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ABSTRACT

The findings of four independent surveys on various trends in science and engineering (S/E) in the United States are presented in these reports. The first report contains findings obtained from institutions granting a graduate science or engineering degree and/or performing at least $50,000 in separately budgeted research and development (R&D) activities on expenditures in FY 1984. Academic R&D spending rose in each major S/E field in 1984. The second report presents data on the employment of foreign scientists and engineers in U.S. industry which was obtained from a telephone survey of 152 large firms (Fortune 500) and 150 other firms. One-half of the firms utilized foreign scientists and engineers. Results of a survey of graduate S/E students and postdoctorates are discussed in the third report. In 1984 graduate S/E enrollment showed the smallest increase since 1977. The fourth report states that the number of S/E doctorates awarded in 1985 was slightly greater than in 1984, but below the peak reached in 1972. Women continued to increase their representation among S/E doctorates, but not as rapidly as in the seventies and early eighties. (ML)

SCIENCE RESOURCES STUDIES HIGHLIGHTS

NATIONAL SCIENCE FOUNDATION WASHINGTON, D.C. 20550 FEBRUARY 21, 1986 NSF 86-302

8% Real Growth Projected Annually for Academic R&D Expenditures Through 1986

This report contains the findings of the National Science Foundation's (NSF's) Survey of Scientific and Engineering Expenditures at Universities and Colleges, FY 1984. The survey was mailed to a random sample of approximately 400 universities and colleges selected from the 566 institutions granting a graduate science or engineering (S/E) degree and/or performing at least $50,000 in separately budgeted research and development (R&D) activities. Estimates made by NSF for R&D expenditures of nonrespondent or nonsampled institutions represented 6 percent of total academic R&D expenditures in fiscal year (FY) 1984. Estimates for FY's 1985 and 1986 are based on Federal obligations patterns, on unpublished data from the Office of Management and Budget for R&D activities at universities and colleges, and on recent trends in non-Federal funding. All R&D expenditures in this report refer to FY spending levels, and data are given in current dollars except where specified as constant 1972 dollars. In the absence of a reliable R&D cost index, the gross national product (GNP) implicit price deflator developed by the Department of Commerce is used to convert current dollars to constant 1972 dollars calculated as of July 1985. The use of the GNP deflator can only approximate changes in costs.

Highlights

• Expenditures by universities and colleges for separately budgeted research and development (R&D) activities in science and engineering are estimated to reach $10.6 billion in 1986, up 8 percent per year in real terms during the 1984-86 period. This upsurge results from the rise in Federal R&D obligations in 1984 and 1985, coupled with increased funding for academic R&D activities from all other sources. Reductions anticipated in 1986 Federal R&D funds, however, would have a dampening effect on 1987 academic R&D spending levels.

• In 1986, Federal agencies are expected to provide nearly two-thirds of the total R&D support, about $6.6 billion, an average annual increase of 8 percent in real terms over the 1984 total of $5.4 billion. Support from all non-Federal sources combined is also expected to increase on the average of 8 percent per year in constant dollars between 1984 and 1986, to a total of approximately $3.8 billion.

• Basic research spending by academic institutions is estimated to reach $7.1 billion in 1986, an average yearly rise of 8 percent in constant-dollar terms above the 1984 level of $5.6 billion. The major portion of this increase will come from Federal agencies (particularly the National Institutes of Health) which are expected to provide two-thirds of these funds, or about $4.8 billion.

• In 1984, the most recent year for which detailed academic R&D data are available, current-fund expenditures for separately budgeted R&D activities totaled $8.4 billion, nearly one-tenth of the $96 billion expended nationally for research and development. The 9-percent increase in university R&D spending (5 percent in constant dollars) from 1983 to 1984 was attributable in large part to renewed real-dollar growth in Federal support.

• Academic R&D spending rose in each major science/engineering (S/E) field in 1984. Rates of growth were similar for engineering and all sciences combined, between 8 percent and 9 percent over 1983 levels. The most rapid spending increases among the major science fields occurred in the computer and mathematical sciences, up 25 percent and 18 percent, respectively. Growth in R&D expenditures kept pace with, or exceeded, the 1984 inflation rate in all fields except the social sciences.

• Current-fund expenditures for academic research equipment totaled $518 million in 1984, a rise of 15 percent in constant dollars over 1983 levels, and accounted for 6 percent of the R&D total, similar to previous years. Federal agencies supplied nearly two-thirds of these funds.

• Expenditures from capital accounts for facilities and equipment for research, development, and instruction amounted to over $1.2 billion in 1984. The largest portion (61 percent) of this total was in the life sciences. Non-Federal sources of support provided almost nine-tenths of total capital expenditures.

Prepared in the Universities and Nonprofit Institutions Studies Group, Division of Science Resources Studies

Sources of Support

Separately budgeted expenditures for R&D programs in the sciences and engineering totaled $8.4 billion in 1984, up 9 percent (5 percent in constant dollars) over 1983 levels. R&D spending is estimated to reach $10.6 billion in 1986, a rise averaging 8 percent per year in real terms during the 1984-86 period. Federally financed academic R&D spending rose 9 percent in 1984 (5 percent in constant dollars) to more than $5 billion, an indicator of renewed growth after two years of barely keeping pace with inflation. The average annual 9-percent real-dollar rise in R&D obligations from Federal agencies in 1984 and 1985 provides reasonable assurance of continued spending increases through 1986, when expenditures from Federal sources are estimated to reach $6.8 billion (chart 1).[1] The 1986 Federal budget reflects a real-dollar downturn in obligations to universities for R&D activities, however, which would result in a leveling off or decline in academic spending levels in 1987.[2]

Non-Federal R&D expenditures totaled $3.1 billion in 1984, an increase of 9 percent over 1983 levels, or 5 percent in constant-dollar terms. Industrial support ($457 million), although still accounting for a 5-percent share of total academic R&D spending in 1984, showed the most rapid real-dollar increase, 17 percent. This surge in industrial support is consistent with and largely attibutable to the increase in levels of industry/university collaboration and partnerships during the past decade. The categories "institutions' own funds" ($1.3 billion) and "all other sources" ($630 million), which includes nonprofit foundations and voluntary health agencies, reflected real growth of 4 percent each in 1984.

Fields of Science and Engineering

Growth rates in 1984 R&D spending in most major S/E fields either equaled or exceeded the 1983-84 inflation rate of 4 percent (chart 2). For the fourth consecutive year, the fastest increase occurred in the computer sciences, up 25 percent, followed by mathematical and physical sciences, up 18 percent and 11 percent, respectively. The rise in computer science expenditures has consistently outpaced all other fields, growing at an average yearly rate of about 20 percent over the past decade, fueled mainly by Federal sources of support. Still, the computer sciences accounted for only 3 percent, or $222 million, of total academic R&D spending in 1984. Engineering fields showed an 8-percent increase over 1983 levels, led by civil engineering which showed a jump of 21 percent. Engineering expenditures in 1984 once again accounted for a 14-percent share of total academic S/E spending. Spending in the social sciences showed the first current-dollar increase since 1981 but still failed to keep pace with inflation.

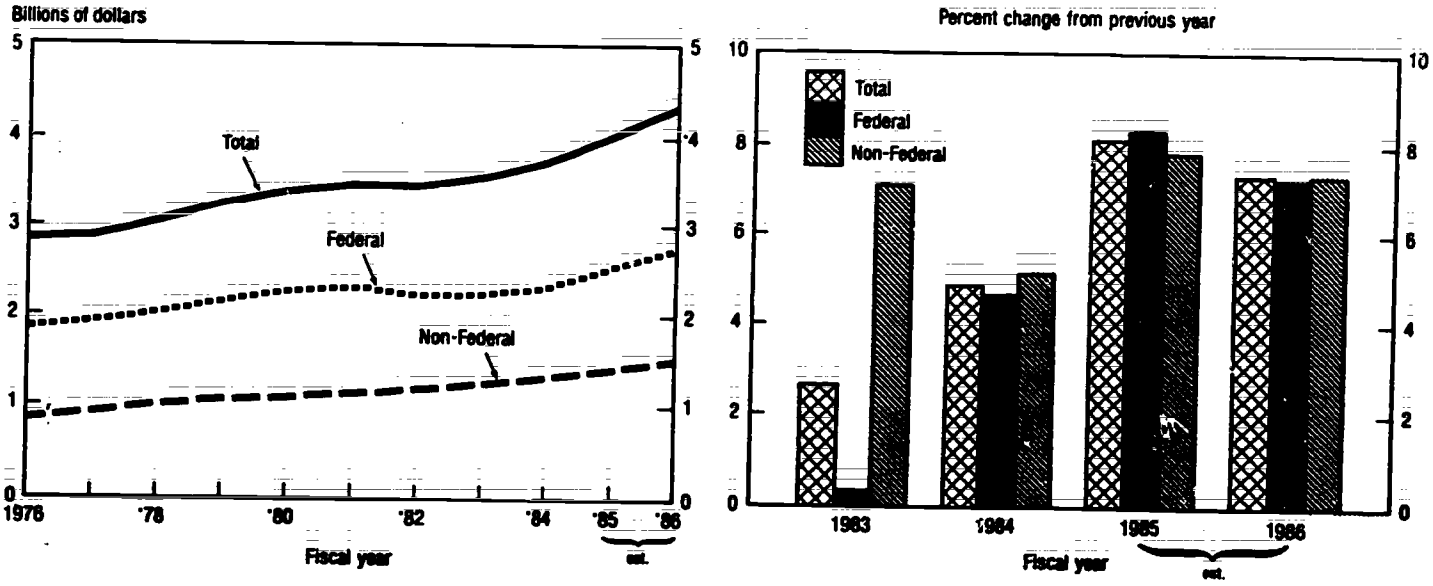
Character of Work

Academic basic research expenditures rose 7 percent in 1984, or 3 percent in constant dollars. Of the $5.6 billion expended on basic research, two-thirds was provided by the Federal Government. Growth in 1984 Federal funds devoted to fundamental research outpaced inflation for the first time since 1981, up 3 percent in real dollars over 1983 levels (chart 3). Non-Federal support ($1.8 billion) rose about 4

[1] National Science Foundation. *National Patterns of Science and Technology Resources: 1986* (Washington, D.C., 1986), table 1 (in press).

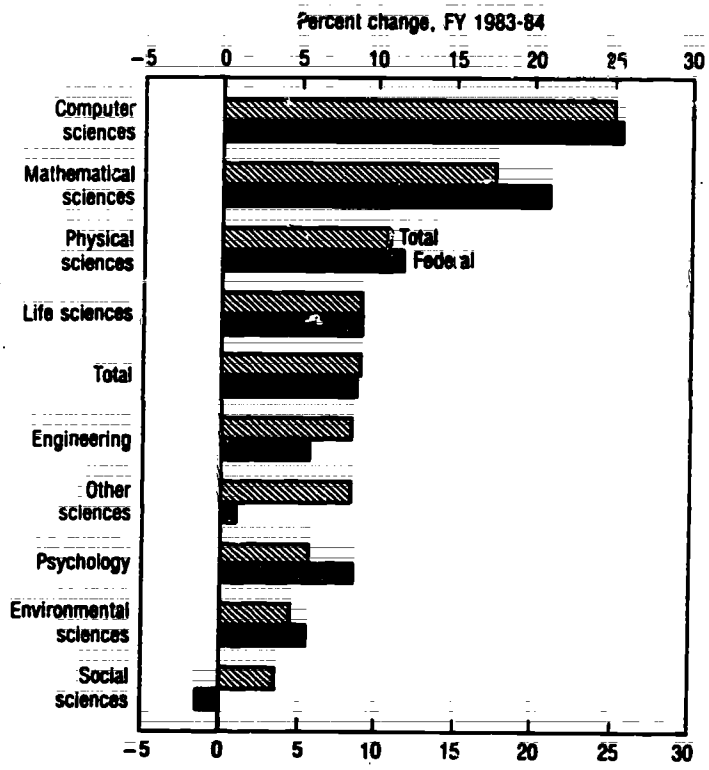
[2] National Science Foundation. *Federal Funds for Research and Development, Fiscal Years 1984, 1985, and 1986*, Volume XXXIV (Detailed Statistical Tables) (Washington, D.C., 1986), table C-1.

Chart 1. Academic R&D expenditures by source
Constant (1972) dollars[a]



[a] Based on GNP implicit price deflator.
SOURCE: National Science Foundation

Chart 2. Academic R&D expenditures by science/engineering field



SOURCE: National Science Foundation

percent in real terms. The 1984 and 1985 Federal budgets reflect continued real-dollar increases in academic basic research suppport, averaging 7 percent per year.[3] These gains, combined with growth in non-Federal funds and a relatively low projected rate of inflation, should result in significant real growth in basic research expenditures over the 1985-86 period.[4]

Higher education expenditures for applied research and development combined totaled $2.9 billion in 1984, an increase of 12 percent (8 percent in real terms) over 1983. This represents the first substantial real-dollar growth in such activities since 1980 and can be attributed to rises in support from both Federal and non-Federal sources.

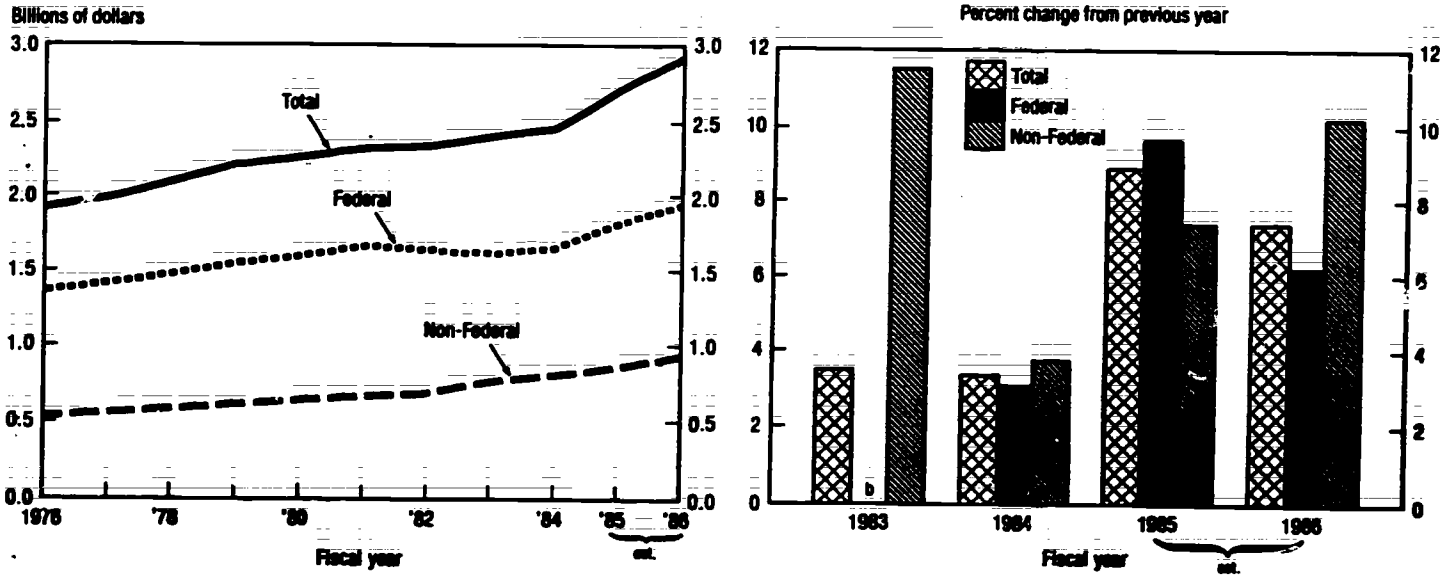
Research Equipment Expenditures

Separately budgeted academic R&D expenditures for S/E research equipment from current-fund accounts were up an estimated 19 percent in 1984 to approximately $518 million, constituting a 6-percent share of total academic R&D spending, similar to the portion reported since 1980. Growth in research equipment spending exceeded the inflation rate in all of the eight major S/E fields. Over one-third of the total 1983-84 increase in equipment expenditures took place in the physical sciences. Federally funded equipment spending grew an impressive 23 percent from 1983 to 1984 and accounted for almost two-thirds of the total.

[3] *Ibid.*

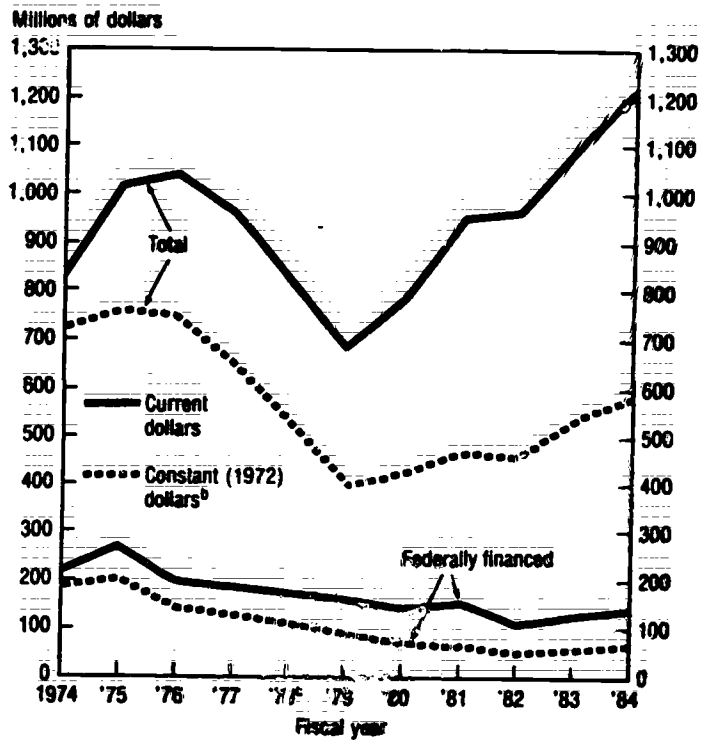
[4] National Science Foundation, *National Patterns of Science and Technology Resources: 1986, op cit.*

Chart 3. Academic expenditures for basic research by source
Constant (1972) dollars[a]



[a] Based on GNP implicit price deflator.
[b] Less than 0.05 percent change.
SOURCE: National Science Foundation

Chart 4. Capital expenditures for scientific/engineering activities at universities and colleges by source[a]



[a]Includes facilities and equipment for research, development, and instruction.
[b]Based on implicit price deflators for nonresidential fixed investments developed by the Department of Commerce.
[c]Estimated. Data not collected in FY 1978.
SOURCE: National Science Foundation

Capital Expenditures

In addition to the $8.4 billion in separately budgeted R&D expenditures, academic institutions expended $1.2 billion in 1984 for capital investment in S/E facilities and equipment for research, development, and instruction (chart 4). This is the second consecutive year that capital spending has topped $1 billion, a level attained in 1983 for the first time since peaking in 1976. Considering the effects of inflation, however, 1984 capital spending was only about 80 percent of the amount reported a decade ago.[b] The Federal role was limited, providing a 12-percent share of the total spent, compared to 27 percent in 1974.

[b]Constant 1972 dollars are based on the implicit price deflator for nonresidential fixed investments developed by the Bureau of Economic Analysis, Department of Commerce.

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Detailed Statistical Tables for *Academic Science/Engineering: R&D Funds, Fiscal Yeor 1984* will be available early in 1986. For further information on the tables, contact the Editorial and Inquiries Unit, Division of Science Resources Studies, tel.: (202) 634-4622.

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NSF 86-302

SCIENCE RESOURCES STUDIES HIGHLIGHTS

NATIONAL SCIENCE FOUNDATION WASHINGTON, D.C. 20550 FEBRUARY 28, 1986 NSF 85-336

Survey of 300 U.S. Firms Finds One-Half Employ Foreign Scientists and Engineers

This report presents data on the employment of foreign scientists and engineers in U.S. industry. A telephone survey conducted in June 1985 for the National Science Foundation (NSF) obtained responses from 152 large firms (Fortune 500) and 153 other firms. The survey included the following industries: Mining, construction, petroleum refining and extraction, chemicals/drugs, primary and fabricated metals, office equipment, electronics (including communications equipment and computers), electrical machinery, aircraft/aerospace, other transportation equipment, machinery, electric and gas services, engineering/architectural services, and independent research and development (R&D) laboratories. The groups covered in the survey employ 75 percent of the scientists and engineers working in American industry. The responding firms employ about 400,000 scientists and engineers, approximately 16 percent of such industrial employment. The firms surveyed were not part of a statistical sample; therefore, the data are not weighted to represent national estimates. Throughout the report, the term "foreigner" refers to a non-U.S. citizen employed in this country.

Highlights

- One-half of the firms surveyed in June 1985 utilize foreign scientists or engineers. Their employment is particularly widespread in the chemical and drug industry (62 percent of firms), the electronics industry (52 percent), and among independent research and development (R&D) laboratories (72 percent).

- American industry has a substantial dependency on foreign supply of scientists and engineers. In the firms employing foreign citizens, they accounted for an average 9 percent of the science and engineering (S/E) work force. In addition to these foreigners, another 11 percent of the S/E employment in the responding firms was of naturalized U.S. citizens.

- There were differences between industries in the utilization of S/E workers from abroad. In the responding firms that employed foreigners, these workers, plus naturalized U.S. citizens, accounted for about one-third of the S/E employment at commercial R&D laboratories, computer/electronics firms, and petroleum extraction and refining firms. However, less than one-fourth of the S/E workers in chemicals, metals, machinery/transportation, and mining were of foreign origin.

- Over two-thirds of foreigners hired had previous S/E work experience; the remainder were recent graduates at the time their current employer hired them. On average, the experienced personnel had been working as scientists and engineers for five years when hired.

- Foreign workers had higher than average level of education—35 percent held S/E doctorates compared to a national average of 12 percent for the S/E work force. About three-fourths of all the foreign personnel received their highest level of S/E training in the United States.

- On average, in all firms that employed them, foreigners accounted for 8 percent of the scientists and engineers hired between June 1984 and June 1985. They represented 14 percent of all newly hired scientists and engineers in the electronics firms, 12 percent in independent R&D laboratories, 7 percent in chemical/drug firms, and 2 percent among firms in other industries combined.

Introduction

The Nation's reliance on immigration for staffing the S/E work force has increased substantially. Studies of the U.S. S/E population show that the proportion made up of foreign citizens and naturalized U.S. citizens increased from 10 percent to 17 percent between 1972 and 1982.[1] Evidence points to an increase in the rate of naturalization to U.S. citizenship over the period, with naturalized citizens increasing from about 6 percent of the S/E workers in 1972 to over 13 percent in 1982. The increase in the proportion of the S/E labor force made up of persons from abroad has focused attention on the utilization patterns of foreigners in this country. In addition, the impact of U.S. immigration laws,

[1] For a detailed analysis of the demographic and employment characteristics of foreign origin scientists and engineers in the United States in 1982, see National Science Foundation, *Foreign Citizens in U.S. Science and Engineering: History, Status, and Outlook* (NSF 85-) (Washington, D.C., 1986). For historical trend data for 1966-84, see National Science Foundation, *Immigrant Scientists and Engineers: 1962-84* (Detailed Tables and Charts) (NSF 85-328) (Washington, D.C., 1985).

which affect the flow of foreign scientists and engineers, has become an issue of concern to policymakers. This report, which includes information obtained from a June 1985 survey of employers in the private industry sector, addresses the extent and magnitude of current employment of foreign scientists and engineers.

Employment of Foreign Citizens

Many firms utilize foreign scientists and engineers in their work force. Employment of such workers was reported by 50 percent of the survey respondents and was particularly widespread in the chemical/drug industry (62 percent of firms), the electronics[1] industry (52 percent), and independent commerical R&D laboratories (72 percent) (chart 1).

Foreign personnel represented an average of 9 percent of the total S/E work force of all the surveyed firms employing them. They accounted for 11 percent of S/E personnel in the electronics firms, 22 percent in the independent R&D laboratories, 5 percent in chemical/drug firms, and 4 percent in other industries combined.

Respondents in one region of the United States—the "Silicon Valley" area of Northern California—utilize foreign workers at a much higher level than the average for the country. The survey found that foreign scientists and engineers were employed by two-thirds of the "Silicon Valley" respondents. One-third of the S/E workers hired by those respondents between June 1984 and June 1985 were foreign.

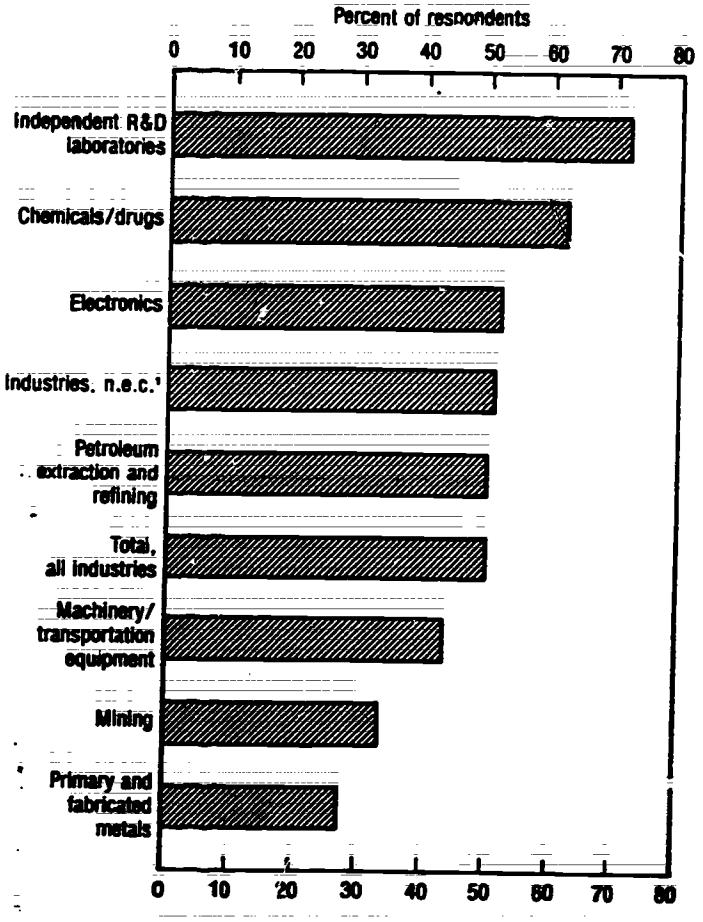
Primarily, the surveyed firms employ foreign workers in the following fields: Electrical and electronics engineering, computer science and engineering, chemistry and chemical engineering, biology, biochemistry, and medical sciences (table 1).

Approximately three-fourths of the employing firms reported turnover for foreigners to be about the same as for U.S. citizens in comparable positions. A majority of the firms also said that the same career opportunities were open to both U.S. and foreign citizens.

Many foreigners in the U.S. eventually become naturalized; therefore, data on foreign citizens understate the participation of those from abroad in the S/E work force. In firms that employed foreigners, these personnel accounted for 9 percent of total S/E workers, and naturalized U.S. citizens accounted for another 11 percent. In some industries—

[1] The electronics, computers, and communications equipment industries' respondents had similar foreign citizen utilization patterns and were combined into the "electronics" category for purposes of this report.

Chart 1. Employment of foreign scientists and engineers in selected firms by industry: 1985



[1]Not elsewhere classified. Includes aerospace, construction, engineering and architectural services, and utilities.
NOTE: Based on information provided by 305 firms.
SOURCE: National Science Foundation

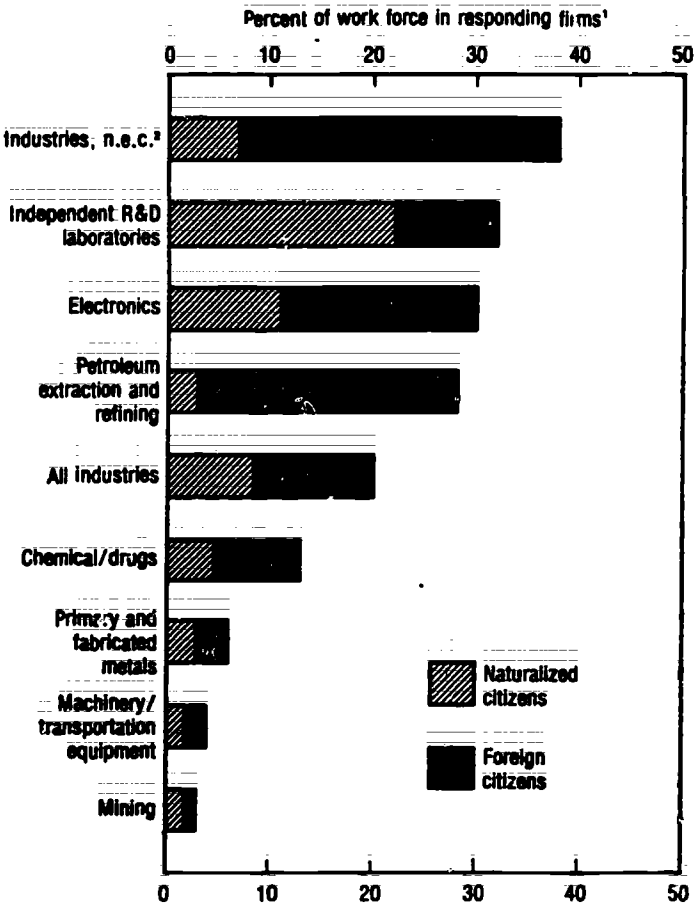
Table 1. Percent of responding firms employing foreign scientists and engineers by industry and occupation: June 1985

Occupation	Industry				
	All firms	Chemical/ drugs	Electronics	R&D laboratories	Other[1]
Scientists					
Computer scientists	14	8	23	15	13
Computer systems analysts	8	8	11	8	9
Chemists	9	29	[2]	[2]	13
Biochemists	8	21	[2]	31	[2]
Biologists	5	21	[2]	[2]	[2]
Medical scientists	6	17	[2]	15	[2]
Engineers					
Chemical engineers	16	25	13	8	20
Computer engineers	14	8	24	8	13
Electrical engineers	15	[2]	20	8	21
Electronics engineers	10	[2]	21	8	[2]
Manufacturing engineers	9	[2]	14	8	11

[1] See complete list of surveyed industries on page 1.
[2] Less than 5 percent.
SOURCE: National Science Foundation

independent R&D laboratories, electronics, and petroleum extraction and refining—foreigners and naturalized U.S. citizens accounted for roughly one-third or more of all S/E workers (chart 2).

Chart 2. Foreign and naturalized U.S. citizens as percent of science/engineering work force in selected firms by industry: 1985



¹Data refer only to responding firms employing foreign citizens (chart 1).
²Not elsewhere classified. Includes aerospace, construction, engineering and architectural services, and utilities.
SOURCE: National Science Foundation

Patterns of Hiring Foreign Scientists and Engineers, June 1984-June 1985

Although one-half of the surveyed firms hired foreign scientists and engineers, patterns differed by industry. Foreigners represented 14 percent of newly hired scientists and engineers in the electronics firms employing them, 12 percent in independent R&D laboratories, 7 percent in chemical/drug firms, and 2 percent in all remaining industries combined, for an overall average of 8 percent.

Most (68 percent) of the foreign personnel in all industries combined had previous work experience at the time of being hired, with an average of five years in the work force. They were more likely to have been already employed in the United States (80 percent) rather than working abroad (20 percent) at the time of hire. Electronics firms were the most likely to hire experienced foreign workers instead of new graduates (75 percent versus 25 percent). Generally, about two-thirds of hires, both experienced and new graduates, had permanent resident status when hired. Foreigners employed by independent R&D laboratories were the exception—about 40 percent of them were recruited from abroad.

Foreigners hired by the respondents appear to have a higher level of educational attainment than that of the S/E work force of the United States. Overall, about 12 percent of U.S. S/E workers held Ph. D.'s, and 29 percent, master's degrees,[3] whereas 35 percent of the foreign citizens hired by the respondents held doctorates, and 25 percent, master's degrees. Approximately three-fourths of these personnel received their highest level of S/E training in the United States.

Chemical/drug firms were the least likely to hire foreign bachelor's-level personnel (8 percent of those hired) and most likely to hire those at the doctoral level (75 percent); electronics firms were the reverse—about 55 percent of recent foreign hires were at the bachelor's level and 15 percent held doctorates. Almost 60 percent of new hires by the independent R&D laboratories were at the doctoral level.

The most frequent reasons given for hiring foreign workers were that they were the most qualified applicants (56 percent of responses), and that there was a shortage of qualified U.S. candidates (35 percent). Nearly 9 percent of the respondents cited superior overseas training, more value for the salary, knowledge of foreign markets, and satisfaction of EEO requirements as reasons for hiring foreign citizens. On the other hand, of those firms that did not hire foreign citizens, three-fifths stated that there was a sufficient supply of qualified U.S. citizens to fill their staffing needs without having to hire foreigners, and one-fourth stated that they were not hired because of the red tape and costs involved (chart 3).

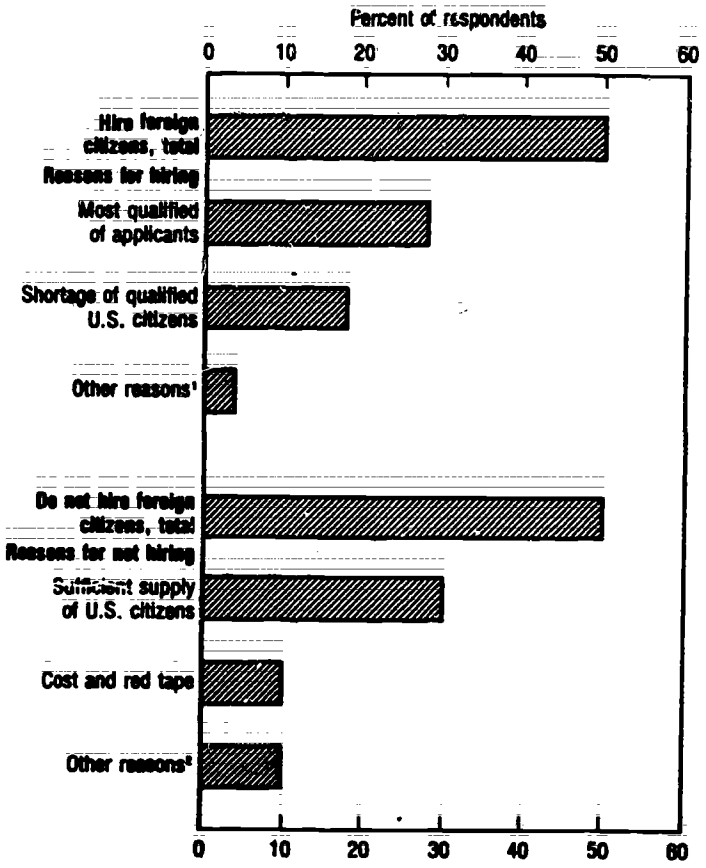
Future Hiring Plans

Most firms (71 percent) expected foreigners to be about the same proportion of new hires between June 1985 and June 1986 as during the prior year. Twenty-three percent expected foreign hires to be at a lower rate, and only 6 percent indicated plans to increase their hiring rate. The most common reasons firms provided for plans to hire foreigners at a lower rate were a sufficient supply of qualified U.S. citizens and the anticipation of decreased hiring requirements for scientists and engineers in general through June 1986.

Four out of five firms that employ foreigners would not change their hiring practices if, in the future, U.S. procedures for the employment of noncitizens became less cumbersome. There were virtually no differences between industries.

[3] National Science Foundation, *U.S. Scientists and Engineers: 1982 (Detailed Statistical Tables)* (NSF84-321) (Washington, D.C., 1984).

Chart 3. Reasons underlying employer decisions regarding the use of foreign science/engineering personnel



¹Includes the following reasons: Superior overseas training, more value for the salary, knowledge of foreign markets, satisfaction of EEO requirements.
²Includes the following reasons: Lower motivation than U.S. citizens, inferior training, less value for the salary, and national security restrictions.
SOURCE: National Science Foundation

Sponsorship of Foreign Citizens

Under the immigration laws, foreign citizens who enter the United States as immigrants (for legal permanent residence) but who do not have familial relationship with U.S. citizens or permanent residents, and therefore do not have entry privileges, must be sponsored by a U.S. employer. In 1984, two-fifths of S/E immigrants fell into the employer-sponsorship category. The sponsoring employer must prove that a qualified U.S. worker is not available for the job vacancy in order to obtain a labor certification from the Department of Labor. The employer must then petition the Immigration and Naturalization Service for issuance of a visa to the would-be immigrant. If the employer's petition is approved, the alien may then apply for a visa.

Of the firms that hire foreign scientists and engineers, a majority (57 percent) undertake sponsorship of people who do not have permanent resident status. Seventy-five percent of the independent R&D laboratories, 69 percent of the electronics firms, 50 percent of the chemical/drug firms, and 33 percent of the firms in the remaining industries sponsor foreign citizens. Two-thirds of the firms that sponsor foreign citizens pay all of the costs (application fees, legal services, etc.) required to obtain permanent resident status, and an additional 18 percent pay partial costs.

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SCIENCE RESOURCES STUDIES HIGHLIGHTS

NATIONAL SCIENCE FOUNDATION WASHINGTON, D.C. 20550 MARCH 21, 1986 NSF 86-303

Graduate S/E Enrollment Shows Smallest Increase Since 1977

This report presents data collected in the National Science Foundation's (NSF's) Survey of Graduate Science and Engineering Students and Postdoctorates, Fall 1984. Estimates are based on responses from all 325 doctorate-granting institutions in the United States and a stratified random sample of the 293 U. S. institutions with one or more master's-level programs in science and engineering (S/E) fields. Data are believed to be accurate within ± 3 percent at the 95-percent confidence level. Responses were received from 93 percent of the departments surveyed, and estimates for nonresponse made up less than 6 percent of the graduate S/E total shown in this report. Unless otherwise specified, "graduate S/E enrollment" includes all students enrolled either full- or part-time in programs leading to graduate S/E degrees.

Highlights

ALL GRADUATE INSTITUTIONS

• The estimated 415,000 S/E graduate students enrolled in all institutions of higher education in fall 1984 represented almost no change from the prior year. Various factors which have contributed to the slowdown in enrollment growth are expected to continue, and an increase of less than 1 percent is estimated for fall 1985 graduate S/E enrollment. By contrast, the 1977-83 yearly increase averaged 2 percent. The current leveling off follows the general slowdown in the rate of expansion of academic enrollment at all levels.

• The leveling off in overall graduate S/E enrollment occurred primarily as a result of smaller enrollment among nondoctorate institutions coupled with a slight drop in the enrollment growth rate in doctorate-granting institutions.

• Graduate engineering enrollment rose by 2 percent to about 95,000 in 1984, compared to a 5-percent average annual growth rate between 1977 and 1983. Graduate science enrollment was virtually unchanged from 1983, after an average increase of 2 percent per year during 1977-83.

DOCTORATE-GRANTING INSTITUTIONS

• Graduate S/E enrollment in doctorate-granting institutions reached 363,000 in 1984, up 2 percent from 1983. This compares to a 3-percent average annual growth rate over the previous six years. This growth reflects a 1-percent rise in the number of students enrolled full time and a 2-percent increase in part-timers since 1983, compared to average annual rates of increase of 2 percent and 4 percent, respectively, during 1977-83.

• Among individual S/E fields, full-time graduate enrollment in computer science continued to increase at the fastest rate. The 9-percent increase from 1983 to 1984 represented a sharp reduction from the 14-percent average annual increase reported in the 1977-83 period. In view of the slackening of the growth rate in total S/E enrollment, however, the 1983-84 increase indicates that the market for computer scientists is still relatively strong. Graduate engineering enrollment growth also slowed, from a 7-percent average annual rise between 1977 and 1983 to 2 percent in 1984.

• The number of women enrolled full time grew by 2 percent in 1984, a rate of growth that was about one-half the 4-percent average of the 1977-83 period. The number of men rose by 1 percent, equalling the rate of the previous six years.

• Full-time S/E graduate students receiving their primary support from the Federal Government increased by 1 percent, repeating the growth rate of the previous year. The 48,000 total reported for 1984 is 10 percent below the 1980 peak of nearly 53,000. NSF and the National Institutes of Health (NIH) were primarily responsible for the 1983-84 growth, up 4 percent and 3 percent, respectively. Full-time S/E graduate students receiving their main support from their institutions rose by 4 percent, and from other U.S. sources, by 6 percent. Decreases were reported in self and family support (1 percent) and foreign support categories (8 percent).

• All support categories (research assistants, teaching assistants, etc.) except "other types of support" showed slight increases in 1984. The 1-percent increase in the number of fellowships and traineeships awarded was the first growth since 1977.

Prepared in the Universities and Nonprofit Institutions Studies Group, Division of Science Resources Studies

• The 61,000 foreign students enrolled full time in graduate S/E programs in doctorate-granting institutions in 1984 represented a 2-percent increase, down considerably from their 8-percent annual rise during the 1977-83 period. The number of U. S. citizens rose by 1 percent.

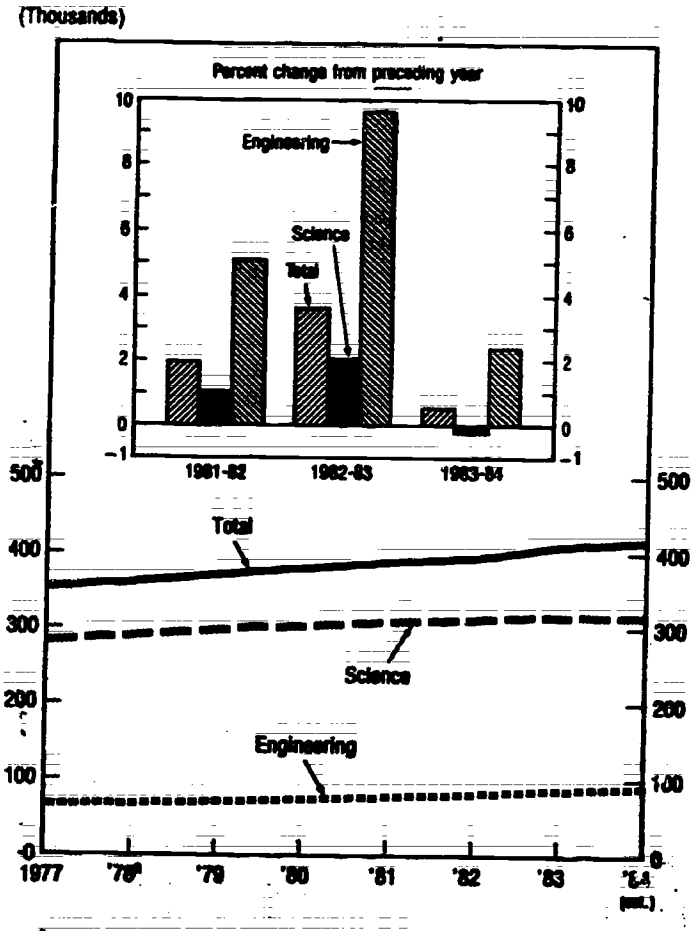
Total Graduate S/E Enrollment

Total graduate enrollment in S/E programs in all institutions in the United States in fall 1984 is estimated at 415,000, virtually the same as in 1983 (chart 1).[1] A slowdown in the rate of graduate enrollment growth was also reported by the Council of Graduate Schools, which showed a slight decline in 1984 in graduate enrollment in all fields at master's-granting institutions and an increase of less than 1 percent in doctorate-granting institutions, for an overall level of enrollment almost unchanged from 1983.[2] Data from the Department of Education's Center for Statistics (CS) also show an increase of less than 1 percent in total graduate enrollment.

[1] Because the sampling error at the total level is significantly larger than the apparent growth rate in total graduate S/E enrollment from 1983 to 1984, universe data presented in this report should be used with caution.

[2] *CGS Communicator*, Special Report, Vol. XVIII, No. 2, February 1985, p. 6.

Chart 1. Graduate enrollment in the sciences and engineering in all institutions



[a] Includes interpolated data for master's-granting institutions.

SOURCE: National Science Foundation

Full-time Graduate Students in Doctorate Institutions

The remainder of this report concentrates on full-time graduate S/E enrollment in doctorate-granting institutions, which comprises 59 percent of total graduate S/E enrollment in all institutions.

The 247,000 graduate students enrolled full time in programs leading to a master's or doctorate S/E degree represented an increase of 1 percent over the 1983 total, compared to nearly 2 percent in the number of part-timers. Both groups showed substantial declines from their 1977-83 average annual growth rates of 2 percent and 4 percent, respectively.

S/E FIELDS

Although full-time enrollment in most S/E fields was up slightly from the 1983 levels, the rates of increase were significantly lower than those of the 1977-83 period. Engineering enrollment, which showed an average annual growth of 7 percent over the previous three years, rose by only 2 percent in 1984. In the computer sciences, the 1983-84 growth was 9 percent, compared to 14 percent per year from 1977 through 1983. Only in the social sciences was an actual decline recorded—2 percent—continuing a drop which began in 1981 (table 1).

The slowdown in graduate engineering enrollment growth may be partly attributable to the declining rates of growth in the number of foreigners enrolled. From 1983 to 1984, the number of foreign graduate engineering students increased at only about one-half the 3-percent growth rate of U.S. citizens. As indicated below, about two out of every five graduate students in engineering in recent years have been

Table 1. Full-time graduate science/engineering enrollment in doctorate-granting institutions by field: 1984

Field	1984	Percent change, 1983-84
Total, all S/E fields	246,800	1
Engineering	54,800	2
Sciences	192,000	1
Physical sciences	25,100	3
Environmental sciences	11,300	−2
Mathematical sciences	10,600	3
Computer sciences	10,100	9
Life sciences	66,200	2
Agricultural sciences	9,300	−1
Biological sciences	36,000	2
Health sciences	20,900	2
Psychology	21,600	1
Social sciences	47,100	−2

SOURCE: National Science Foundation

non-U.S. citizens; however, the proportion has declined slightly since 1981. According to the American Society for Engineering Education, undergraduate enrollment fell by nearly 3 percent in 1984, primarily in the freshman and sophomore classes.[3] Graduate engineering enrollment may therefore level off or decline in the next few years.

The patterns of growth by field differ significantly for men and women. For men, computer science was still the fastest growing field, up 10 percent since 1983; for women, however, engineering showed the highest 1983-84 increase, up 7 percent. Both of these rates represent sharp declines from the 1977-83 period, when the number of men enrolled in graduate computer science programs grew at an average annual rate of 12 percent and the number of women in engineering rose by 16 percent per year.

SOURCES AND TYPES OF SUPPORT

The number of full-time graduate students receiving their primary support from the Federal Government increased by 1 percent from 1983 to 1984, the same rate as the previous year, an average annual decline of 4 percent from the 52,900 in 1980. Growth in graduate students supported by NSF (4 percent) and NIH (3 percent) accounted for most of the rise in the federally supported graduate student total. The largest relative growth, 6 percent, was reported in students supported by "other U.S. sources," including industry and nonprofit institutions. These sources, however, still accounted for only about 7 percent of all full-timers. As in earlier years, institutional funds supported the largest number of S/E graduate students—two out of every five. The number relying primarily on self and family support declined 1 percent, the first drop since 1979, while those receiving their primary support from foreign sources showed an 8-percent decrease in 1983-84.

The number of graduate students relying on fellowships increased for the second consecutive year, with institutional fellowships and those from other U.S. sources accounting for most of the increase. Students holding federally funded fellowships declined slightly, with increases in the number of NSF and NIH fellowships offset by decreases in those supported by other agencies. The latest data on Federal support for fellowships and traineeships indicate a 6-percent rise in the dollar amount obligated for fellowships and traineeships from 1983 to 1984.[4] The growth in NSF-supported fellows reflects a 36-percent rise in the amount budgeted for fellowships.[5]

Research assistants showed the largest relative increase, 5 percent over the 1983 figure. This increase is consistent with a 5-percent constant-dollar rise in academic R&D expenditures from FY 1983 to FY 1984.[6] Major growth came from non-Federal sources, with smaller growth in federally supported research assistantships. On the basis of data presented in the FY 1985 and 1986 budget documents, the number of NSF-supported research assistants is expected to level off after steady growth since 1981.[7] As in previous years, almost all teaching assistants—99 percent of the total reported—depended primarily on institutional funding (chart 2).

[3] "Engineering Enrollments, Fall 1984," in *Engineering Education*, Vol. 76, No. 2 November 1985, p. 104.

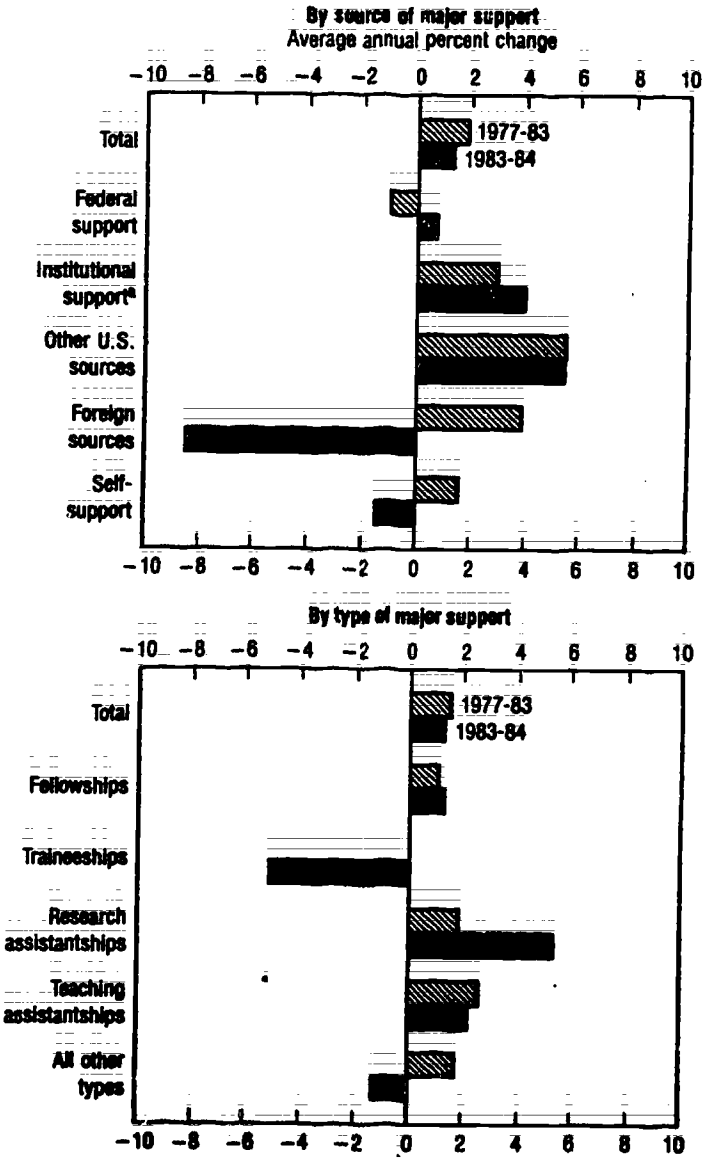
[4] National Science Foundation, *Federal Support to Universities, Colleges, and Selected Nonprofit Institutions, Fiscal Year 1984* (Washington, D.C., 1986), unpublished data.

[5] National Science Foundation, *Justification of Estimates of Appropriations to the Congress, Fiscal Year 1985* (Washington, D.C., 1985), p. 43.

[6] National Science Foundation, *Academic Science/Engineering: R&D Funds, Fiscal Year 1984* (Detailed Statistical Tables)(in press)(Washington, D.C., 1986), table B-6.

[7] National Science Foundation, *Justification of Appropriations to the Congress, Fiscal Year 1985*, p. 17, and *Fiscal Year 1986*, p. 20, op. cit.

Chart 2. Full-time graduate science/engineering enrollment in doctorate-granting institutions by source and type of major support



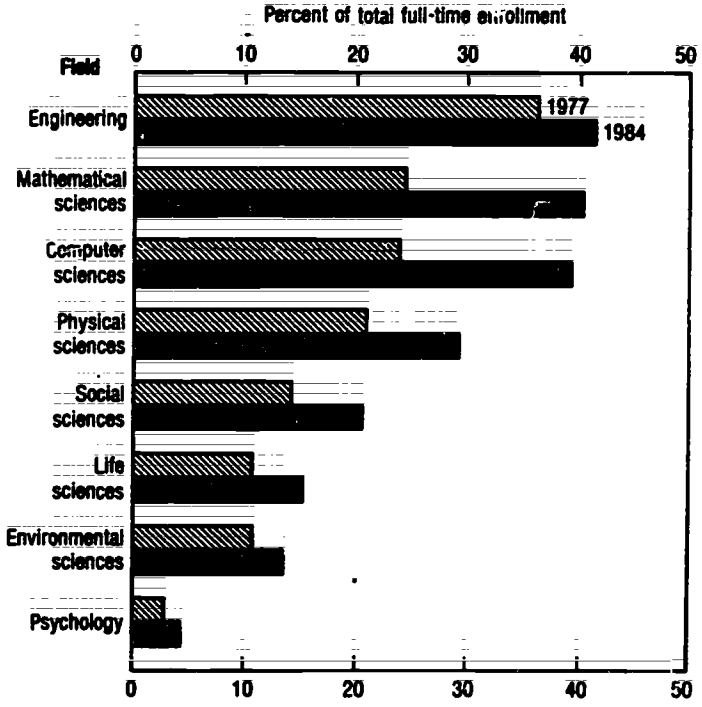
[a] Includes support from State and local governments.

SOURCE: National Science Foundation

CITIZENSHIP

Although the total number of foreign students continued to rise, the 1983-84 increase of 2 percent was well below the 8-percent average annual growth rate over the 1977-83 period. By comparison, the 1983-84 rise in foreign enrollment at all levels of higher education in all fields was less than 1 percent. Factors contributing to the 1983-84 reduction in the rate of growth include the strength of the U.S. dollar, which has made it more costly for foreigners to come to the United States to study, and the decline in oil prices, which has reduced the foreign exchange available to the OPEC countries. These nations accounted for 21 percent of the foreign students enrolled in American institutions of higher education in 1984.[8] Foreigners were more heavily concentrated in graduate engineering programs than were U. S. students but were underrepresented in psychology and the life and social sciences in comparison to their proportion of total graduate enrollment (chart 3).

Chart 3. Foreign full-time graduate science/engineering enrollment in doctorate-granting institutions as a percent of total by field



SOURCE: National Science Foundation

[8]This proportion represents a sharp decline from the 24 percent in 1983/84 and 26 percent in 1982/83. See Institute of International Education, *Open Doors: 1983/84* (New York: Institute of International Education, 1984), p. 23. *Open Doors: 1984/85* is currently in press.

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Detailed Statistical Tables for *Academic Science/Engineering: Graduate Enrollment and Support, Fall 1984* will be available early in 1986. For further information on the tables, contact the Editorial and Inquiries Unit, Division of Science Resources Studies, tel: (202) 634-4622.

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NSF 86-303

SCIENCE RESOURCES STUDIES HIGHLIGHTS

NATIONAL SCIENCE FOUNDATION WASHINGTON, D.C. 20550 JUNE 6, 1986 NSF 86-308

Output of Science and Engineering Doctorates Stable in 1985, But Non-U.S. Citizens and Women Increase Their Shares of the Total

The Survey of Earned Doctorates is conducted annually by the National Research Council for the National Science Foundation, the National Endowment for the Humanities, National Institutes of Health, and the Department of Education[1]. Approximately 95 percent of the 1985 recipients of the Ph. D. and similar doctorates, e.g., Ed. D., responded to the survey questionnaire. The date base also includes some information on nonrespondents that was obtained from public sources. Recipients of first-professional degrees are not included (the M.D. degree, for example).

Highlights

• The number of science and engineering (S/E) doctorates awarded in 1985—10,255—was slightly greater than in 1984 and 7 percent above the recent low point in 1978. Although S/E doctorates have been increasing, the 1985 total was still 4 percent below the peak reached in 1972.

• Non-U.S. citizens earned 4,850 S/E doctorates in 1985, an increase of 10 percent over 1984. They received 28 percent of all S/E doctorates awarded in the United States in 1985, up from 25 percent in 1984, and more than in any previous year. Most of these non-U.S. citizens, 81 percent in 1985, held temporary visas.

• The number of engineering doctorates was 3,165 in 1985, a gain of 9 percent over 1984. Both U.S. and non-U.S. citizens contributed to the increase. The 1,730 doctoral degrees awarded to foreign citizens in 1985 represented a new high level for this group. A 3-percent increase for U.S. citizens was their second consecutive increase after an almost unbroken series of declines following a peak reached in 1970. Over the 1970-85 period, the number of engineering doctorates awarded to U.S. citizens fell by one-half, and their share of the total in this field declined from 74 percent to 43 percent.

• The number of science doctorates was 15,090 in 1985, slightly less than in 1984. Non-U.S. citizens earned 3,120 science doctorates, an all-time high, increasing their share from 17 percent in 1978 to 22 percent in 1985. The number of U.S. citizens receiving science doctorates declined during this period, a result of fewer awards to U.S. males.

• S/E doctorates were awarded to foreign citizens from more than a hundred countries. An increasing share of the recipients are from countries in East Asia. Consistently since 1960, over one-half the East Asians were from China, mostly from Taiwan.[2]

• Women continued to increase their representation among S/E doctorate recipients, but not as rapidly as in the seventies and early eighties. The 4,650 degrees earned by women in 1985 were only 2 percent more than in 1984, significantly below the average annual increase of about 6 percent achieved during the preceding 10 years. In 1985, women earned 1,340 more S/E doctorates than in 1978; men, in contrast, earned 135 fewer. The net effect of these divergent trends has been an increase in the proportion of degrees awarded to women, from 19 percent in 1978 to 25 percent in 1985. Over the years women have earned over 80 percent of their degrees in psychology, life sciences, and social sciences.

[1] Additional information is available from the National Research Council's annual publication series, *Summary Report: Doctorate Recipients from U.S. Universities* (Washington, D.C.)

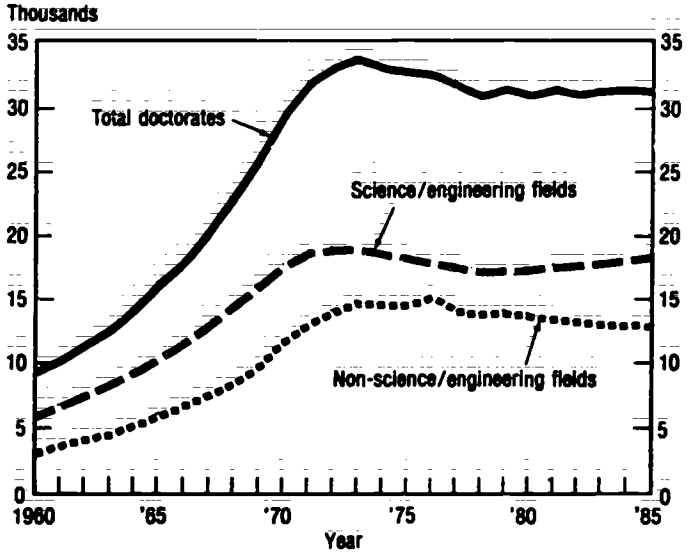
[2] Some respondents report that "China" was their country of citizenship, not allowing a clear distinction to be made between the People's Republic of China and Taiwan. Based on permanent addresses and educational history, however, it is believed that most of those respondents are from Taiwan.

Prepared in the Supply and Education Analysis Group, Division of Science Resources Studies

Overall Trends in Doctorate Production

There have been three distinct phases in S/E doctorate production during the 1960-85 period (chart 1). Dramatic growth marked the sixties with increases for both men and women and for both U.S. and foreign citizens in number of degrees in each of the major fields. The annual number of S/E doctoral graduates rose from 6,260 in 1960 to a peak of 19,000 in 1972, an increase of over 200 percent. During the second phase, which covered most of the seventies, the total number of S/E doctorates declined to a low of 17,050 in 1978, reflecting the rapid decrease for male U.S. citizens. During the third and current phase, gains in the number of doctorates awarded to women and non-U.S. citizens have offset the continuing decline for U.S. male recipients, gradually producing by 1985 an overall 7-percent growth over the 1978 level.

Chart 1. Long-term trends in doctorate production



SOURCE: National Science Foundation

The annual production of engineering doctorates has increased by 31 percent since 1978. The 3,165 doctorates in 1985, however, remained below the peak production of 3,500 in 1971 and in 1972. Within science fields, natural sciences are increasing, while the social and behavioral fields are decreasing. Since 1978, natural sciences gained 10 percent to reach 9,400, while social and behavioral sciences declined by 6 percent. Changes for S/E fields since 1978 are summarized in table 1.

Foreign Citizen Participation

Doctoral education in the United States continued to attract increasing numbers of foreign citizens. The most rapid growth in S/E doctorates earned by non-U.S. citizens occurred in the sixties and early seventies when awards to this group increased from 900 to more than 4,000. After declining to less than 3,500 in 1978, the numbers have again increased

Table 1. Science/engineering (S/E) doctorates: 1978 and 1985

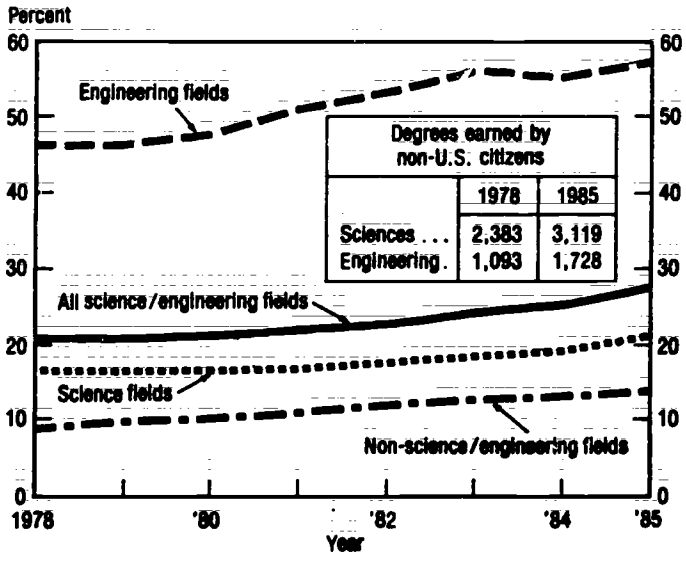
Field	1978	1985	Change	
			Number	Percent
Total S/E degrees	17,048	18,255	1207	7
All sciences	14,625	15,090	465	3
Natural science	8,562	9,408	846	10
Physical sciences	3,234	3,531	297	9
Life sciences	4,369	4,877	508	12
Mathematics	838	689	−149	−18
Computer science	121	311	190	157
Social and behavioral sciences	6,063	5,682	−381	−6
Social sciences	3,008	2,607	−401	−13
Psychology	3,005	3,075	20	1
Engineering	2,423	3,165	742	31
Non-S/E degrees	13,827	12,946	−881	−6

SOURCE: National Science Foundation

rapidly, particularly in the last three years. In fact, this increase was more than sufficient to account for the growth in S/E doctorates; the increase of 1,440 in foreign recipients with temporary visas since 1978 was greater than the increase of 1,200 in all S/E doctorates.

Foreign citizens earned 4,850 S/E doctorates in 1985, almost 10 percent more than in 1984, and about 21 percent of total S/E doctorates in 1978 (chart 2). This share, showing a defi-

Chart 2. Shares of doctorates earned by non-U.S. citizens



SOURCE: National Science Foundation

nite upward trend in the last five years, reached 28 percent in 1985.

The increase in the foreign doctorates since 1978 follows a substantial increase in the number of full-time foreign S/E graduate students since 1977: 63 percent for science and 71 percent for engineering between fall 1977 and fall 1984.[3] The trend suggests even more foreign doctorate recipients in the years ahead.

Most foreign doctorate recipients have temporary visas, which are relatively easy to obtain and which normally grant them permission to remain in the United States only while they are students. This group constitutes an increasing proportion of the non-U.S. recipients. The number of S/E doctorates earned by temporary residents has increased in each year since 1978, from 2,500 to 3,950 in 1985. During the same period, the number of S/E doctorates earned by non-U.S. permanent residents declined from 970 to 900. As a result, the proportion of foreign S/E doctorates received by temporary residents rose from 72 percent in 1978 to 81 percent in 1985.

Field distribution. For non-U.S. citizens, engineering has been the primary major field since 1967, and it has represented a growing proportion of the awards to non-U.S. citizens since that time. An upturn in the last two years has restored the number of U.S. citizens earning engineering doctorates to the same level as in 1978; however, the doctorates earned by non-U.S. citizens have increased over this 7-year period by 58 percent, from 1,100 to 1,730. Therefore, beginning in 1981 and continuing through 1985, non-U.S. citizens have received more than one-half of the engineering doctorates. In 1985, non-U.S. temporary residents received 47 percent, and non-U.S. permanent residents received 10 percent of the engineering doctorates.

The engineering disciplines attracting the most non-U.S. citizens in 1985 were electrical/electronics, mechanical, civil, and chemical engineering, in that order. Foreign citizens earned between 48 percent and 67 percent of the doctorates in each of these four disciplines. Other engineering specialties with high proportions of doctorates awarded to non-U.S. citizens included aeronautical/astronautical, agricultural, computer, industrial, and ocean engineering. Representation of foreign citizens was considerably lower in some engineering specialties; in bioengineering, for example, they earned 27 percent of the doctorates.

Foreign citizens also earned relatively large shares of the 1985 doctorates in mathematics (43 percent), computer sciences (37 percent), and agricultural sciences (37 percent), but only 17 percent of the doctorates in the social and behavioral sciences, and 14 percent in biological sciences. They have increased their shares substantially in mathematics and computer sciences since 1978.

The total number of science doctorates has increased by 465, or 3 percent, since 1978. There was an increase of 800 in non-U.S. citizens with temporary visas, while the number of U.S. citizens and non-U.S. permanent residents declined. As a result, the share earned by non-U.S. temporary residents increased from 12 percent to 18 percent, permanent residents declined from 4.5 percent to 4.0 percent, and U.S. citizens declined from 83 percent to 78 percent.

Support for doctoral study. Foreign graduate students were more likely than U.S. citizens to obtain their primary support through research and teaching assistantships (chart 3). Sixty-one percent of the foreign recipients versus 47 percent of the U.S. citizens received their primary support through these sources. In part, this reflects the limited eligibility of foreign students for direct U.S. Federal programs. Those with temporary status may also face restrictions on employment in the United States because of visa limitations or language difficulties, and are less likely to have working spouses. Family contributions were a more frequent primary source for foreign citizens than for U.S. citizens. Many non-U.S. citizens with temporary visas relied on "other" sources, which in most cases was support from their home countries.

World regions. U. S. universities award doctorates to students from more than a hundred different countries. For 25 years, East Asia and West Asia have each provided about one-fourth of the foreign recipients, but in the last four years and particularly in 1985, there has been an increasing proportion from East Asia.[4] Among those non-U.S. citizens who reported their country of citizenship in 1985, 32 percent were from East Asia and 24 percent from West Asia. The recent increases from East Asia have been provided primarily by China (including Taiwan) and Korea, with increases of 76 percent and 145 percent, respectively, since 1981. Doctorate recipients from Iran reached a peak of 280 in 1984 and declined by 20 percent in 1985 (table 2).

Table 2. Leading countries of origin of foreign citizens receiving science/engineering (S/E) doctorates: 1985

Country of citizenship	S/E doctorates
Total	4,847
China (including Taiwan)*	792
India	453
Korea	316
Iran	225
Canada	147
Nigeria	105
Egypt	100
Mexico	100
England	99
Japan, Okinawa, Rykus	95
Thailand	93
Other countries	1,803
Country not reported	519

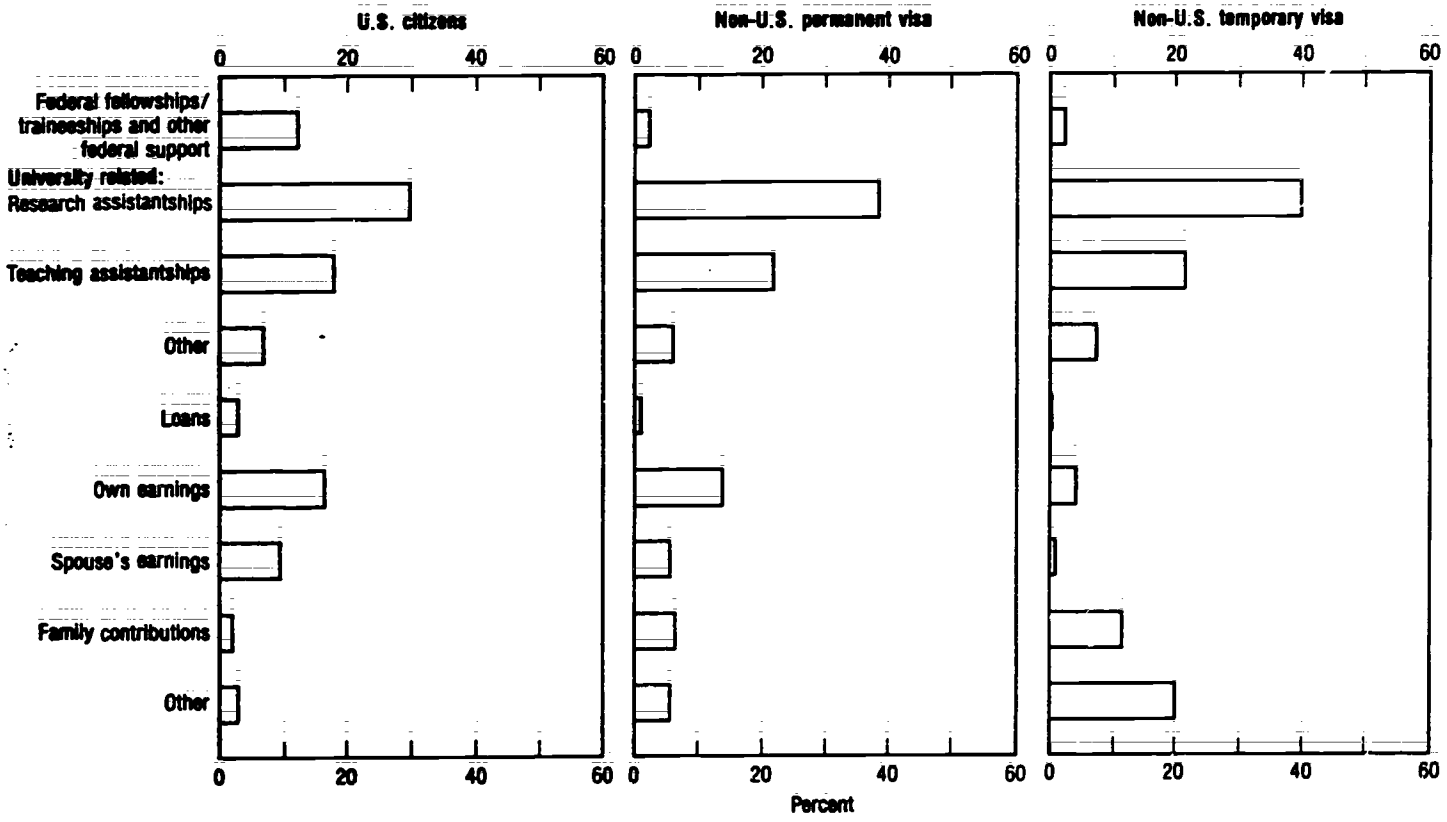
*Based on permanent address and educational history, it is believed that most of the "Chinese" respondents are from Taiwan.

SOURCE: National Science Foundation

[3] National Science Foundation, *Academic Science/Engineering: Graduate Enrollment and Support, Fall 1984* (Detailed Statistical Tables) (Washington, D.C., 1986).

[4] The countries providing most recipients from East Asia were China (including Taiwan), Korea, Thailand, Japan, and Hong Kong. The principal countries from West Asia were India, Iran, Israel, and Turkey.

Chart 3. Primary source of support in graduate school of science/engineering doctorate recipients, by citizenship: 1985[1]



[1]Excludes doctorate recipients who did not report primary source of support.
SOURCE: National Science Foundation

Postdoctoral location. Foreign citizens do not necessarily leave the United States upon receipt of a doctorate from a U.S. institution. Temporary visas may be renewed under certain conditions. Of those S/E recipients in 1985 reporting definite commitments (a signed contract or similar arrangement) and expected location at the time of graduation,[5] 97 percent of the U.S. citizens, 92 percent of the non-U.S. citizens on permanent visas, and 54 percent of those on temporary visas expected to locate in the United States.[6] For the latter group, equal numbers had commitments for postdoctoral study as for employment, about 600 each. Recipients of doctorates in engineering reported higher rates of definite commitments and expected locations in the United States than did the science doctorates. The rates in engineering were 96 percent for U.S. citizens, 96 percent for non-U.S. citizens on permanent visas, and 63 percent for those with temporary visas.

Participation of Women

The increasing participation of women, both U.S. and non-U.S. citizens, continues to be one of the most significant developments in higher education over the last 20 years. The proportion of women earning master's degrees (S/E and non-S/E combined) exceeded one-half of all master's degrees awarded in the United States for the first time in 1981, and they exceeded one-half of all bachelor's degrees in 1982.[7] The proportion earning S/E doctorates reached 25 percent in 1985 (chart 4).

Women earned 4,650 S/E doctorates in 1985, only 2 percent more than the previous year, but 40 percent more than in 1978. During the last seven years women increased their annual number of S/E degrees by over 1,300, while the number earned by men decreased by 135. Consequently, women increased their representation among S/E doctorate recipients, though not as rapidly as in the seventies and early eighties.

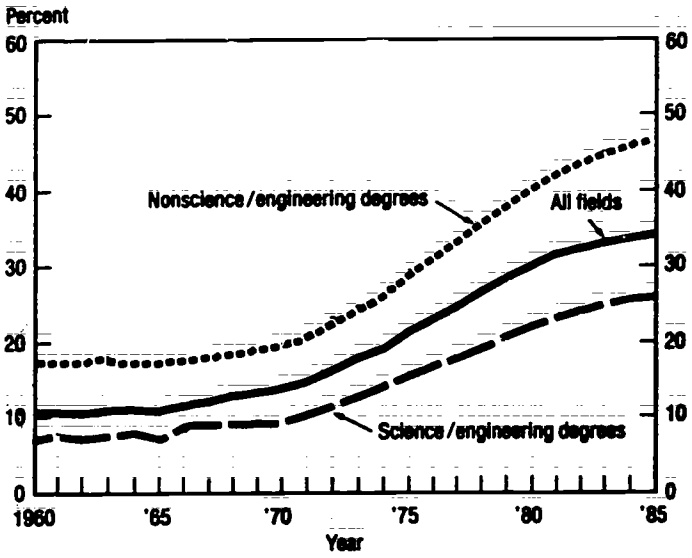
The representation of women among doctorate recipients is greater for U.S. than for non-U.S. citizens. Among U.S. citizens, 30 percent of the S/E doctorates in 1985 were earned by women; the comparable figures for non-U.S. citizens with permanent visas were 20 percent, and only 13 percent for those with temporary visas.

[5]Sixty-seven percent reported definite commitments in 1985.

[6]Among all foreign S/E doctorate recipients, 41 percent expected to be located in the United States and 31 percent outside the United States; 29 percent did not report a location.

[7]Department of Education, National Center for Education Statistics, *Survey of Degrees and Other Formal Awards Conferred*, annual surveys (Washington, D.C.)

Chart 4. Shares of doctorates earned by women



SOURCE: National Science Foundation

Field distribution. Traditionally, women have earned more doctorates in non-S/E fields than in S/E fields. For men, just the opposite is true. In 1985, 66 percent of the doctorates earned by men were in S/E fields, compared with only 43 percent for women. Nonetheless, women have increased their representation in S/E fields; their 198 engineering degrees accounted for more than 6 percent of the total doctorates in that field. Inasmuch as the full-time enrollment of women in undergraduate engineering increased from 34,000 in 1978 to 62,700 in 1984, an 84-percent increase, both the number and share of engineering doctorates awarded to women can be expected to increase.[8]

Women earned 29 percent of all science doctorates in 1985. They earned 23 percent of the degrees in natural sciences and 41 percent in social and behavioral sciences. The greatest proportions of women among doctorate recipients in 1985, as in the last 10 years, were in psychology (49 percent of the doctorates), social sciences (32 percent), and life sciences (29 percent). The lowest participation rate for women was in computer sciences (11 percent).

The field distributions differed for U.S. and foreign women. More than 53 percent of U.S. women chose social and behavioral science fields, compared to less than 30 percent of foreign women; this difference resulted primarily from differences in doctorates in psychology, chosen by 37 percent of U.S. women but by only 8 percent of non-U.S. women. Biological sciences attracted nearly equal proportions of the U.S. and foreign women earning S/E doctorates (27 percent), while engineering doctorates were more likely among foreign women (11 percent) than U.S. women (3 percent).

[8] Engineering Manpower Commission. *Engineering and Technology Enrollment, Fall 1984* (New York: American Association of Engineering Societies).

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