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ABSTRACT

In 1973, 1975, and 1977 surveys of the doctorate-holding scientists and engineers in the United States were conducted by the National Research Council of the National Academy of Sciences. The science and engineering (S/E) population surveyed consisted of individuals who held S/E doctorates or who had received doctorates in non-S/E fields but were employed in S/E positions. The 1973 survey took account of individuals who had received their doctorates between January 1, 1930 and June 30, 1972, inclusive. Subsequent surveys in this series continued to take account of the 42-year period by dropping the two oldest cohort years while adding the two most recent. Results of the latest survey indicate the following for the years 1973-1977: (1) There has been a shift in the work activities of the S/E doctoral work force, especially in the areas of teaching and research and development (R&D); (2) The educational level of the total R&D work force has improved as indicated by an increase in the proportion of Ph.D.'s; (3) The unemployment rate of S/E Ph.D.'s has remained low and stable; and (4) Significant gains have been made by women and racial minorities in joining the ranks of doctoral S/E's. (Author/MA)

nsf SCIENCE RESOURCES STUDIES HIGHLIGHTS

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Work Activities of Doctoral Scientists and Engineers Show Substantial Change Between 1973 and 1977

In 1973, 1975, and 1977 surveys of the doctorate-holding scientists and engineers[1] in the United States were conducted for the National Science Foundation and other Federal Government agencies by the National Research Council of the National Academy of Sciences. The science and engineering (S/E) population surveyed consisted of individuals in the United States who held S/E doctorates or who had received doctorates in non-S/E fields but were employed in S/E positions. The 1973 survey took account of individuals who had received their doctorates between January 1, 1930 and June 30, 1972, inclusive—a 42-year period. Subsequent surveys in this biennial series continued to take account of a 42-year period by dropping the two oldest cohort years while adding the two most recent.

Surveys were based on stratified samples numbering between 55,000 and 65,000 (about 22 percent of the population); response rates of the S/E sample members contacted in the three surveys were 79 percent, 76 percent, and 69 percent, respectively.

This report contains the first analytical results from the third in this biennial series of surveys; the 1973 data[2] are presented for comparative purposes. Detailed statistical results of the 1973 and 1975 surveys may be found in reports previously published.[3]

Assessment Highlights

- A shift in the work activities of the S/E Ph.D. work force has occurred between 1973 and 1977. In academia there has been a relative decline in teaching activities while both R&D and "Other" activities have shown proportional increases, the former primarily because of increases in postdoctorates. During this period, the total employment of S/E Ph.D.'s in academia grew by 26 percent while the number primarily engaged in teaching increased only 13 percent. As a result, the proportion of S/E Ph.D.'s in academia engaged in teaching was 55 percent in 1977, down from 61 percent in 1973. In other sectors of the economy there has been a relative shift away from R&D activities. In business and industry, for example, the proportion of S/E Ph.D.'s engaged primarily in R&D declined from 71 percent to 66 percent. Similar relative shifts in work activities have occurred among other nonacademic employers. These shifts have had a compensatory effect. As a result, the overall proportion of S/E Ph.D.'s primarily engaged in R&D has remained stable at about 44 percent between 1973 and 1977.
- The educational level of the total R&D work force has improved during this 4-year period as indicated by an increase in the proportion of Ph.D.'s from 19 percent to 22 percent. This "upgrading" has occurred in all major employment sectors with the greatest relative increase taking place in the academic R&D work force where the proportion of Ph.D.'s increased from 47 percent to 55 percent, with about one-third of the increase resulting from growth of the postdoctoral population.
- Between 1973 and 1977 there was a decline in the proportion of employed S/E Ph.D.'s receiving Federal support. In 1973 about 47 percent acknowledged such support; by 1977 this proportion had declined to 42 percent. Factors contributing to this decrease have been a stable level of Federal R&D expenditures (in constant dollars) accompanied by a 27-percent increase in the number of Ph.D.'s primarily engaged in R&D.

[1] The 1977 survey was expanded to include doctorate-holding engineers in the United States.

[2] The 1973 data presented in this report differ somewhat from estimates previously published for that year. These revised estimates are based principally on data reconciliation of the U.S. doctoral S/E population in 1973 which resulted in the contacting of some foreign citizens who had left this country following receipt of a Ph.D. from a U.S. institution and a certain coding refinement which permitted resolution of ambiguous or null responses to selected questionnaire items.

[3] National Science Foundation. *Detailed Statistical Tables, Characteristics of Doctoral Scientists and Engineers in the United States: 1973*. NSF 75-312. Washington, D.C. 20550, 1975; *Characteristics of Doctoral Scientists and Engineers in the United States: 1975*. NSF 76-312, 1976; *Characteristics of Doctoral Scientists and Engineers in the United States: 1977*. NSF 77-306, 1977. Washington, D.C. 20402. Supt. of Documents, U.S. Government Printing Office; and National Academy of Sciences-National Research Council. *Profile of Engineers in the United States: 1975 Profile*. Washington, D.C. 1976; *Profile of Doctoral Scientists and Engineers in the United States: 1975 Profile and Science, Engineering, and Humanities Data Tapes*. Washington, D.C. 1976; and *Profile of Engineering Graduates in the United States: 1977 Profile*. Washington, D.C. 1978.

Prepared in the Demographic Studies Group, Division of Science Resources Studies

- The unemployment rate of S/E Ph.D.'s has remained low and stable during this period (about 1.2 percent). However, unemployment rates reflect only one aspect of employment and do not address problems or issues related to underutilization. Moreover, low unemployment rates among Ph.D.'s are to be expected since unemployment, generally, is inversely related to educational attainment.
- Significant gains have been made by women and racial minorities in joining the ranks of the most highly educated S/E's. Between 1973 and 1977 the number of women in this group increased by nearly 50 percent, about twice the rate of growth for men. In 1977 women were still underrepresented and accounted for 10 percent of the S/E Ph.D. population, up from 9 percent four years previously. Racial minorities also registered gains during this period accounting for 6 percent of the S/E Ph.D.'s in 1977, up from 5 percent in 1973. While all racial minority groups showed numerical increases, the overall relative increase is almost entirely attributable to Ph.D.'s of Asian extraction. Racial minorities, however, are still underrepresented among S/E Ph.D.'s since they comprise about 13 percent of the Nation's population.

Data Highlights

- In 1977 the population of S/E Ph.D.'s numbered about 303,000—a 27-percent increase since 1973. During this period the number of Ph.D.'s in the labor force increased at a slightly faster rate (29 percent). In 1977 they numbered about 288,000, resulting in a labor force participation rate of about 95 percent.
- The proportion of Ph.D.'s in S/E-related jobs declined slightly during this period, from about 94 percent to 92 percent. However, the vast majority of those engaged in non-S/E work are doing so voluntarily.

Introduction

The professional work activities of scientists and engineers provide a measure of the utilization of this segment of the Nation's human resources. Of particular interest are the work activities of S/E doctorate-holders who, because of their advanced level of training, provide much of the leadership in scientific and technological endeavors. There is considerable concern about the activities of these individuals, particularly in light of forecasts which for a variety of reasons project an oversupply of Ph.D.'s in most fields in the near and midterm future. Thus, it is anticipated that the employment characteristics of Ph.D. scientists and engineers are likely to undergo significant change including, probably, a relative shift from R&D activities to less traditional activities and a trend toward relatively more nonacademic employment.

An examination of recent trends (1973 to 1977) in employment characteristics is pertinent in determining whether such shifts are starting to take place. Even significant shifts would likely be modest, however, since large numerical values would be necessary to influence proportional distributions in a major way. Because of the stability of Ph.D. employment, generally, proportional shifts which have occurred during this time period are probably most directly attributable to the large influx of young Ph.D.'s in the S/E labor force. Thus, changes in characteristics yielded by the following analysis are probably more indicative of the initial employment choices of new Ph.D.'s than of mobility patterns of their older peers.

Population and Labor Force

The population of doctoral scientists and engineers in the United States numbered about 303,000 in 1977, a 27-percent increase since 1973. During this 4-year period the number of Ph.D.'s in the labor force grew somewhat faster. As a result the labor force participation rate of Ph.D.'s increased slightly in 1977 to 95 percent, signifying a small inactive pool of talent at this educational level (table 1).

The success of these individuals in the labor market remains very high. This is to be expected since success in employment is highly related to educational attainment. In 1977 the unemployment rate of S/E Ph.D.'s was 1.2 percent, essentially the same level reported in 1973. This unemployment rate was lower than the 1977 unemployment rates for individuals with five or more years of college (2.3 percent) and for professional, technical, and kindred workers (3.0 percent).

Table 1. Characteristics of doctoral scientists and engineers in the U.S.: 1973 and 1977

Characteristics	1973		1977	
	Number	Percent	Number	Percent
Total	248,900	100.0	303,400	100.0
Sex				
Men	218,000	91.3	271,600	89.5
Women	20,900	8.7	31,800	10.5
Race				
White	236,900	90.3	270,300	87.1
Black	2,200	*	2,900	*
American Indian	300	*	600	*
Asian	9,400	3.9	15,700	5.2
Not reported	10,000	4.2	13,900	4.5
Employment Status				
Labor force	222,900	93.4	287,400	94.8
Full- and part-time employed	214,700	89.9	274,500	90.4
Part-time workers	5,700	2.4	9,000	3.2
Unemployed, seeking	2,500	1.0	3,900	1.1
Outside the labor force	16,000	6.7	15,700	5.2

The percent is for an unemployment rate since it is based on the total population rather than the labor force.

*Less than 0.05 percent.

NOTE: Detail may not add to totals because of rounding. Boldface entries indicate noteworthy changes between 1973 and 1977.

SOURCE: National Science Foundation.

Table 2. Characteristics of employed doctoral scientists and engineers in the U.S.: 1973 and 1977

Characteristics	1973 Number	1973 Percent	1977 Number	1977 Percent
Total employed	220,400	100.0	284,200	100.0
Type of Employment				
Science/engineering	208,400	94.5	261,300	91.9
Nonscience/engineering	12,300	5.5	22,900	8.1
Sector of Employment				
Business and ind'l	53,400	24.2	71,500	25.2
Educational institutions	129,400	58.7	160,300	57.4
Hospitals/clinics	4,500	2.0	8,600	3.0
Nonprofit organizations	8,000	3.6	10,200	3.6
Federal Government	18,200	8.3	21,400	7.5
Other	6,600	3.0	8,200	2.9
Not reported	800	.3	1,400	.5
Primary Work Activity				
Research and development	97,700	44.3	123,200	43.3
Basic research	34,600	15.7	44,500	15.7
Applied research	28,700	13.0	36,400	12.8
Development	8,500	3.9	13,700	4.8
Management of R&D	26,200	11.9	28,700	10.1
Teaching	80,000	36.3	90,400	31.8
Other work activity	39,000	17.7	63,600	22.4
Not reported	3,500	1.6	7,000	2.5
Federal Support Status				
Federally supported	103,300	46.9	120,000	42.1
Not federally supported	108,100	49.1	154,700	54.4
Status unknown				
or not reported	9,000	4.0	11,000	3.9

Between 1973 and 1977 the number of employed Ph.D.'s rose from about 220,000 to 284,000—a 29-percent increase. Over this period, the number of S/E postdoctorates, which accounted for about 3 percent of the S/E doctoral labor force in 1977, increased by 72 percent.

The overall proportion of employed Ph.D.'s engaged in S/E work declined during this 4-year period from 94 percent to 92 percent (table 2). However, available data indicate that only a small proportion (about 10 percent) of those working in non-S/E positions were unable to find S/E work. Higher salaries, better promotional opportunities, and locational preferences were cited as the major factors influencing the decision to work in non-S/E jobs.

Women and Racial Minorities

The proportion of women and racial minorities in the doctoral S/E population has increased over the 1973-77 period. In 1977 there were about 32,000 women S/E doctorates in the United States representing a 50-percent increase since 1973, approximately double the increase for men. As a result, the proportion of women increased from 9 percent to 10 percent of the Ph.D.'s in science and engineering (table 1). The more rapid increase in the number of women probably reflects affirmative action programs and women's increasing awareness of opportunities in science and engineering. However, it must be realized that even assuming a continuation in this trend, it will take over 40 years for women to achieve parity based upon population proportions because of their relatively small current representation.

The proportion of racial minorities in the Ph.D. population also increased during this period. Collectively, these individuals comprised 5 percent of the doctoral S/E population in 1973; by 1977 this proportion had grown to 6 percent. During this 4-year period, the number of racial minority S/E Ph.D.'s grew by about 7,000—a 60-percent increase. Persons of Asian extraction who comprise about four-fifths of the racial minorities in the United States holding S/E Ph.D.'s accounted for most of this growth.

The number of Blacks holding S/E Ph.D.'s increased by 30 percent over the 1973-77 period, approximately the same relative increase experienced by the total S/E doctoral labor force. In 1977 Blacks, who represent about 12 percent of U.S. population, accounted for only about 1 percent of the S/E doctorate-holders. These data suggest that the education of Black scientists and engineers at the doctorate level needs to be significantly increased if they are to continue their progress towards parity.

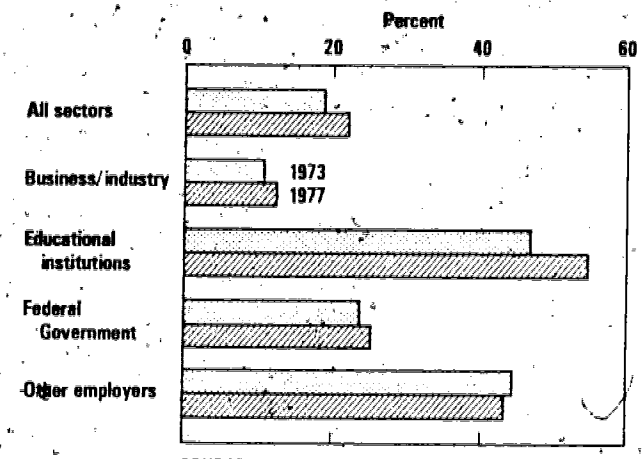
Work Activities by Sector of Employment

The work patterns of doctoral scientists and engineers are undergoing change, but the patterns differ substantially among employment sectors. In educational institutions there has been a relative decline in teaching activities with corresponding gains in other activities, including research and development. In other employment sectors, however, there has been a relative shift from R&D to non-R&D work activities. These shifts have had a compensatory effect. As a result the overall proportion of S/E doctorate-holders primarily engaged in R&D activities has remained stable (about 44 percent) between 1973 and 1977.

Some changes in R&D work patterns by character of work have occurred during this period. While absolute increases are noted in all aspects of R&D work, the number of Ph.D.'s in development activities increased by about 60 percent as compared with a combined 24-percent increase in other R&D activities. The higher rate of growth in development activities reflects an increase in the Ph.D. intensity in this aspect of research and development. As might be expected more than 60 percent of the growth in the number of Ph.D.'s in development took place in business and industry where

Although the rates are statistically correct, it should be noted that R&D expenditures in constant dollars actually declined from 1973 through 1975 and then increased for the next two years. National Science Foundation, *National Patterns of R&D Resources: Funds & Manpower in the United States 1953-1978 & 1979* (in preparation).

Chart 1. Proportion of science/engineering Ph.D.'s in the R&D work force by selected employment sector: 1973 and 1977



SOURCE: National Science Foundation

the bulk of those activities are conducted. The smallest increase (17 percent) took place among Ph.D.'s engaged in R&D management, resulting in a relative decline in this activity (table 2).

The overall relative stability of R&D activities in the growing work force of doctoral scientists and engineers assumes added significance when other R&D measures during this 4-year time frame are taken into account. While the number of S/E doctorate-holders primarily engaged in some aspect of R&D work has increased at an annual rate of about 6 percent, R&D expenditures (in constant dollars) have increased at a much slower rate (about 1 percent per year).[4] The sharp increase in the supply of Ph.D.'s is also evident when considered within the context of the total R&D work force. Thus, during this period, the proportion of Ph.D.'s in the total R&D work force increased from 19 percent to 22 percent, suggesting that employers are upgrading the educational level of their R&D staff (chart 1).

EDUCATIONAL INSTITUTIONS

Educational institutions have traditionally provided the principal source of employment for S/E Ph.D.'s. Between 1973 and 1977, the number of Ph.D.'s so employed increased by about 26 percent; this absolute increase in employment was slightly less than the growth of the total employed Ph.D. labor force, possibly indicating the initiation of the expected shift toward nonacademic employment.

In educational institutions the proportion of S/E Ph.D.'s engaged primarily in teaching activities declined from about 61 percent to about 55 percent between 1973 and 1977. The proportion of Ph.D.'s engaged primarily in R&D activities increased from about 27 percent to about 30 percent while the proportion of individuals engaged in activities other than research and development or teaching increased from about 10 percent to 14 percent. Significant changes included relative increases in applied research and in development activities (chart 2). To some extent, the relative decline in teaching and the relative increase in R&D activities reflects the increasing number of Ph.D.'s holding postdoctoral appointments. Approximately 30 percent of the increase in the number of academically employed Ph.D.'s primarily in research and development was accounted for by increases in the number of postdoctorates.

The growth in the Ph.D. intensity of the R&D work force was quite evident in academia; between 1973 and 1977, the proportion of Ph.D.'s in the academic R&D work force increased from 47 percent to 55 percent (chart 1). Again, the gain in the number of postdoctorates accounts for about 30 percent of this increase.

BUSINESS AND INDUSTRY

A small relative increase in the employment of Ph.D.'s was registered by business and industry between 1973 and 1977; industrial employment increased from about 24 percent to 25 percent of the employed Ph.D. total (table 2). This increase, although modest, is consistent with forecasts of greater employment in business and industry during the near and midterm future, and most likely reflects reduced employment opportunities in academia.

The R&D activities of Ph.D.'s in business and industry have shown a relative decline. Between 1973 and 1977, the proportion of Ph.D.'s primarily engaged in research and development decreased slightly from about 71 percent to 66 percent, and this decline was most evident in the management of R&D activities. The decline in R&D activities was offset by relative increases in non-R&D activities (chart 2).

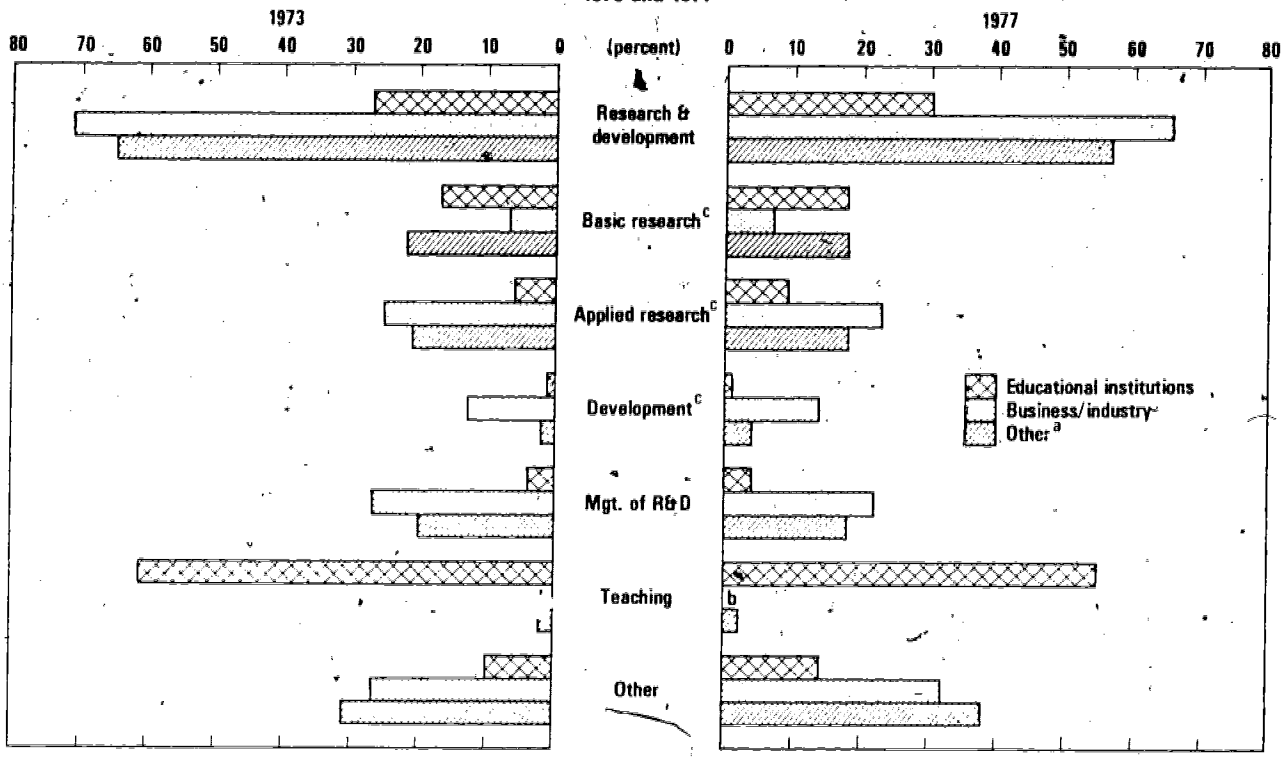
The relative decline in R&D work among industrially employed Ph.D.'s must be interpreted within the context of a rapidly growing Ph.D work force. Thus, the relative shifts reported above do not signify a reduction in research and development, but rather that non-R&D activities have increased at a faster rate during the 4-year period ending in 1977. Nevertheless, the growth in the number of R&D Ph.D.'s in industry during this time has exceeded the growth in the total industrial R&D work force. As a result the proportion of Ph.D.'s in the industrial R&D work force has increased from 11 percent to 12 percent (chart 1).

OTHER EMPLOYMENT SECTORS

In 1977 about 17 percent of the S/E Ph.D.'s were employed by organizations other than educational institutions and business/industry, about the same proportion as in 1973. There were, however, some relative shifts in the employment of S/E Ph.D.'s among this group of employers. During this period, Federal

[4] As measured in terms of full-time-equivalent numbers.

Chart 2. Doctoral scientists/engineers by primary work activity in selected employment sectors: 1973 and 1977



[a]Includes employed individuals who gave no report of affiliation.
[b]Less than 0.5 percent.
[c]Subsumed under "Research & development".
SOURCE: National Science Foundation

civilian employment showed a relative decline, while the proportion of Ph.D.'s employed by hospitals/clinics increased (table 2).

A relative shift to non-R&D activities also occurred within these employment sectors. Between 1973 and 1977, the proportion of Ph.D.'s engaged in R&D activities declined in the Federal Government, hospitals/clinics, nonprofit organizations, and among "other" (unspecified) employers. Collectively, about 57 percent of the S/E Ph.D.'s employed in these sectors were primarily engaged in research and development in 1977, down from about 65 percent four years earlier. This relative decline encompassed all aspects of research and development except development activities, which showed a relative gain. Relative gains were also evident in the proportion of Ph.D.'s engaged in non-R&D teaching activities. Collectively, these activities were reported to be the primary work of 32 percent of S/E Ph.D.'s in 1973; the 1977 proportion increased to 38 percent (chart 2).

Federal Support

The proportion of S/E Ph.D.'s acknowledging Federal support in their work has declined in the last four years. In 1973, 47 percent of all employed S/E Ph.D.'s reported Federal support; by 1977, this proportion had decreased to 42 percent (table 2). This relative decline is not unexpected considering that the number of Ph.D.'s primarily engaged in research and development grew by 27 percent during this period, while Federal expenditures for research and development (in constant dollars)[9] remained essentially level.

[9] National Science Foundation, *National Patterns of R&D Resources: Funds & Manpower in the United States, 1953-1978 & 1979*, op. cit.