CHAPTER ONE

INTRODUCTION

THE CHALLENGE FOR US SCIENCE AND ENGINEERING

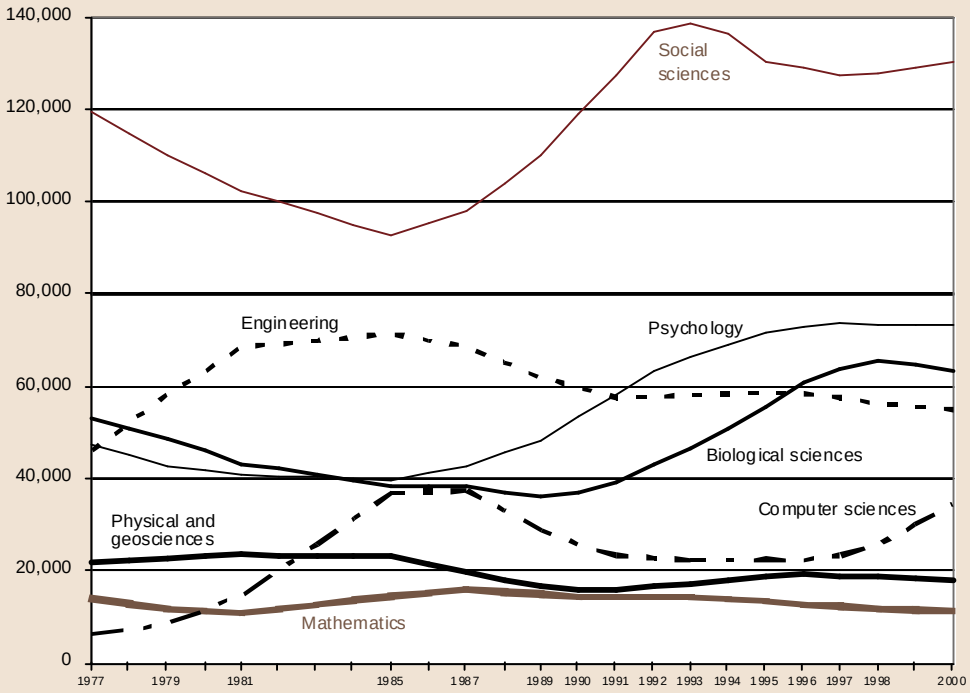
Science and technology have been and will continue to be engines of US economic growth and national security.[2] Excellence in discovery and innovation in science and engineering (S&E) derive from an ample and well-educated workforce – skilled practitioners with two- and four-year degrees and beyond, 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.

[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

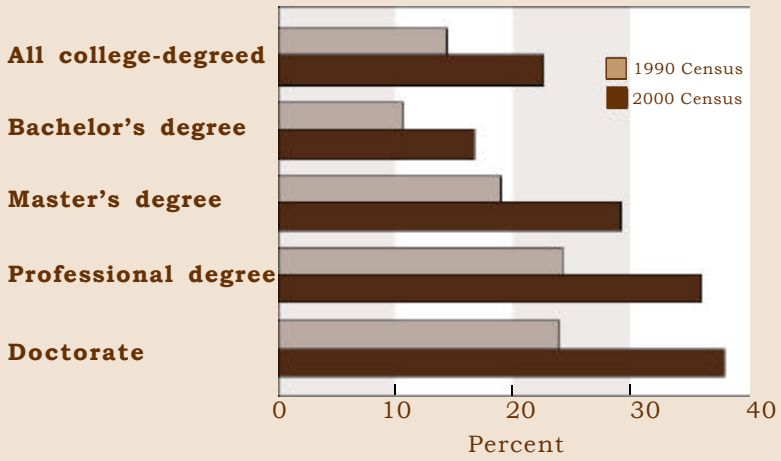
[5] "The Government should accept new responsibilities for promoting the flow of new scientific knowledge and the development of scientific talent in our youth. These responsibilities are the proper concern of the Government, for they vitally affect our health, our jobs, and our national security." V. 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;

[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.