACHELOR'S DEGREES EARNED IN SELECTED S&E FIELDS BY U.S. CITIZENS AND PERMANENT RESIDENTS: SELECTED YEARS, 1977-2000



SOURCES: National Science Foundation, Division of Science Resources Statistics (NSF/SRS) Science and Engineeering Degrees, by Race/Ethnicity of Recipients 1991-2000, Detailed Statistical Tables, NSF 02-329; and NSF/SRS, WebCASPAR database system, http://caspar.nsf.gov

The Federal Government accepted a major role for developing and broadening the S&E research and education enterprise in colleges and universities after the Second World War.[5] Federal support for S&E research and education successfully expanded access for Americans to S&E careers. It fueled the technological and information revolutions that transformed the economy. The transformation changed the skill mix required in the national workforce and dramatically increased demand for scientists and engineers. Yet today, the Nation lacks the necessary long-term national goals and strategies to ensure the recruitment, education, and on-going development of an adequately sized and appropriately qualified S&E workforce.

US employers have grown increasingly dependent on the global S&E workforce to meet needs in industry, government, and academia. For example, in 1999, one-third of all S&E PhD-holders working in industry were born abroad. Among computer scientists, the proportion was half, and among engineers it was more than half. For the Federal Government workforce, 16 percent of PhD holders in 1999 were born abroad.[6] In

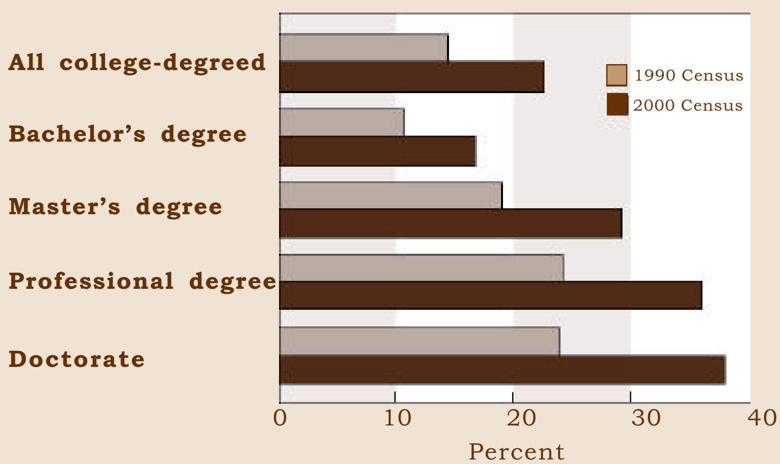
[5] "The Government should accept new responsibilities for promoting the flow of new scientific knowledge and the development of scientific talent in our youth. These responsibilities are the proper concern of the Government, for they vitally affect our health, our jobs, and our national security." V. Bush, *Science—The Endless Frontier*, 1945: 8.
[6] SEI-2002: 7-8.

academia, about 20 percent of the yearly job openings for college and university faculty in S&E are being filled by permanent residents or temporary visa holders.[7]

The United States has always benefited from international science and engineering talent. However, the US S&E workforce has become increasingly dependent on the Nation's ability to attract scientists and engineers from other countries. Census-based estimates of the proportion of S&E occupations[8] filled by scientists and engineers born abroad show steep increases at every degree level from 1990 and 2000, reflecting both the immigration patterns of the 1990s and the inflow of foreign specialists under various work visa categories (Figure 2).[9]

FIGURE 2

SHARE OF FOREIGN-BORN SCIENTISTS AND ENGINEERS IN U.S. S&E OCCUPATIONS, BY DEGREE LEVEL: 1990 AND 2000



NOTE: Data exclude postsecondary teachers.
SOURCE: U.S. Bureau of the Census, 5 percent public use microdata system files, 1990 and 2000.

For all degree levels, the share of US S&E occupations filled by scientists or engineers who were born abroad increased from 14 to 22 percent. At the bachelor's degree level, the share increased from 11 to 17 percent; at the master's level, from 19 to 29 percent; and at the doctorate level, from 24 to 38 percent. The growing US dependence on international S&E talent, particularly on foreign nationals, has become problematic. The future US S&E workforce is imperiled by two long-term trends documented in this report:

- 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;

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[7] B. Lindsay Lowell, "State of Knowledge on the Flow of Foreign Science and Technology Workers to the United States", paper prepared for the Task Force on National Workforce Policies for S&E: 29.
[8] People in occupations classified as science and engineering jobs. Professional degrees include specialties such as medicine and law.
[9] These figures exclude US-educated scientists and engineers born in foreign countries hired by US firms into positions at their overseas affiliates.

Forecasting Demand and Supply

This National Science Board report addresses the implications of long-term trends for Federal policies for the science and engineering workforce. In doing so, the Board acknowledges the inherent uncertainties involved in forecasting demand and supply for S&E skills in the workforce. A recent study by the National Research Council of forecasting models for PhD scientists and engineers reviews the shortcomings of existing forecasting models and identifies a broad range of issues that must be addressed to develop better tools for policy and planning. (*Forecasting Demand and Supply of Doctoral Scientists and Engineers: Report of a Workshop on Methodology*, National Academy of Sciences: 2000). This is important research and should be pursued, but it is outside the scope of the Board's study. It is not the intention of the Board to address numerical goals for the current or future supply of science and engineering talent based on current projections of workforce demand. The Board does, however, assume that the growing US reliance on science and technology produces a complementary growth in the need for science and engineering skills in the workforce, as it has in the past (see SEI-2002, 3-3).

- The number of native-born S&E graduates entering the workforce is likely to decline unless the Nation intervenes to improve success in educating S&E students from all demographic groups, especially those underrepresented in S&E careers.

The National Science Board has examined the issues and finds it imperative that the Federal Government lead an aggressive effort to better prepare the Nation's S&E workforce starting at the earliest years of education. The government must focus substantial effort on strengthening that workforce in ways unlikely to be addressed by market mechanisms or interventions at the State and local levels. This Board report focuses on necessary national policies for the domestic S&E workforce in its evolving relationship with the global S&E enterprise. A 1999 Board report, *Preparing Our Children*[10], dealt with curricular issues at the precollege and undergraduate levels of the US education system.[11] That topic will not be revisited other than to reaffirm the necessity of a strong curriculum in mathematics, science, engineering, and technology from the earliest grades to build the knowledge needed by citizens and members of the workforce.

National workforce policies, such as those recommended in this report, must be implemented coherently across Federal agencies responsible for education and research and coordinated with efforts to advance science, technology, engineering and mathematics by other sectors. Efforts will require increased Federal resources commensurate with the role and planned contribution of each Federal agency to the development of the S&E workforce. The level and focus of investment must be sufficient to reverse the trend of declining numbers of domestic students electing careers in S&E.

In view of potential peril to US strength in science and engineering, the Board endorses the following imperative for Federal action:

RECOMMENDED NATIONAL POLICY IMPERATIVE

The Federal Government and its agencies must step forward to ensure the adequacy of the US science and engineering workforce. All stakeholders must mobilize and initiate efforts that increase the number of US citizens pursuing science and engineering studies and careers.

The fundamental arguments for this imperative are developed in the remaining sections of this report. Chapter Two, "The Global and Domestic Contexts," provides data to support the two major findings noted above. Chapter Three offers specific "Findings and Recommendations" subdivided into five policy areas:

- Undergraduate education in science and engineering;
- Advanced education in science and engineering;
- Knowledge base on the science and engineering workforce;
- Precollege teaching workforce for mathematics, science and technology; and
- US engagement in the international science and engineering workforce.

[10] NSB. *Preparing Our Children/Math and Science Education in the National Interest* (NSB 99-31)
[11] See Box E, 34-35.

CHAPTER TWO

THE GLOBAL AND DOMESTIC CONTEXTS

GLOBAL COMPETITION FOR THE SCIENCE AND ENGINEERING WORKFORCE

Governments throughout the world recognize that a high-skill S&E workforce is essential for economic strength. Countries beyond the United States have been taking action to increase the capacity of their higher education systems, attract foreign students and workers, and raise the attractiveness to their own citizenry of staying home or returning from abroad to serve growing national economies and research enterprises.

Many countries have substantial capacity in their higher education systems for advanced S&E study, including doctoral degrees. Global data grouped by broad world regions indicate that European universities produce the largest number of natural science doctorates, while Asian universities produce the most engineering doctorates.[12] Some major industrial countries with substantial educational capacity are experiencing a decline in college-age populations. To use their capacity for advanced education and sustain academic research, they are aggressively recruiting graduate students from countries with growing student populations, in competition with the United States.[13]

Countries compete for their own educated citizens through attractive living standards and job opportunities. One mechanism many countries use to spur job growth is to increase investment in research and development (R&D). A measure of the impact of R&D investment is the number of researchers in a country. Growth in the number of researchers in many countries of the Organisation for Economic Co-operation and Development (OECD) has outstripped that in the US. From 1993 to 1997, the number of reported researchers in OECD countries increased by 23.0 percent, while reported US researchers increased 11.8 percent. The greatest growth, 120.0 percent, was in OECD countries other than the United States, Japan, and the European Union.[14] Another indicator of a country's commitment to growth in scientific knowledge and technology development is the ratio of R&D spending to gross domestic product (GDP). The United States ranked fifth among OECD countries in reported ratio of total R&D to GDP for the 1996-98 period.[15]

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[12] Jean M. Johnson, "International Mobility of Doctoral Recipients from U. S. Universities," SRS data.
[13] Johnson, SRS data: SEI-2002, O-4.
[14] SEI-2002: 3-28.
[15] Total R&D includes defense and nondefense. SEI-2002: 4-4.

Some economies have been particularly successful in enticing scientists and engineers to return after advanced training and research experience abroad; for example, Taiwan, Korea, and Ireland.[16] China pursues the strategy, introduced as policy in 1992, of supporting study abroad and encouraging return with free movement in and out of the country.[17] A growing strategy is to treat educated citizens living abroad as a distributed resource to be networked for knowledge exchange and entrepreneurial partnering in service to national economic development.

Increased competition for S&E workers comes at a time when demand for their skills is projected to rise significantly – both in the United States and throughout the global economy.[18] Growing demand for technical skills can be met in several ways. One mechanism is for a country to increase immigration; however, as discussed above, competition for scientific talent is intensifying. Alternatively, a country can induce people engaged in non-S&E occupations or degree programs to switch to S&E. For the United States, this approach has not been a significant source of S&E workers. In fact, the direction of flow is from S&E degrees into non-S&E occupations.[19]

Finally, a country can meet skill needs by enticing a larger share of its domestic college-age population to attain a first university degree in natural science and engineering (NS&E).[20] Economies beyond the United States are building up the NS&E capabilities at a greater rate than the US has been able to achieve, as shown in Figure 3.[21] Indeed, thirteen economies now outrank the United States in the ratio of NS&E first university degrees to the 24-year-old population, while in 1975, the United States ranked third. Clearly, this enticement strategy is underused by the United States. Indeed, S&E degree attainment by domestic students has dropped in many areas of the physical sciences and engineering and in mathematics and computer science, both at the undergraduate and graduate levels.[22]

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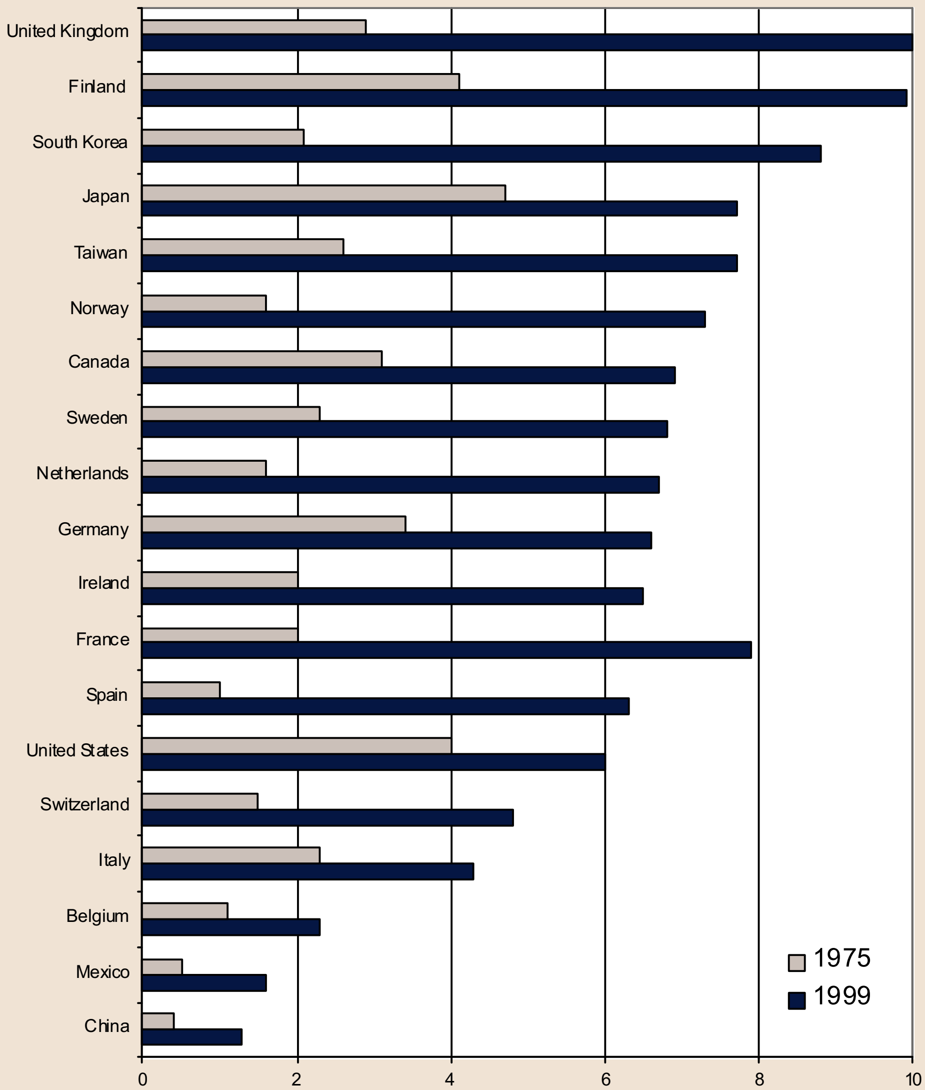
[16] Johnson: 8.
[17] Yugui Guo, paper prepared for NWP Workshop, June 2002: 11.
[18] SEI-2002: 3-27, 28, 29.
[19] In 1999, of the approximately 8 million employed persons whose highest degree was in science or engineering, only 3 million were employed in occupations classified as S&E. The majority of those in occupations classified as non-S&E reported that the skills demanded on the job were closely or somewhat related to their field of study. Members of the workforce educated in science and engineering are mobile among occupations, with large numbers employed as managers, teachers, and marketing personnel. (SRS InfoBrief, NSF 02-325).
[20] NS&E is the natural sciences and engineering, where natural sciences include physics, chemistry, astronomy, and earth, atmospheric, ocean, biological, and agricultural sciences, as well as mathematics and computer sciences. (SEI-2002: 2-39, Figure 2-27).
[21] SEI-2002: O-3.
[22] SEI-2002: Figure 2-11 and Appendix Table 2-25.

FIGURE 3.

RATIO OF NS&E FIRST UNIVERSITY DEGREES TO 24-YEAR-OLD POPULATION, 1975 AND 1999



First university degrees per 100 24-year-olds

NOTES: Natural sciences include physics, chemistry, astronomy, earth, atmospheric, ocean, biological, agricultural, as well as mathematics and computer sciences. The ratio is the number of natural science and engineering degrees to the 24-year-old population. China's data are for 1985 and 1999. Other locations' data are for 1975 and 1998 or 1999.[23]

[23] SEI-2002: Figure 2-27.

DOMESTIC HUMAN RESOURCES FOR SCIENCE AND ENGINEERING

Greater success in attracting and preparing US students for S&E careers will require that policymakers have an understanding of the Nation's domestic student population and their record of participation in S&E. Table 1 provides data on the college-age population by race/ethnicity.[24] Table 2 details bachelor's degree attainment by sex and by race/ethnicity. In the coming decades, an increasing proportion of US students – and an increasing proportion of college graduates – will come from demographic groups that have not heretofore participated in S&E careers at a rate commensurate with their share of the US 24-year-old population.

TABLE 1:
U.S. POPULATION OF 18- TO 24-YEAR-OLDS, BY RACE/ETHNICITY: 2000–2025

Year	Number	Percent
Total		
2000	26,631,733	100%
2010	30,138,083	100%
2025	30,372,078	100%
White		
2000	17,555,265	66%
2010	18,880,000	63%
2025	16,785,000	55%
Asian/Pacific Islander		
2000	1,041,519	4%
2010	1,521,000	5%
2025	2,114,000	7%
Hispanic		
2000	3,965,297	15%
2010	5,101,000	17%
2025	6,560,000	22%
Black		
2000	3,827,679	14%
2010	4,354,000	14%
2025	4,609,000	15%
American Indian/Alaskan Native		
2000	241,888	1%
2010	282,000	1%
2025	304,000	1%

NOTE: Populations for 2010 and 2025 are projected.
SOURCE: U.S. Bureau of the Census, Population Division, Projections of the Resident Population by Age, Sex, Race and Hispanic Origin: 1999 to 2100 (Washington, DC, 2000). Available at <www.census.gov/population/estimates/nation>.

Science & Engineering Indicators – 2002

As shown in Table 1, the 2000 census figures and projections for 2010 and 2025 indicate a college-age population that does not increase significantly after 2010. The proportion of whites (non-Hispanic) is projected to decrease significantly, while that of Hispanics will increase significantly. The minority

[24] SEI-2002 appendix table 2.2.

groups who are currently underrepresented in S&E careers — Hispanics, African-Americans, and American Indian/Alaskan Natives — are projected to increase as a share of the college-age population from 32 percent in 2010 to 38 percent in 2025. Hispanics account for 90 percent of the projected increase in underrepresented minorities.

As shown in Table 2, column A, the rates of bachelor's degree attainment per 100 24-year-olds for whites and Asian/Pacific Islanders are more than twice that of the underrepresented minorities. As shown in column B, the proportion of bachelor's degrees that are in NS&E is around 15 percent for both whites and underrepresented minorities, while over 30 percent for Asian/Pacific Islanders. The resultant participation rate in NS&E degree attainment per 100 24-year-olds, in column C, shows wide differences – from 14.7 per hundred for Asian/Pacific Islanders to 6.3 per hundred for whites to 2.6 per hundred for underrepresented minorities. Given the population shifts detailed above, if participation rates remain the same, the US will suffer a drop over the years in bachelor's-level NS&E degree attainment.

Table 2:
Participation Rate in Natural Sciences and Engineering Bachelor's Degrees in 1998

Race/ ethnicity and sex	Total 24-year-old Population	Total bachelor's degrees	Total NS&E degrees	A Bachelor's degrees per 100 24-year-olds	B NS&E % of bachelor's	C NS&E degrees per 100 24-year olds
Total	3,403,039	1,199,579	205,355	35.3	17.1	6.0
Sex						
Male	1,714,571	525,714	128,481	30.7	24.4	7.5
Female	1,688,468	673,865	76,874	39.9	11.4	4.6
Race/ethnicity						
White	2,251,292	878,018	142,500	39.0	16.2	6.3
Asian/Pacific Islander	149,413	69,988	22,003	46.8	31.4	14.7
Underrepresented minority	1,002,334	181,709	25,820	18.1	14.2	2.6
Black	473,402	95,878	12,731	20.3	13.3	2.7
Hispanic	497,620	78,125	12,006	15.7	15.4	2.4
American Indian/Alaskan Native	31,312	7,706	1,083	24.6	14.1	3.5

NOTE: Population data are for US residents only and exclude members of the Armed Forces living abroad
SOURCE: *Science and Engineering Indicators-2002*, from text table 2-9

The participation rates documented in Table 2 point clearly to underused resources – underrepresented minorities and women. For underrepresented minorities, the pressing need is for a higher overall rate of bachelor's degree attainment with the rate of participation in NS&E

ideally increasing. For women, the overall rate of bachelor's degree attainment is higher than for men, but the rate of NS&E degree attainment is half that of men. Most importantly, to meet projected growth in S&E jobs while growth in the college-age population levels off, the United States must devise a means to increase the rate of NS&E degree attainment from all population groups.

The issue is not only the number of degrees attained, but also the distribution of degrees among disciplines and the fit to job opportunities. In the 15-year period 1985-2000, the number of bachelor's degrees in all S&E fields rose by 15.3 percent. The number of bachelor's degrees in NS&E declined 1.1 percent. If biological sciences are excluded, the number of baccalaureates awarded in the remaining NS&E fields dropped by 18.6 percent. This drop in bachelor's degrees includes fields of engineering, mathematics and computer sciences, physical sciences, and geological sciences.[25] In many cases, openings in graduate study and the job market have been filled by foreign students and workers.

[25] SEI-2002 appendix table 2-17, Figure 1 of this report.

CHAPTER THREE

FINDINGS AND RECOMMENDATIONS

The National Science Board's findings and recommendations focus on national workforce policies in five areas:

- Undergraduate education in science and engineering;
- Advanced education in science and engineering;
- Knowledge base on the science and engineering workforce;
- Precollege teaching workforce for mathematics, science and technology; and
- US engagement in the international science and engineering workforce.

UNDERGRADUATE EDUCATION IN SCIENCE AND ENGINEERING

The global competitiveness of the US S&E workforce and domestic competitiveness of S&E careers will depend ultimately on how schools, colleges, universities, and other education providers develop and refine human resources. The Federal Government has long supported graduate S&E education through fellowships, traineeships, and research grants. At the undergraduate level, however, the responsibility for development of the S&E workforce has been shouldered primarily by States and localities through public institutions of higher education and an array of private institutions. The Federal Government has a stake in the workforce of the Nation as a whole, especially the S&E workforce needed to serve Federal missions.[26] It cannot rely solely on the aggregated State and institutional efforts at the baccalaureate level to ensure that there will be an adequate complement nationwide of high-quality teachers and practitioners in S&E fields and a sufficient pool of students prepared for graduate studies to meet the needs of the workforce for advanced S&E skills. The States and institutions of higher education lack the resources and incentives to provide sufficient support for the S&E workforce that the Nation needs.

[26] The United States Commission on National Security/21st Century, *Road Map for National Security*: Chapter II.

For the Nation to be successful in attracting students to S&E study, policymakers must understand the context in which students make career decisions and institutions make resource decisions. They must understand the trends in S&E bachelor's degree attainment documented in the previous section of this report. The Board has examined the current situation in undergraduate education and identified actions that must be taken to increase success in educating students from the largest possible pool of talent.

The context of S&E study for the student

From the vantage point of the talented high school graduate, the postsecondary educational marketplace offers a huge array of choices and ways to invest time and money. Careers in S&E hold promise of good lifetime earnings, expanding job opportunities, and interesting work. [27] But preparation for such careers poses challenges. Research shows that student success in attaining a degree correlates with rigorous academic preparation in high school, especially in mathematics, and with "traditional" paths in college – continuous, full-time enrollment to obtain the degree.[28]

The issue for students is not only the choice of S&E study, but continuation in a course of study. Surveys of freshmen intentions show high levels of interest in S&E, with approximately 25-30 percent intending to major in S&E.[29] However, the net movement of students over their undergraduate years is out of S&E and into other majors or out of college. As a result, less than half of those intending to major in S&E fields complete an S&E degree within 5 years. Underrepresented minorities drop out of S&E majors at a higher rate than other groups.[30]

The affordability of a college education can have a major impact on a student's persistence and ultimate success in attaining a degree. The cost has been rising. Our current system of higher education is experiencing a steady decline of state support, rising tuition, and increased reliance on debt-based financing. The majority of students are turning to loans to finance college, with 64 percent of graduating students in 2000 reporting student loan debt.[31] The average student loan debt has nearly doubled over the past eight years to $16,928. For low-income students, the percentage of the cost of attending a public four-year college covered by the maximum Pell Grant award has fallen over the past 25 years, from 84 percent in 1976 to 40 percent in 2001.[32]

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[27] Natural scientists and engineers fall within one of the highest wage categories from the Bureau of Labor Statistics http://www.bls.gov/ncs/ocs/sp/ncbl0539.pdf, although wages vary among fields. NSF reports that S&E degree holders enjoy rising salaries over the years after receiving their degrees (SEI-2002: 3-11) and relatively low unemployment rates. In 1999 the unemployment rates for S&Es were 1.5 percent for men and 1.8 for women, while the unemployment rate was 4.4 percent for all workers and 1.9 percent for professional specialty workers (SEI-2002: 3-8,9).
[28] Jane V. Wellman, "State Policy and Community-College-Baccalaureate Transfer," August 2002, National Center for Public Policy and Higher Education.
[29] SEI-2002: 2-4.
[30] SEI-2002: 2-4.
[31] The State PIRGs' Higher Education Project, "The Burden of Borrowing: A Report on Rising Rates of Student Debt," March 2002.
[32] State PIRGs' Higher Education Project: 1.

The rising cost of higher education has led to a decrease within the college student population in the number and share of "traditional" students – those who enroll full-time immediately after high school and depend on parents for financial support. Only 27 percent of today's undergraduates are traditional students. Nontraditional students are most likely to attend public two-year colleges. However, 37 percent of students at public four-year institutions and 35 percent at private, nonprofit institutions are nontraditional. [33]

The difficulties faced by students unable to pursue full-time study are severe for S&E majors because of curricula built on prerequisites, limited course offerings at accessible times and places, and the necessity of laboratory work. S&E curricula generally require the sequential acquisition of knowledge and skills along directed paths. Should the student step off the path to an S&E career, it is difficult to rejoin.

Institutional resources for S&E education

Increasing the number of scientists and engineers from among all domestic students depends on adequate capacity in high-quality degree programs in a range of institutions. The highest quality S&E degree programs are found in institutions that can provide laboratories and equipment, the quality of faculty that are typically engaged in research, and curricula that are up to date. A primary issue in building institutional capacity is the higher cost of education in S&E as compared with other subjects. This cost differential has favored S&E capacity in institutions that are wealthier, whether by virtue of endowment, high tuition, Federal research funds, or state support.[34] For many institutions where enrollments are increasing and the percentage of students graduating in S&E is low, the sources of revenue are essentially limited to tuition and state/local support – and the latter is under great stress. New and augmented revenue streams are needed to give these institutions the capacity to better serve the needs of the S&E workforce.

Community colleges represent a special opportunity for expanding the number of S&E majors. Community colleges enroll about 38 percent of all students and their student enrollments are growing at twice the rate as those of four-year institutions. Minority students in higher education are concentrated in community colleges – 46 percent of Asians/Pacific Islanders, 46 percent of African-Americans, 55 percent of Hispanics, and 55 percent of American Indians/Alaskan Natives.[35] Community colleges are also important feeders to more advanced studies. Fifty percent of students in the California State University system attended a community college before entering a bachelor's degree program at a four-year institution.[36] Seventy-five percent of upper division education majors in the California State University system

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[33] *The Chronicle of Higher Education: Daily News*, 6/4/2002:1, citing National Center for Education Statistics, US Department of Education.
[34] Research universities enroll only 19 percent of the students in higher education, but they play the largest role in S&E degree production. They produce most of the engineering degrees and a large proportion of the NS&E degrees. In 1998, the Nation's 127 research universities awarded more than 42 percent of all S&E bachelor's degrees and 52 percent of all S&E master's degrees. SEI-2002, Chapter 2.
[35] Data for 1997, SEI-2002.
[36] California Council on Science and Technology, Critical Path Analysis of California Science and Technology Education System. Presentation by Dr. Susan Hackwood, Executive Director, California Council on Science and Technology, to the NSB Task Force on National Workforce Policies for Science and Engineering, March 2002.

began their studies at community colleges. Community colleges are also highly important in educating members of the technology workforce and keeping them current in their fields.

It is important that all institutions focus greater attention on retention as a strategy for expanding participation in S&E careers. Research on reasons for able students persisting or switching out of S&E programs concludes that improvement in the yield of S&E majors will require modification of the educational environment, particularly better teaching and advising, for improved retention of not only underrepresented minorities and women but able students from all demographic groups.[37] More institutional resources must be directed to improving the quality of teaching, the nature of introductory classes, the design of facilities to support new teaching methods, and more effective academic support mechanisms, including more effective advising. Strategies that focus on the individual student, such as are often directed to minority students, are not enough. The challenge is to change the conditions that give rise to retention problems and thereby improve the quality of the undergraduate learning experience for all students.

Attracting more US students to science and engineering studies must be multifaceted, targeting both the individual student and the institutions serving undergraduates.

RECOMMENDATION:

The Federal Government must direct substantial new support to students and institutions in order to improve success in S&E study by American undergraduates from all demographic groups.

The Federal Government should:

- Ensure that scholarships and other forms of financial assistance are available to well-qualified students who otherwise would be unable to attend school full time to pursue an S&E major;
- Provide incentives to institutions to expand and improve the quality of their S&E programs in areas in which degree attainment nationwide is insufficient;
- Provide financial support to community colleges to increase the success of high-ability students in transferring to four-year S&E programs in colleges and universities; and
- Expand funding for programs that best succeed in graduating underrepresented minorities and women in S&E.

[37] Elaine Seymour, "Tracking the Process of Change in US Undergraduate Education in Science, Mathematics, Engineering, and Technology," reviewed by NSB/EHR Committee, March 2002 meeting. A four-year study by Seymour and Nancy Hewitt identified the most important factors that distinguish undergraduates who switch out of science, technology, engineering and mathematics from those who persist. The two groups did not differ significantly in performance, motivation, or study-related behavior, but those who persisted in S&E were more able than those who did not to overcome the difficulties from poor teaching and advising.

Advanced Education in Science and Engineering

Although there has been considerable debate over the last decade about the overproduction of PhD scientists and engineers in certain fields, it is beyond dispute that society is – and will become even more – dependent on science and technology. Future progress and world leadership depend on a steady stream of scientific discoveries and developments that, in turn, depend on a cadre of individuals with a high level of scientific training and education.

Recent data on graduate enrollments of US citizens and permanent residents show a decline of 3 percent from 1999 to 2000.[38] Overall gain in graduate enrollment between 1999 and 2000 was more than accounted for by students with temporary visas, which increased 11 percent from 109,890 in 1999 to 121,827 in 2000. Nearly all growth in S&E PhDs awarded to US citizens is attributable to the rise in the number of women and minorities earning PhDs. The number of US white males earning S&E doctorates actually declined from 9,262 earned in 1980 to 8,138 in 1999.[39]

There is widespread concern that some subfields of the physical sciences, engineering, mathematics and computer science are not attracting domestic students in the numbers that will be required in the near future, in part because declining Federal support for research sends negative signals to interested students.[40] These individuals will be crucial to maintaining and advancing our technological infrastructure and our national security, as well as contributing to our economic well-being.

A number of factors will contribute to growth in the need for US personnel with advanced S&E degrees in the next few decades. These factors include accelerating retirements,[41] greater competition internationally for S&E talent, and national security concerns that may both affect access and attraction of foreign students and scholars to the United States and raise the demand for US citizens in national security-related areas.

The context for advanced S&E studies

Federal research and education policy to strengthen the domestic workforce of highly skilled professionals must recognize the competitive environment for talented students – both domestic and international. In the

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[38] NSF, "Growth Continued in 2000 in Graduate Enrollment in S&E Fields" (02-306) December 21, 2002.
[39] SEI-2002, Figure 0-7.
[40] For example, The President's Council of Advisors on Science and Technology (PCAST) report, *Assessing the US R&D Investment* (2002), found that "Federal support…for US graduate students in science and engineering has declined significantly". The report quotes IBM that "there is a dramatic shortage of people with the needed skills" in physical sciences for nanotechnology research. The 1998 House of Representatives National Science Policy Study, *Unlocking Our Future*, notes with concern the drop in enrollments by American students in physics, mathematics, computer science and engineering, and states that: "There appears to be a serious incongruity between the perceived utility of a degree in science and engineering by potential students and the present and future need for those with training in our society". Likewise the Council on Competitiveness reports that US national vulnerabilities include static or declining undergraduate and graduate degrees in engineering, the physical sciences, and math and computer sciences. For other nations, unlike the United States, the share of science and engineering degrees increased over the decade 1987-1997 (*US Competitiveness* 2001: 21).
[41] SEI-2002: 3-26.

US labor market, there are attractive, highly remunerative S&E and non-S&E career opportunities that do not require advanced S&E training. Opportunities for outstanding students are also growing in other nations, many of which have developed strategies to attract and retain scientists and engineers who might otherwise be drawn to US education and careers.

Attracting more US students to enroll in and complete graduate training depends in part on their expectations that investment in science or engineering education will be rewarded by careers employing the skills they acquire. It also depends on considerations including costs to the students in lost opportunities they might otherwise have pursued, the quality of life during the educational period, and the debt burden incurred while pursuing a degree. The opportunity and educational costs of graduate education in science and engineering fields can be high, especially for US students who, unlike many foreign students, are able to take advantage of a range of career opportunities open to high-ability baccalaureate S&E graduates.

Long-standing Federal policy has encouraged students to pursue advanced S&E degrees by subsidizing the cost of education through a number of mechanisms. Mechanisms to support graduate students used by both Federal and non-Federal sources include fellowships, traineeships, research assistantships, teaching assistantships, and other mechanisms such as work-study and employer financing.[42] Federal support for graduate education is predominantly through research assistantships. The Federal Government supports half of all research assistantships, about two-thirds of all traineeships and one-quarter of all fellowships. Teaching assistantships are the predominant mechanism for support from non-Federal funding sources.[43]

Since teaching assistantships and assistantships on research grants are the predominant mechanisms of support for graduate students, undergraduate teaching requirements and research funding to academic institutions directly affect the employee pool for jobs requiring advanced education.[44] Any mismatch between undergraduate enrollments and funded research, on the one hand, and the skill needs in the workforce, on the other, can result in problems of under- and over-production of human resources across diverse disciplinary and multidisciplinary areas.

In the mid-1960s the Federal Government funded most of the Nation's research, primarily to serve Federal missions. Therefore, at that time the education of scientists and engineers at the graduate level who gained research experience on Federal grants might have been expected to roughly parallel the emphasis of the national R&D portfolio. An expanding university system created many new academic faculty positions that absorbed PhD-level scientists and engineers into jobs that drew on skills obtained through traditional graduate education.[45]

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[42] SEI-2002, 2-32,33.

[43] The Federal Government has a dominant role in supporting graduate education in some fields and plays a less important role in others. It supports most research assistantships in the physical sciences, most traineeships in physical and biological sciences and chemical engineering, but is not a significant source of support in mathematics. Primary mechanisms of support differ widely by field, with physical sciences supported mainly through research assistants (42 percent) and teaching assistants (41 percent). Research assistants are also important in engineering (42 percent) and earth, atmospheric, and ocean sciences (41 percent). In mathematics, the primary source of support is teaching assistantships (57 percent).

[44] Charles A. Goldman and W. F. Massy. *The PhD Factory*. 2001.

[45] SEI-2002, 4-7, 8, 9.

Today industrial research dominates the US R&D enterprise – more than two-thirds of US R&D. The private, for-profit sector is by far the largest provider of S&E employment. In 1999, approximately 74 percent of scientists and engineers with bachelor's degrees and 62 percent with master's degrees were employed in private, for-profit companies. For those with doctorates, 48 percent were employed in academic institutions, but the majority of PhDs in the workforce were employed outside of the academic sector. Academic demand for PhD-level scientists and engineers has grown slowly during the last decade, particularly in research universities (about 1.7 percent for all academic institutions and 0.6 percent for research institutions). In comparison, the business sector experienced a 4.4 percent growth and the public sector 4.9 percent growth.[46]

The need for action

The Board has addressed graduate and postdoctoral education in two previous reports (see Boxes B and C). Other studies have offered suggestions to improve the alignment of PhD and postdoctoral education with workforce demand. Recommendations for graduate education include improving guidance and information for graduate students in their career choices, reducing reliance on research assistantships within grants to principal investigators in favor of research/training grants to institutions, voluntarily reducing graduate enrollments in oversupplied disciplines, and broadening students' experience during graduate training to prepare them for a range of careers.[47]

It is in the national interest as well as the interest of individual students and scholars that the Federal Government – with other stakeholders in the S&E workforce – take action to guide the advanced education of scientists and engineers to better align with expected national skill needs. Areas of national skill needs include:

- National priorities in emerging areas – e.g., nanoscale science and engineering;
- Interdisciplinary skills – e.g., bioinformatics;
- Traditional disciplines where enrollments are insufficient to maintain national infrastructure for S&E in the face of level or increasing demand projections – e.g., in computer sciences; and
- Federal mission-related fields where enrollments are falling and projected needs rising, e.g., nuclear physics and engineering.

[46] SEI-2002: 3-9 and text table 5-5.
[47] National Research Council, *Reshaping the Graduate Education of Scientists and Engineers, 1995; Trends in the Early Careers of Life Scientists*, 1998.

RECOMMENDATION:

Federal support for research and graduate and postdoctoral education should respond to the real economic needs of students and promote a wider range of educational options responsive to national skill needs.

Federal strategies should:

- Ensure that Federal stipends for graduate and postdoctoral students provide benefits[48] and are competitive with opportunities in other venues[49];
- Invest in innovative approaches to doctoral and master's education that prepare students for a broad range of disciplinary and cross-disciplinary careers in academia, government, and industry; and
- Provide consistent, long-term support for high-quality disciplinary and interdisciplinary doctoral training programs in S&E.

[48] Fringe benefits, especially for health care.
[49] Currently, NSF is recommending an annual stipend of $30,000 for its graduate fellowship and traineeship programs. NSF Summary of Budget Request to Congress/FY 2004.

BOX B:

REPORT OF THE TASK FORCE ON GRADUATE AND POSTDOCTORAL EDUCATION (1996)

The Task Force recommends that limited studies be conducted on alternative modes of graduate support, with defined goals and assessment criteria. Among these might be programs for:

- Traineeships for programs and encouraging breadth and interdisciplinary studies, and including specific attention to ethics and the responsible conduct of research
- Fellowships for professional technical masters degrees
- Fellowships for interdisciplinary research for students who have advanced to Ph.D. candidacy in a traditional discipline
- Fellowships or other support modes permitting internships in industry, government agencies, and/or public schools as part of the graduate research experience
- Devising new means to provide incentives for attracting U.S. citizens (particularly from underrepresented groups) to graduate programs in science and engineering
- NSF, possibly through SRS and/or the SBE directorate, should support data collection and/or research on the effects of funding mechanisms on the number, retention, programmatic quality, time-to-degree, and demographic and institutional distribution of students being supported.

The task force has recommended limited studies because, despite extensive study, we find inadequate data to compel a recommendation of a major shift in funding mode among fellowship, research assistantships, teaching assistantships, and traineeships for supporting graduate education in science and engineering. We have found:

- Major institutional and disciplinary variation in time-to-degree
- Shorter time-to-degree for students who are supported than for those who are not
- Specific attention should be paid to the role of foreign students in the SME enterprise. This should include collection of data on the number, support mode, and placement of foreign students.

Box C:

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

1. Federal Support to the Enterprise

- The Federal government should reward and recognize institutions that initiate model programs for the integration of research and education.
- Mission agencies funding agency-initiated research in academic institutions should recognize the intimate connection between research and graduate education in universities. They should adopt principles and practices exploiting that interconnection and insure that their funding reaps the dual benefits of simultaneously advancing both research and graduate education.
- The Federal government should contribute to promoting closer collaboration between faculty in non-research and research institutions. Such collaboration in research offers opportunities for greater exposure to a variety of career options for graduate students. It can also improve the transition from undergraduate to graduate programs across institutions. The improvement of that transition is especially important for reaching minority undergraduates. Federal investments, particularly in communications infrastructure, can expand the scope of these programs.

2. Breadth vs. Narrowness of Graduate Education

Recommends that:

- University programs and Federal support policies continue to encourage exceptionally talented students to pursue Ph.D. programs and to develop their capacities to advance knowledge in their chosen disciplines;
- The Federal partner recognize and reward institutions that, in addition to the core Ph.D. education, provide a range of educational and training options to graduate students, options tailored to the career interests of the individual Ph.D. candidate. These might include interdisciplinary emphasis, teamwork, business management skills, and information technologies;
- The Federal and university partners seek more effective ways of promoting diversity and full access to graduate education, guarding against strategies that inadvertently keep underrepresented groups from the mainstream of research and graduate education. Efforts should emphasize identification of high-ability students earlier in the educational experience, including the precollege level, and encouraging them to consider careers in science and engineering.

The Board recommends the attention of universities to the following areas:

- To assure access for high ability students, examine the current use and possible misuse of assessment tools for entry to, and financial support for, graduate education, e.g. the Graduate Record Examination scores (GREs); and

Box C (continued):

- Recognize postdoctoral researchers as a significant component of the system of graduate research and education in some areas, and better integrate postdoctoral scholars into the university community.

The Board recommends that the Federal government:

- Support university-initiated efforts to insure in the science and engineering faculty reward systems an appropriate balance between recognition for excellence in research and excellence in teaching, mentoring, and other areas of faculty responsibility;
- Examine how it can prevent unnecessary and unintentional interruptions in academic research programs and in associated support to graduate students that may result from the vagaries of the Federal research funding environment;
- Review conflicting or confusing treatment of graduate students and postdoctoral researchers—as students or employees—in Federal regulations and policies. The review should entail consideration of both consistency across agencies and coherence between the purposes of regulations and administrative requirements and Federal objectives for supporting and integrating research and education in academic institutions.

The Board recommends that the following areas be explored:

- Strategies to attract and retain talented students from underrepresented groups. These strategies might include consideration, in some cases, of criteria for support on research grants;
- The respective Federal and university responsibilities for reducing the administrative burden on faculty researchers/teachers to increase time available for mentoring and other educational and service activities that enrich the learning environment. This reduction in administrative burden needs to be coupled with the alignment of faculty reward systems;
- Improved policy data to assess the effectiveness of current Federal support for graduate education including attention to attrition and time-to-degree, and to identify current and emerging national needs for the science and engineering workforce.

This exploration should include input from a broad range of stakeholders in graduate education and be attentive to maintaining the benefits of graduate and postdoctoral research and education in science and engineering for the Nation.

KNOWLEDGE BASE ON THE SCIENCE AND ENGINEERING WORKFORCE

The science and engineering workforce is a dynamic system, reflecting the aggregated educational and career choices of individuals, educational offerings of institutions of higher education, financial considerations in acquiring an education, guidance and career counseling to students and professionals, availability of jobs, and any number of other factors. Individual members of the workforce may enter and leave occupations several times during their working lives. Workforce needs for specific skills can rise and fall—sometimes rapidly.

Even within science and engineering professions and among individuals who have invested the most in their education in a given specialty, substantial changes in career paths over their lifetimes are common.[50] For example, emerging research areas attract not only newly minted PhDs, baccalaureates, technicians, and postdoctoral scholars just entering the job market, but also those who have built careers in other specialty areas. Science and engineering degree holders at all levels may go on to pursue careers in such areas as law, technical management, or university administration and move out of research and teaching. Nonetheless, they may still use the skills gained through their previous S&E education and employment.

The organizational structures and processes for educating, maintaining skills, and employing science and engineering talent in the workforce are diverse and their interrelationships complex and dynamic.[51] As a result, production and employment of scientists and engineers are not well understood as a system. Adding the international context for science and engineering to the domestic system multiplies its complexity.

Federal policies and strategies for interventions in the workforce must be sensitive not only to impacts on areas targeted for intervention, but also to other impacts on broader workforce capabilities. There is a need for a fuller understanding of the S&E workforce as part of the national economy. There is a further need to understand the variables and interrelationships that affect choices and opportunities of individuals in various science, technology, engineering and mathematics careers. Strategies to impact the system as a whole now tend to target individual components in efforts to address identified areas of weakness. Interventions are often employed without critical analysis of impacts on other aspects of the workforce.[52]

Federal policymakers need an adequate base of knowledge to be able to assess impacts of interventions to the system as a whole and to better

[50] SEI-2002: 3-4 to 3-10.
[51] SEI-2002: 2-7 to 2-15.
[52] Academia is an example. Twenty percent of the average yearly job openings for college and university faculty are being filled by permanent residents and H-1B visa holders (Lowell report for NWP). The percentage is considerably higher in many fields of engineering, computer science, and physical science. Both the short-term and long-term impacts of this situation upon the educational experience of domestic undergraduate and graduate students are not understood.

understand the integration of this complex system.[53] Greater understanding of the system would help avoid policies and strategies that are ineffective in strengthening national capabilities or that unintentionally undermine the health of US science and engineering.[54]

Lacking reliable tools for policy and strategies affecting the future S&E workforce, the consensus strategy is to attract more talented undergraduates to science and engineering majors in areas of need and encourage them to continue on to graduate school – particularly undergraduates from groups who have been underrepresented in natural science and engineering.[55]

Over the long term, there is a need to develop a quantitative, dynamic model of the global S&E workforce with respect to skills, mobility, occupational and geographic migration and demographic characteristics, and to understand the impacts of the global workforce on US science and engineering, especially the impacts of temporary workers and international students in S&E fields. As an initial focus, increased financial support is needed for academic research to develop more adequate models of domestic supply and demand for science and engineering skills. A special focus is needed on doctorates and postdoctorates, due to the high level of investment by the individual and society required to produce scientists and engineers at these levels of education.

New approaches to graduate and postdoctoral education must address factors within the education system that contribute to making careers in science and engineering uncompetitive. An important area requiring attention is time-to-degree and duration of time in postdoctoral appointments in some fields. Research is needed to better understand the transition rates to independent careers for graduate students and new PhDs. Another area that should be a high priority for research is the effects of international students and temporary workers on the US domestic workforce and S&E capabilities.

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[53] Integration of data among Federal agency sources that measure and track factors relevant to the national S&E workforce, such as Bureau of Labor Statistics, National Science Foundation SESTAT, and the Census Bureau, would enable more productive research on S&E workforce dynamics. NSF's data system on the science and engineering labor force (SESTAT) is able to add data only once a decade on individuals with only foreign-school science and engineering degrees. This is done through an NSF follow-up survey on college-educated individuals identified through the decennial U.S. census. Thus anyone with foreign, but not U.S. S&E degrees who entered the United States after April 1990, will not be surveyed by NSF until October 2003. NSF's data are unique in having large samples of individuals with science and engineering degrees with information on both field of degree and occupation. Data from the Bureau of Citizenship and Immigration Services (BCIS, formerly the INS) include the occupation of those entering under many visa classes, but not degree level or field, and not the number currently in the United States at any point in time. The Bureau of Labor Statistics' monthly Current Population Survey will pick up individuals in S&E occupations, but there is no information on field of degree, and sample sizes (approximately 60,000 households) are not sufficient to make estimates of foreign-born scientists by occupation and degree.

[54] There are few methodological tools to support such action. For example, good models of supply and demand for doctoral scientists and engineers are lacking and notoriously difficult to construct (see *Forecasting Demand and Supply of Doctoral Scientists and Engineers,* National Academy Press, 2000). While data on PhDs in academia are good, data on career paths of PhDs in industry are lacking. Demand in specific fields can be subject to short-term fluctuations, while the supply of domestic degree holders is relatively inelastic in the short run due to the long lead time necessary to complete a PhD.

[55] See, for example, Building Engineering & Science Talent (BEST), *The Quiet Crisis/Falling Short in Producing American Scientific and Technical Talent*; National Science and Technology (NSTC), *Ensuring a Strong U.S. Scientific, Technical, and Engineering Workforce in the 21st Century*, April 2000; Educational Testing Service (ETS), *Meeting the Need for Scientists, Engineers, and an Educated Citizenry in a Technological Society*, May 2002.

As part of a multilevel, inclusive effort to attract more domestic students to S&E studies and careers, there is a need to provide better and more accessible information, career guidance, and early experience in S&E settings.[56] Students need to understand not only the opportunities offered by careers in science and engineering, but also the educational pathways to achieve such careers.[57]

Therefore, in addition to the long-term goal of understanding the dynamics of the S&E workforce, there is also an immediate need for a coordinated effort to develop a national clearinghouse of information to facilitate individual career decisions and publicize successful model programs. A centralized information resource should serve the needs of individuals, employers, guidance counselors, educational institutions and other stakeholders in the science and engineering workforce. It should enable the development and dissemination of effective strategies to attract and retain the best students in science and engineering studies and careers and also serve as a tool for career guidance for both students and science and engineering professionals already in the workforce.

RECOMMENDATION:

To support development of effective S&E workforce policies and strategies, the Federal Government must:

- **Substantially raise its investment in research that advances the state of knowledge on international S&E workforce dynamics;**

- **Lead a national effort to build a base of information on:**
  1. **The current status of the S&E workforce,**
  2. **National S&E skill needs and utilization and**
  3. **Strategies that attract high-ability students and professionals to S&E careers.**

[56] At the program level, one successful example among many is NSF's Research Experience for Undergraduates (REU).
[57] NRC, *Reshaping the Graduate Education of Scientists and Engineers*, 1995.

Precollege Teaching Workforce for Mathematics, Science and Technology

The workforce-related needs for science, mathematics and technology learning at the precollege level can be divided into two categories: first, the need for basic science and mathematics literacy of the entire workforce; and second, the need to provide the foundation for students to pursue college majors in science and engineering fields.[58] Recent "No Child Left Behind" legislation[59] explicitly addresses science and mathematics education at the precollege level and in effect establishes the expectation that public precollege education will produce adequate national literacy in science and mathematics, validated by regular student assessments in the K-12 system.

Reports over the last several decades (see Box D) have identified a quality precollege teaching workforce in mathematics, science and technology as key to achieving both science and mathematics literacy and to preparing students for advanced studies in science and engineering to meet workforce demands. Nonetheless, identified reasons for failure to attract and retain qualified individuals in precollege teaching remain inadequately addressed. These reasons include the low status of the teaching profession, an unsupportive working environment, frustration with low student interest, inadequate and poorly enforced training and certification standards for teachers, insufficient financial rewards, failure to provide long-term opportunities for advancement, and a non-enabling classroom environment.

In February 2001 The United States Commission on National Security/21st Century identified the condition of precollege education as a critical national security problem: "we do not now have, and will not have with current trends, nearly enough qualified teachers in our K-12 classrooms, particularly in science and mathematics...A continued shortage of the quantity and quality of teachers in science and math means that we will increasingly fail to produce sufficient numbers of high-caliber American students to advance to college and post-graduate levels in these areas."[60] Indeed, 1999 estimates by the Department of Education indicate the need for 240,000 middle and high school mathematics and science teachers over the next 10 years, 70 percent of whom will be new to the teaching profession.[61]

The Board recognizes that the precollege science, math and technology teaching workforce is a dynamic resource, drawing its members from a range of educational and occupational backgrounds. Recruitment and retention strategies must be creative and flexible, responsive to potential entrants and reentrants to the teaching workforce at different points in individual careers and from a variety of socioeconomic and ethnic backgrounds. Entering

[58] See Box E: NSB report on *Preparing Our Children: Math and Science Education in the National Interest*, 1999, listing the recommendations of that report.
[59] HR-1, 2001.
[60] The United States Commission on National Security/21st Century, *Road Map for National Security*: 40.
[61] National Commission on Mathematics and Science Teaching for the 21st Century: 29.

teachers include new baccalaureate-level graduates with education, science, or engineering majors, as well as professionals at various stages of their careers and from all levels of science and engineering education – from baccalaureate to postdoctorate. They include S&E professionals and retirees from careers in industry, government or the military as well as from academia. A critical barrier to participation in precollege teaching by scientists, mathematicians and engineers is the separation between precollege teaching and other science and engineering professions.

Further, even if a sufficient number of students and professionals with strong backgrounds in their subject areas can be attracted to precollege teaching, additional efforts are needed to retain them in teaching. Job satisfaction for well-qualified teachers requires a supportive working environment.

RECOMMENDATION:

In partnership with other stakeholders[62], the Federal Government should act now to attract and retain an adequate cadre of well-qualified precollege teachers of mathematics, science, and technology.

To make precollege teaching more competitive with other career opportunities, resources must be provided to:

- Compensate teachers of mathematics, science and technology comparably to similarly trained S&E professionals in other sectors;
- Reinforce the profession of teaching as an important and rewarding career and include teachers as an integral part of the scientific and engineering professions;
- Support classroom training and expedite teacher certification of scientists and engineers from professions other than teaching;
- Support in-service training to enhance classroom skills and subject matter expertise; and
- Support programs in teacher preparation at institutions that succeed in integrating faculty and curricula of schools of engineering and science with schools of education.

To improve effectiveness of precollege teaching, stakeholders must collaborate to:

- Support outreach efforts to K-12 by science and engineering professionals to motivate high-quality curricular standards and expand content knowledge for classroom teachers; and
- Support research on learning that better informs K-12 mathematics and science curricula and pedagogy development.

[62] Stakeholders include teachers, parents, students, employers, and S&E professionals; local school districts and schools; higher education faculty and institutions for S&E and teacher education; national and State certification bodies; S&E and teacher professional organizations; textbook and instructional materials publishers; sponsors of educational research; State and local governments; and Federal policymakers and agencies.

Box D:
Selected Sources Identifying Issues in Attracting and Retaining Precollege Science and Mathematics Teachers

A range of organizations have explored the conditions that make precollege teaching of mathematics and science particularly unrewarding to well-qualified teachers. A reflection of the unrewarding environment and more attractive careers outside of teaching is the higher attrition rate for mathematics and science teachers, exceeding not only that of other occupations, but also of other teachers (16 percent versus 11 percent and 14.3 percent, respectively). Moreover 40 percent of mathematics and science teachers leave because of job dissatisfaction, compared with 29 percent of all teachers, according to The National Commission on Mathematics and Science Teaching for the 21st Century. The reports below discuss the long-term, well- recognized problems involved in attracting and retaining precollege mathematics and science teachers.

The United States Commission on National Security/21st Century. "Education as a National Security Imperative," *Road Map for National Security: Imperative for Change*. February 15, 2001: 38-46.

National Science Board. "Teacher Preparation," in *Preparing Our Children/Math and Science Education in the National Interest*. Arlington, VA: National Science Foundation, 1999.

______. *Science & Engineering Indicators 2002*, 1-37, 38.

National Science Board Commission on Precollege Education in Mathematics, Science, and Technology. *Educating Americans for the 21st Century*. September 1983.

National Commission on Mathematics and Science Teaching for the 21st Century. *Before It's Too Late*. September 2000.

National Research Council. "The Continuum of Teacher Education in Science, Mathematics, and Technology: Problems and Issues" in *Educating Teachers of Science, Mathematics and Technology/New Practices for the New Millennium*, Washington DC: National Academy of Sciences, 2001: 30-40.

Box E:

Preparing Our Children/Math And Science Education In The National Interest (1999)

The Board believes that stakeholders must develop a much-needed consensus on a common core of mathematics and science knowledge and skills to be embedded consistently in classroom teaching and learning.

Recommendation 1: To implement the core recommendation through instructional materials:

1. The NSB urges (a) broad adoption of the principle of citizen review; (b) active participation on citizen advisory boards by educators and practicing mathematicians and scientists, as well as parents and employers from knowledge-based industries; and (c) use of public forums to foster dialogue between textbook publishers and advisory boards in the review process.

2. Accompanying this process should be an ongoing national dialogue on appropriate measures for evaluation of textbooks and instructional materials for use in the classroom. The NSB urges professional associations in the science community to take a lead in stimulating this dialogue and in formulating checklists or content inventories that could be valuable to their members, and all stakeholders, in the evaluation process.

Recommendation 2: To implement the core recommendation through teacher preparation and professional development:

1. The NSB urges formation of three-pronged partnerships: institutions that graduate new teachers working in concert with national and state certification bodies, and local school districts. These partnerships should form around the highest possible standards of subject content knowledge for new teachers, and aim at aligning teacher education, certification requirements and processes, and hiring patterns.

2. Mechanisms for the support of teachers, such as sustained mentoring by individual university mathematics, science, and education faculty, as well as other teacher support mechanisms such as pay supplements for board certification, should be implemented through the three-pronged partnerships.

Recommendation 3: To implement the core recommendation through the college admissions process, the NSB urges:

1. institutions of higher education to form partnerships with local districts/schools that create a more seamless K-16 system, increasing the congruence between high school graduation requirements in math and science and undergraduate performance demands; and,

2. faculty and student incentives that motivate interactions to reveal linkages between classroom-based skills and experiences and the demands on thinking and learning in the workplace.

Recommendation 4: To implement the core recommendation through research:

1. The National Science Foundation and the Department of Education must spearhead the Federal contribution to SMET education research and evaluation.

2. Overall, the investment should increase—by the Federal government, private foundations, and other sponsors—in research on schooling, educational systems more generally, and teaching and learning of mathematics and science in particular. To focus and deepen the knowledge base, an interagency Education Research Initiative, led by NSF and the Department of Education, should be implemented. It should be distinguishable as a joint venture within the agencies' respective research missions, and cooperatively funded.

US ENGAGEMENT IN THE INTERNATIONAL SCIENCE AND ENGINEERING WORKFORCE

It is more essential than ever to think about workforce development in a global context. Progress in science and engineering relies on knowledge and skills found throughout an international community. With the rise in electronic communication, knowledge is flowing faster and farther, enabling more widespread participation and competition in research and development. The US needs the perspectives and talents of both the native-born and foreign-born for the best possible S&E workforce. And most importantly, US students must be prepared for involvement in the complex world of international science and engineering.

The Board has addressed issues of US involvement in international S&E in a recent report, *Toward a More Effective Role for the U.S. Government in International Science and Engineering.*[63] That report documents the global dimension of S&E. For example, collaborative activities and international partnerships are an increasingly important means of keeping abreast of important new insights and discoveries critical to maintaining US leadership in key fields. In the industrial sector, research collaboration internationally is on the rise with the growth of R&D activities located overseas and a rising number of cooperative arrangements among US and foreign firms.

While the United States faces strong challenges, it has many competitive advantages in the global S&E labor market as it looks to the future. The United States experience with integrating immigrants into society and the economy is a major national asset and competitive advantage. The US has a rich tradition as an internationally diverse S&E workforce. It also has experience in educating large numbers of foreign students and there is strong public support for international education.[64] As expressed in congressional testimony by Dr. Bruce Alberts, President of the National Academy of Sciences: "International science and technology cooperation is an extremely effective way to leverage one of the defining strengths of the United States. We benefit from an extraordinary set of personal, professional, and cultural relationships due to the many people from other countries who are working in the U.S. science and technology enterprise, and due to the large number of science and technology leaders in other countries who have been trained in the United States."[65] Moreover, the United States like other nations can gain substantial benefits for the national science and technology enterprise from citizens working and studying abroad who serve as vital resources for knowledge exchange and entrepreneurial partnering.

Continued leadership of US universities in international education is an important component of US strength in S&E, drawing the best students and scholars to study and work in the United States. Since September 11, 2001, however, security-motivated policies and requirements – such as tracking

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[63] See Box F for the recommendations of that report.
[64] According to a survey by the American Council on Education, the American public recognizes the importance of global involvement of US students and professionals and supports more international education opportunities, including study and internships abroad, scholarly exchanges, and opportunities to interact with international students. "Beyond September 11: A Comprehensive National Policy on International Education", ACE, 2002.
[65] Testimony before the Committee on Science, US House of Representatives, March 25, 1998.

foreign students in the Student and Exchange Visitor Information System (SEVIS) – have changed the climate for foreign students who wish to come to the United States. Host institutions are facing growing complications as they seek to maintain a healthy flow of international graduate students, postdoctoral researchers, and visiting scholars.[66]

Impact on S&E of visa policies

The Board looked in depth at the kinds of visas for entry into the United States and how these various visa categories are used.[67] Broadly described, the system is a mixture of visas for permanent residence or for non-immigrant status (e.g., temporary residence visas, such as H-1B, and student and exchange visitor visas). For permanent residence status, policy favors reunification of families. A relatively small percentage of immigration opportunities are geared to high-skill workers.

The major vehicle by which foreign workers join the Nation's S&E labor force is the temporary residence visa in various forms. About two-thirds of those attaining permanent residence who are classified as scientists and engineers adjusted into permanent status from a prior non-immigrant status. Of the two-thirds, 11 percent had been academic students, 7 percent visitors for pleasure, 6 percent exchange visitors and, significantly, 56 percent had been H-1B specialty workers.[68] The H-1B visa is a limited-term visa designed to address immediate demand for skills in the job market, as identified by employers. Demand for H-1B visas is dependent upon business cycles. Having the Nation's future skilled workforce needs met through a visa process that relies on the short-term needs of industry is not an effective long-term strategy.

The student visa (non-immigrant F visa) is intended for temporary study, as applicants must certify that they plan to return to their home country. In reality, the F visa often provides entree to permanent resident status. The best estimate is that about one-fifth of the foreign students moved both directly from F visas and indirectly through H-1B visas to achieve a permanent status in FY 1996.[69]

In summary, there are various pathways by which high-skill immigrants navigate from temporary to permanent status, but these pathways are undertaken at the initiative of individuals, not promoted by the design of immigration law. In light of growing international competition for high-skill students and professionals in S&E, the United States needs visa and immigration policies that provide a clearly understood and straightforward set of options for foreign S&E students and workers.

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[66] Willie Schatz, "Congressional committee hears tales of ongoing problems with visas and SEVIS," *The Scientist*, March 27, 2003.
[67] Report commissioned by the NSB: "State of Knowledge on the Flow of Foreign Science and Technology Workers to the United States," B. Lindsay Lowell, Institute for the Study of International Migration, Georgetown University (see Appendix V).
[68] Ibid:11.
[69] Ibid: 8.

RECOMMENDATION:

During the current reexamination of visa and other policies concerning the mobility of scientists and engineers, it is essential that future US policies:

- **Strengthen the capacity of US research universities to sustain their leadership role in increasingly competitive international S&E education;**
- **Strongly support opportunities for American students and faculty to participate in international S&E education and research; and**
- **While enhancing our homeland and national security, maintain the ability of the United States to attract internationally competitive researchers, faculty and students.**

Box F:
Toward a More Effective Role for the U.S. Government in International Science and Engineering (2001)

In February 1999, the NSB established a Task Force on International Issues in Science and Engineering, charged to develop recommendations for strengthening the Federal institutional framework of policies and agency relations that support S&E research and education in an international setting and for an effective leadership role for the National Science Foundation (NSF) in international science and engineering in the 21st century. Based on the task force study, the Board recommended:

The U.S. Government should move expeditiously to ensure the development of a more effective, coordinated framework for its international S&E research and education activities. This framework should integrate science and engineering more explicitly into deliberations on broader global issues and should support cooperative strategies that will ensure our access to worldwide talent, ideas, information, S&E infrastructure, and partnerships;

and recommended the following specific actions:

1. The Office of Science and Technology Policy (OSTP) should strengthen its international focus to ensure an effective, integrated, visible, and sustained role in monitoring, coordinating, and managing U.S. international S&E research and education activities. As part of this effort, OSTP should actively encourage Federal agencies to identify and increase the visibility of their international S&E research and education activities, to provide an adequate level of funding for these activities, and to allocate adequate funding and resources for their coordination and management. The Office of Management and Budget should prepare an annual international S&E budget crosscut, similar to its annual research and development (R&D) budget crosscut, that includes international activities found outside specifically designated international program budgets.

Box F (continued):

2. OSTP should encourage agencies to develop more effective mechanisms for gathering and disseminating information about U.S. collaboration and partnerships in international S&E activities and similar activities in other countries, with emphasis on fundamental research and S&E education.

3. The United States Government should promote the development of international S&E policy aimed at facilitating international cooperation in research and education. The formulation and implementation of policies related to areas such as immigration, intellectual property rights, and the exchange of scientific information and personnel should include consideration of their impact on international cooperation in research and education.

4. Federal agencies should encourage and support policies and programs that provide incentives for expanding participation in international cooperative research and education activities by younger scientists and engineers.

5. Federal agencies should encourage development of human and physical infrastructure for science and engineering in developing countries through partnerships with international, multilateral, and private organizations providing support to developing countries for S&E research and education.

6. The U.S. Government, especially the Department of State, with its primary responsibility for U.S. foreign policy, should recognize and address the importance of science and engineering in achieving its objectives. Mechanisms should be identified to improve communication among science officers, other U.S. embassy personnel, and science and engineering staff of other Federal agencies, including those working abroad, to facilitate sharing of information critical to planning and decision making, and to improve the general flow of information on critical S&E issues.

7. The U.S. Government should strongly endorse the spirit of the recommendations of the 1999 NRC report to the State Department and ensure that responses to those recommendations are implemented expeditiously. Because developing an appropriate U.S. capability in this arena requires a long-term concerted effort, effective change will require a multi-year, multi-Administration, and bipartisan response, with appropriate levels of funding.

CHAPTER FOUR

CONCLUSION

The United States has for many years benefited from minimal competition in the global labor market for S&E personnel. As our economy and high-technology industry grew, a fortuitous set of circumstances gave our Nation the benefit of some of the best minds in the world from other countries to help us build and sustain US world leadership in science and technology. The Federal Government has played a crucial role as sponsor of science and engineering research and advanced education, by means of which many foreign scholars and professionals have been drawn to our shores to study and work and many of our own students have pursued science and engineering degrees and careers.

The ready availability of outstanding science and engineering talent from other countries is no longer assured, as international competition for the science and engineering workforce grows. Threats to world peace and domestic security create additional constraints on employment of foreign nationals in the United States.

Moreover, demographic data indicate that participation of US students in science and engineering studies will decline if historical trends continue in S&E degree attainment by our college-age population. At the same time, retirements of scientists and engineers currently in the workforce will accelerate over the coming years.

The United States is in a long-distance race to retain its essential global advantage in S&E human resources and sustain our world leadership in science and technology. For international students and workers, attractive and competitive alternatives are emerging around the world. We must develop more fully our native talent to meet opportunities and needs of the workforce – capitalizing on and expanding successful efforts undertaken throughout our society. The Federal Government must enact policies and programs that include:

- A broad-ranging effort at all levels of education to attract, develop, and retain in the S&E workforce American-born scientists and engineers drawn aggressively from all demographic groups, and

- National efforts to enrich US workforce capabilities through opportunities for US students and professionals to participate in international science and engineering and through continued contributions by the best S&E students and professionals from other countries.

The Federal Government has a primary responsibility to lead the Nation in developing and implementing a coordinated, effective response to our long-term needs for science and engineering skills. US global leadership and future national prosperity and security depend on meeting this challenge.

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APPENDICES

APPENDIX I

NSB 00-192
October 16, 2000

CHARGE
COMMITTEE ON EDUCATION AND HUMAN RESOURCES
TASK FORCE ON NATIONAL WORKFORCE POLICIES FOR SCIENCE AND ENGINEERING

Discovery and innovation in science and engineering (S&E), enabled by a robust, highly trained, and talented science and engineering workforce, is the foundation of our Nation's future economic growth and quality of life. Historically, the U.S. has benefited from both an abundant supply of indigenous talent and the contributions of a steady stream of scientists, engineers, and graduate students from other countries. This blend of domestic and foreign talent has helped advance the frontiers of knowledge and propel the U.S. to a position of global leadership in S&E.

The technological and information revolutions transforming the economy are changing the skill mix required in the national workforce and dramatically increasing the demand for scientists and engineers. However, these fundamental changes lack a coherent framework of long term national goals and strategies to insure the continued education, development and recruitment, from both within the US and other countries, of highly trained and talented workers. Important national trends point to the need for a serious assessment of our national S&E workforce needs and policies:

- Dramatic increases in the demand for scientists and engineers by all sectors of the economy;

- Profound inadequacies in U.S. K-12 in science, mathematics, and engineering education and declining rates of participation by domestic students in graduate S&E education;

- Demographic changes resulting in a significantly more diverse U.S. student population coupled with historically lower rates of participation in S&E by ethnic and racial minorities and women;

- Increasing reliance on foreign talent in the face of trends indicating rising rates of return to country of origin by foreign students after degree completion; and

- Inconsistencies among policies related to the recruitment and treatment of foreign scientists to fill the ranks of industry, Federal laboratories, and universities.

The NSB Task Force on National Workforce Policies for Science and Engineering (NWP), reporting through the Committee on Education and Human Resources, is established to assess long term national workforce trends and needs in science and engineering and their relationship to existing Federal policies, and to recommend strategies that will address long term S&E workforce needs. In its review, the task force should include consideration of the following issues:

- How U.S. demographic trends, trajectories of S&E preparation and degree attainment, and availability of foreign scientists and engineers may affect the future S&E workforce;

- How data on industry demand – both for requisite skills and the numbers of workers who possess them – can better inform preparation, hiring, and retention of students at all levels for high technology careers;

- How graduate training can be diversified to support aspirations that match opportunities, especially outside of research and of academe, while insuring continued excellence of traditional preparation of U.S. scientists and engineers; and

- How the mix of Federal law, such as immigration policy, Federal agency and state programs, higher education institution practices, and employer recruitment and other incentives affect student and worker choices related to S&E careers.

The NWP Task Force will submit a plan of work for discussion at the December 2000 meeting. The workplan should include a timetable of activities, including proposals for consultation with stakeholders in the relevant science and engineering education and employer communities, that yields a report with policy recommendations for Board consideration by the November 2001 meeting.

Eamon M. Kelly
Chairman

APPENDIX II

NSB/EHR/NWP 01-1

EHR TASK FORCE ON NATIONAL WORKFORCE POLICIES FOR SCIENCE AND ENGINEERING (NWP)

Task Force Briefing
January 30, 2001

AGENDA

8:15 AM	Welcome and Purpose	Dr. Miller, Chair, NWP Task Force
8:25	Overview: Coverage, Strengths, and Shortcomings of Data	Dr. Golladay, NSF/SRS
8:45	Databases on Occupations and Employment:	
	A. Employment Projections	Dr. William Parks Office of the Commissioner Bureau of Labor Statistics
	B. CPS and Training Issues	Dr. Enrique Lamas Bureau of the Census Demographic Surveys Division
	C. Longitudinal Data and Knowledge Requirements For 21st Century Work	Dr. Clifford Adelman Office of Educational Research and Improvement, U.S. Department of Education
	Discussion	*NSB Members*
10:30	Break	
11:00	A Dialogue on Immigration Data:	
	Presenter	Dr. Lindsay Lowell Institute for the Study of International Migration, Georgetown U.
	Discussant	Dr. Michael Teitelbaum Program Director Alfred P. Sloan Foundation
	Discussion	*NSB Members*
12:30	Lunch	

Task Force Briefing
January 30, 2001

AGENDA (CONT.)

1:30	University Perspectives:	
	A. Market Analysis of Students	Dr. Karen Spahn Institutional Research University of Phoenix
	B. Council of Graduate Schools: What VPs and Deans Say	Mr. Peter Syverson Council of Graduate Schools
	C. Reinventing the Master's Degree in Science: An Overview of Programs, Students, and Jobs	Ms. Sheila Tobias Outreach Coordinator, Sloan Science Master's Degree Initiative and Dr. Michael Teitelbaum Alfred P. Sloan Foundation
	Discussion	*NSB Members*
3:00	Wrap-up	Dr. Miller Dr. Golladay
3:30	Adjourn (Task Force Executive Session)	

APPENDIX III

NSB/NWP 02-3

WORKSHOP ON NATIONAL POLICY OPTIONS
TASK FORCE ON NATIONAL WORKFORCE POLICIES FOR SCIENCE AND ENGINEERING

National Science Board
March 12, 2002
Stafford II, Room 555, NSF

AGENDA

9:00 - 9:30 AM	Welcome	
		Dr. Joseph Miller, Task Force Chairman, National Science Board
		Dr. Eamon Kelly, Chairman, National Science Board
		Dr. Rita Colwell, Director, National Science Foundation
	Introduction to the Workshop	
		Dr. Joseph Miller, NSB Task Force Chairman
9:30 AM –12:00 PM	Panel on national policies addressing the U. S. education system and its ability to move students from secondary school into undergraduate studies and thence into employment and/or graduate studies.	
	Moderator:	Dr. Diana Natalicio, NSB Task Force Member
9:30	Policy focus on precollege to undergraduate transition (Presentation and Q/A)	
		Dr. David Conley, Associate Professor, University of Oregon, Center for Education Policy Research
10:00	Policy focus on multiple pathways to the workforce and mobility of students among kinds of educational offerings (Presentation and Q/A)	
		Dr. Anthony Carnevale, Vice-President, Educational Testing Service
10:30-10:45	Break	

AGENDA (CONT.)

10:45	Policy focus on the system for teacher preparation and certification and the interplay with other career options (Presentation and Q/A)	Dr. Rodger Bybee, Executive Director, Biological Sciences Curriculum Study
11:15	Discussion	
12:00- 1:00	Lunch	
1:00–1:45 PM	Report of Critical Path Analysis of California's Science and Technology Education System	Dr. Susan Hackwood, Executive Director, California Council on Science and Technology
1:45 – 5:00 PM	Panel on national policies to strengthen student interest in science, engineering, and technology and graduate increased numbers of associate and baccalaurate degree recipients well-prepared for employment opportunities and/or advanced study.	
	Moderator:	Dr. George Langford, NSB Task Force Member
1:45	Policy focus on incentives to increase supply of college graduates (Presentation and Q/A)	Dr. Paul Romer, Professor, Stanford University
2:30 – 2:45	Break	
2:45	Policy focus on diversity and student development (Presentation and Q/A)	Ms. Yolanda George, Deputy Director, Directorate for Education and Human Resources Programs, AAAS
3:15	Policy focus on institutional strategies and their impact on undergraduate students (Presentation and Q/A)	Dr. Charles Goldman, Economist, RAND
3:45	Discussion and synthesis	
5:00	Adjourn	
5:15	Reception, National Science Board Suite, Room 1225, Stafford I	

Karolyn Eisenstein, Executive Secretary

APPENDIX IV

NSB/NWP 02-15

WORKSHOP II ON NATIONAL POLICY OPTIONS
TASK FORCE ON NATIONAL WORKFORCE POLICIES FOR SCIENCE AND ENGINEERING

National Science Board
June 28, 2002
Stafford I, Room 375, NSF

AGENDA

9:00 - 9:20 AM	Welcome	
		Dr. George Langford, Task Force Vice-Chair, National Science Board
		Dr. Rita Colwell, Director, National Science Foundation
	Introduction to the Workshop	
		Dr. George Langford, Task Force Vice-Chair, National Science Board
9:20 AM –12:00 PM	Panel on the workforce needs of government and industry	
	Moderator:	Dr. Maxine Savitz, NSB Task Force Member
9:20	Employment serving the U.S. government	
		Dr. John McTague, Vice-President – Laboratory Management, University of California
10:10-10:30	Break	
10:30	U. S. corporations and their workforce needs	
		Dr. Donald Keck, Vice-President and Executive Director for Research (retired), Corning
11:15	Discussion of government and industry needs	
		All panelists and NSB members
12:00- 1:00	Lunch	

AGENDA (CONT.)

1:00–1:45 PM Impact of security policies on the S&E workforce

Dr. John Marburger, Director, Office and Science and Technology Policy, Executive Office of the President

1:45 – 5:00 PM Panel on policies affecting the U. S. and global supply of scientists and engineers

Moderator: Dr. George Langford, NSB Task Force Member

1:45 U.S. policies and regulations affecting international graduate students and postdoctoral researchers

Dr. James Burns, Foreign Relations Associate, American Council on Education

2:30-2:45 Break

2:45 Policies and approaches in other countries: China

Dr. Yugui Guo, Guest Professor, Fudan University

3:15 Factors affecting the choice of domestic students to attend graduate school

Dr. Frank Solomon, Professor of Biology, MIT

4:00 Discussion of U.S. policies for improved development of our domestic advanced S&E workforce

All panelists and NSB members

5:00 Adjourn

Karolyn Eisenstein, Executive Secretary

APPENDIX V

NSB/NWP 01-1
May 2001

"State of Knowledge on the Flow of Foreign Science and Technology Workers to the United States,"

by B. Lindsay Lowell, Georgetown University

EXECUTIVE SUMMARY

This summary presents seven basic data needs and recommendations on the statistical infrastructure needed to monitor or forecast immigrants' contribution to science and engineering. It provides an appendix that describes the data elements currently collected on immigrants.

Occupation and Educational Characteristics *Basic occupational and educational data should be collected for all working-age legal permanent residents (LPRs) and selected temporary-working nonimmigrant (NIV) classes*. It is not possible to identify scientists and engineers unless information is available on the occupation and/or educational characteristics of individual migrants. As far as occupation is concerned, the priority should be for the collection of data on all LPRs and all working temporary visas. The corollary for this priority must be the use of the same occupational classification scheme by the involved agencies. As far as education is concerned, the minimal data priority should be years of education completed. However, additional information on degree completion and field of study would be of value and could either be included in administrative collection systems or as part of special surveys (see below).

Tracking Immigrant Status Transitions.Linking Immigration Statuses *The U.S. needs a reliable administrative and statistical system to track individual transitions in immigrant status*. There are two basic types of immigrants who are often not distinguishable in most immigration statistics. "New" entrants are individuals who have never before resided (at least recently) in the United States. "Transitional" entrants are those who, although counted as new to a given visa class, have actually already been resident in the U.S. Typically, the transitional migrant has legally resided on a temporary visa to study or work (for example, one-fifth of F foreign students adjust and about half of H-1B workers).

Measuring Person Years or Duration of Stay. ***Duration of Stay in Status in the United States*** *There is a need for reliable data on the duration of time that various classes of temporary nonimmigrants have been in the United States*. Duration of stay information is critical for evaluating the relationship between temporary jobs and cycles in the economy. For example, the person-year population is the full-time equivalent contribution of working visas to the labor force: if there were 100 temporary workers with an average stay of one-half year, they would contribute 50 person-years' worth of labor in that year. Further, a reliable administrative and statistical system would permit us to know when an individual left the United States for extended periods of time.

Data On Employer Sponsors. *Basic information about employer-sponsors of immigrants should be collected, i.e., industry, size of the organization, and a common employer identifier.* Systematically tracking industry and employer size class would help businesses and policymakers monitor shifts in national and global demand. Policymakers would have more confidence about the fit between policy and meeting national priorities, while employers would have more information to plan human resource strategy.

Random Surveys and Statistical Data. *Random samples of individuals taken outside of the normal routine of administrative data collection are another way to get the statistical information that policymakers regularly call for and need to reach informed decisions.*

Data elements that would impose an unwarranted burden on administrative systems, or elements that pertain to special subjects not of regular interest, should be collected in random surveys.

A Special Immigrant Current Population Survey. *There should be a pilot CPS supplement on immigrants, and it should include survey items that permit researchers to investigate policy-relevant issues.* The determination of items to be included in the survey should be arrived at after soliciting input from various agencies, the research community, immigrant advocacy groups, and other stakeholders. At the least, a special supplement could shed light on the effect of immigrant status, U.S. experience and residence, where and how much education is completed, and language ability.

Organizational Reform of Data Collection. *For over two decades several panels have condemned the organizational incapacity of the INS in particular to collect and manage data.* Without reform of its capacity it is likely that recommendations on data improvements will subsequently fail. Congress has considered and should establish an independent Bureau of Immigration Statistics. The new organization should conform to the National Academy of Sciences' test of independence: The BIA should be established by statute as a separate entity; it should be headed by a career civil servant; it should require no approval for the release of data, and it should have predetermined/scheduled data releases.

APPENDIX VI

PUBLIC COMMENTS: ORGANIZATIONS AND INDIVIDUALS

Organizations

ACT, Inc., Rose Rennekamp, Vice President, Communications

Advanced Technology Institute, North Charleston, South Carolina, Jon D. Tirpak, Engineering Director

American Association of Community Colleges, George R. Boggs, President and CEO

American Geophysical Union

American Astronomical Society, Andrea Schweitzer, Chair, Committee on Employment

American Institute of Physics, Roman Czujko, Director, Statistical Research Center

American Physical Society, Myriam Sarachik, President

American Society of Mechanical Engineers (ASME), Willard A. Nott, Vice President, ASME Board on Pre-college Education

American Society of Agronomy, Karl M. Glasener, Director of Science Policy

Association of American Universities (AAU), Nils Haselmo, President

Association of Science-Technology Centers, Bonnie VanDorn, Executive Director

Committee on Science, Engineering and Public Policy, National Academies

Committee on Equal Opportunities in Science and Engineering

Corning Incorporated, SPIE Scholarship Committee, Christopher W. Wightman

Crop Science Society of America, Karl M. Glasener, Director of Science Policy

Department of Homeland Security, Office of the Under Secretary for Science and Technology, Vic Tambone, Chief of Staff

EPSCoR Foundation, Royce Engstrom, Chair, Board of Directors

Federation of American Societies for Experimental Biology (FASEB), Howard H. Garrison, Director, Office of Pubic Affairs

Health Physics Society, John R. Frazier, President

Industrial Research Institute, F.M. Ross Armbrecht, Jr., President

Innovative Technology Partnerships, LLC, John P. Jekowski, Principal Partner

Institute of Electrical and Electronics Engineers, Inc., Vin O'Neill, Senior Legislative Representative

McGeary and Smith, Philip M. Smith and Michael McGeary

National Association of State Universities and Land-Grant Colleges (NASULGC), C. Peter Magrath, President

National Postdoctoral Association (NPA), Raymond J. Clark, PhD

National Workshop on Space Education, Executive Committee, Professors Joseph N. Pelton, Donald Flournoy, and Professor Randy Johnson

Office of Science and Technology Policy, James A. Griffin, Assistant Director, Social Behavioral and Education Sciences, SBE Department

Oklahoma Center for the Advancement of Science and Technology/Oklahoma Institute of Technology, W.A. Sibley, Executive Director, CEO

The Packer Foundation, Kenneth F. Packer, Chairman of the Board, Packer Engineering, Inc., Margaret Truax, Director, The Packer Foundation

PeoplePC, Michael Danyo

Semiconductor Industry Association, San Jose, California, Daryl Hatano, Vice President, Public Policy

Alfred P. Sloan Foundation, Ralph E. Gomory, President

Soil Science Society of America, Karl M. Glasener, Director of Science Policy

Tallahassee Scientific Society

Texas Instruments, Paula J. Collins, Director, Government Relations

U. S. Geological Survey, Anna Cruse, Denver, Colorado

U.S. Department of Health and Human Services, Office of Science and Data Policy, Office of the Assistant Secretary for Planning and Evaluation, Jim Scanlon, Acting Deputy Assistant Secretary

U. S. Department of Health and Human Services, National Institutes of Health, National Institute of Allergy and Infectious Diseases, Vicki L. Pierson, Senior Project Officer, Office of Biodefense Research Affairs, Division of Microbiology and Infectious Diseases

U.S. Department of Health and Human Services, The National Institutes of Health, Ruth Kirschstein, Senior Advisor to the Director

University of California, Richard C. Atkinson, President

Individuals

George Allen

Robert Ando

Kevin Aylesworth

Diola Bagayoko, Director Timbuktu Academy, Southern University System Distinguished Professor of Physics

Robert Bartolo

Jeremy Bergsman, Yale University Medical School

Andrea Blake-Garrett, Science Supervisor, Jersey City Public Schools, New Jersey

David F. Brakke, Dean, College of Science and Mathematics, James Madison University

David Bruggeman, Virginia Tech, Northern Virginia Campus

Paul Carliner, Senate staff

Marta Cehelsky

Neal R. Chamberlain, Associate Professor, Kirksville College of Osteopathic Medicine, Department of Microbiology/Immunology

Susan Cure, American University in Paris

C. R. Cvitanich, Postdoctoral fellow, University of California

Lance A. Davis, National Academy of Engineering

Melinda K. Duncan, Associate Professor, Department of Biological Sciences, University of Delaware, Newark

Abraham Eisenstark

Patricia L. Eng

David E. Everhart, Navy

Emanuel Goldman, Professor of Microbiology & Molecular Genetics, New Jersey Medical School, University of Medicine & Dentistry of New Jersey

Dinos Gonatas

Edward R. Greisch

Yugui Guo

W. Christopher Hollinsed

Robert Kaman, Associate Dean, University of North Texas Health Science Center at Fort Worth

Pramod P. Khargonekar, Dean, College of Engineering, University of Florida

Kevin Kilty, Clinical Professor, Manufacturing Engineering, Washington State University, Vancouver

Peter W. Krug, Post-Doctoral Associate, Viral Immunology Center, Department of Biology, Georgia State University

Melanie Leitner, PhD, AAAS Science Policy Fellow

Wendy Lick

Marc Lipsitch, Assistant Professor, Department of Epidemiology, Harvard School of Public Health

Robert Loewy, Georgia Institute of Technology, Aerospace

Carol L. Manahan, Postdoctoral Fellow, Johns Hopkins School of Medicine, Chair, National Postdoctoral Association

Michael Mazzei, Air Liquide America, LP

Mark McCaffrey, Science Communications Specialist, Paleoclimatology Branch, National Climate Data Center, National Oceanographic and Atmospheric Administration

Xenia K. Morin, Keck Fellow and Lecturer, Chemistry Department, Bryn Mawr College

Gary Moritz

Kim V. Robinson, Science Teacher, Blewett Middle School, St. Louis, Missouri

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Jennifer Slimowitz, AAAS Science Policy Fellow

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Michael S. Teitelbaum, Program Director, Alfred P. Sloan Foundation

Ronald Williger

Christopher M. Witty

APPENDIX VII

SRI International

January 31, 2003

National Workforce Policies for Science and Engineering: Bibliography

Submitted by:

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National Science Foundation
SRI Project Number: PDU 02-089

INTRODUCTION

The National Science Board's Task Force on National Workforce Policies for Science and Engineering was established in 2000 to assess long-term national workforce trends and needs in science and engineering and their relationship to existing Federal policies, and to recommend strategies for long-term S&E workforce needs. The National Science Foundation contracted with SRI International to support the Task Force by providing a review of science and engineering workforce policy literature, summaries of the key studies, and an inventory of major recommendations. This resulted in a August 13, 2002 report, *National Workforce Policies For Science And Engineering: Literature Review And Inventory Of Recommendations.* This document reproduces the bibliography of that report in a compact form.

The bibliography includes all the reports identified by the SRI project team that (1) were produced since 1995[69] and (2) identify science and engineering workforce policy issues, options, and recommendations as part of the content. Sources considered in the literature review included national commissions, Federal agency reports, Congressional reports, National Research Council studies, reports from non-governmental organizations, U.S. states, and international organizations, as well as privately authored journal articles.

The bibliography is divided into two categories. The first category is the set of studies the SRI project team selected to summarize, based on the following criteria, which were developed with NSF:

- The importance of the study in national and international policy discussions.
- Intellectual contribution (originality and quality of the data and analysis).
- The reputation and credibility of the sponsoring and performing organizations.
- The extent to which the study reflects the views of important stakeholders.

The second, larger category includes other studies that the SRI project team but did not select to summarize, based on a consideration of the criteria described above.

[69] A few significant studies from 1995 were also considered for inclusion.

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APPENDIX VIII

Selected Acronyms and Abbreviations

A&M	Agricultural and Mechanical
ACE	American Council on Education
BCIS	Bureau of Citizenship and Immigration Services
BEST	Building Engineering and Science Talent
EHR	Education and Human Resources Committee
ETS	Educational Testing Service
FY	fiscal year
GDP	Gross Domestic Product
GRE	Graduate Record Examination
HR	House Resolution
INS	Immigration and Naturalization Service
K-12	kindergarten through grade 12
K-16	kindergarten through undergraduate studies
LIGO	Laser Interferometer Gravitational Wave Observatory
NCAR	National Center for Atmospheric Research
NRC	National Research Council
NS&E	natural science and engineering
NSB	National Science Board
NSF	National Science Foundation
NWP	Task Force on National Workforce Policies for Science and Engineering
NSTC	National Science and Technology Council
OECD	Organisation for Economic Cooperation and Development
OSTP	Office of Science and Technology Policy
PCAST	President's Council of Advisors on Science and Technology
PIRG	Public Interest Research Group
R&D	research and development
REU	Research Experience for Undergraduates
S&E	science and engineering
SEI	*Science and Engineering Indicators*
S&T	science and technology
SBE	Social, Behavioral, and Economic Sciences Directorate
SESTAT	NSF's science and engineering labor force data system
SEVIS	Student and Exchange Visitor Information System
SME	science, mathematics, and engineering
SMET	science, mathematics, engineering, and technology
SRS	Division of Science Resources Statistics
US	United States

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(DO NOT REMOVE LABEL)

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