Women Scientists and Engineers: Trends in Participation

Betty M. Vetter

Summary. Women have made tremendous strides in educational attainment in science and engineering over the past decade, increasing their proportion of doctorate awards in these fields from 7 percent in 1965 to 23 percent in 1980. But they still have higher unemployment rates and lower salaries than men in all fields of science and engineering, at all degree levels, and at all levels of experience; and the disparities between men and women widen with higher degree levels and with years of experience. Graduate enrollments indicate continuing increases over at least the next several years in degree awards to women, but their access to equal employment and advancement opportunities is not yet assured.

The best way to measure trends in the participation of women in science would be to compare statistics on the entire scientific and engineering community collected in the same way at regular intervals over a span of many years, with all significant characteristics delineated by sex. Except for records of academic degrees granted, no such longitudinal data exist. There are, however, some data sets based on samples of particular science or engineering populations which provide information over a shorter time span and can be used to measure progress in the 1970's.

In 1970 a subsample of scientists and engineers, drawn from the Census Bureau's 25 percent sample of the U.S. population, was selected for follow-up at 2-year intervals over the decade. The data from that sample provide, in effect, snapshots taken in 1972, 1974, 1976, and 1978 of the men and women already in the labor force in 1970 (*1*). Only 5.4 percent of this sample are women.

In 1974, the National Science Foundation (NSF) began a series of surveys of "new entrants," generally sampling bachelor's and master's graduates of 2 years earlier. These surveys provide data on employment status, salary, and other characteristics of the graduates in alternate years from 1972 to 1978 (*2*).

A third set of surveys, carried out by the National Research Council (NRC) for the NSF and others, has examined the doctoral population of scientists and engineers in alternate years beginning in 1973 (*3*). These three survey sets are melded by NSF into its Scientific and Technical Personnel characteristic System (STPCS) to provide an estimate of the total science and engineering population and its characteristics. Reports are now available for 1974, 1976, and 1978 (*4*).

Finally, NSF recently published a study of master's degree graduates in science and engineering with some data comparisons between 1960 and 1978 (*5*). These data sets (*1*–*5*) plus data on salary and degrees from other sources enable us to examine trends in the participation of women in science and engineering over the past decade and to attempt to estimate further change during the 1980's.

The author is the executive director of the Scientific Manpower Commission, 1776 Massachusetts Avenue, NW, Washington, D.C. 20036.

Educational Attainment

Our best statistics, in regard to both the length of time covered and the completeness of the sample (effectively 100 percent), are the numbers of earned degrees. Accurate records of bachelor's and master's degrees awarded by U.S. colleges and universities are available, by sex, from 1948 to 1980 (*6*). Doctoral degree data are available from 1920 to 1980 through records maintained by the NRC (*7*).

Between 1970 and 1980, women increased their share of all bachelor's degrees from 43 to 49 percent; of all master's degrees from 40 to 49.5 percent; and of all Ph.D.'s from 13 to 30 percent. In science and engineering, the increases were from 26.1 to 36.9 percent, from 17.5 to 23.7 percent, and from 9.1 to 22.6 percent, respectively (Fig. 1). Increases occurred in all fields but were largest, both numerically and as a proportion of the total, in the life sciences and psychology. The largest percentage increases were in engineering and in the physical sciences, where the proportion of degrees earned by women in 1970 was small.

Between 1965 and 1980 women earned more than 36,500 doctorates in science and engineering, 31,000 between 1970 and 1980. The number awarded annually to men, and the annual total, peaked in 1973 and then declined, while the number awarded to women continued to increase (Table 1). As a result, the proportion of women in the doctoral pool rose from less than 8 percent in 1973 to almost 12 percent in 1981 (Table 1).

More than half (53 percent) of all science and engineering doctorates awarded since 1940 were earned between 1970 and 1980. Men (50.7 percent) as well as women (69.5 percent) in today's work force are somewhat more likely to have earned the doctorate in the past 10 years than in the preceding 30 years.

Current enrollment trends indicate that the number and proportion of science and engineering degrees awarded to women will continue to rise for several years. The proportion of freshman women planning majors in science and engineering continues to increase each year (*8*). The number of undergraduate women enrolled in science and engineering fields is rising steadily, as is the proportion of women continuing into graduate study. Women accounted for 43 percent of graduate enrollments in science or engineering in 1979, up from 24 percent in 1974 and 31 percent in 1977. In doctoral departments, women were 23.6 percent of full-time graduate students in these fields in 1974 and 31.8 percent in 1979. Annual increases in enrollment over these 6 years averaged 0.4 percent for men and 9 percent per year for women (*9*).

These trends strongly suggest that the number and proportion of women will continue to increase despite the impending drop in the 23- to 30-year-old population that will begin in the mid-1980's. However, the only available forecast of degrees to be awarded over the 1980's does not assume a continuing increase either in the number of women earning such degrees or in their proportion of the total. The National Center for Education

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Statistics (NCES) (*10*) projects that the number of women obtaining science and engineering doctorates will drop off after 1980 in the social sciences, engineering, mathematics, and the physical sciences, and after 1981 in the life sciences. Women's proportion of the total was projected by NCES to be 20.5 percent in both 1980 and 1989. Actually, women earned 22.6 percent of these degrees in 1980 and, at present rates of increase, may be expected to earn 35 to 40 percent by 1989. Comparing the 1980 actual totals with the NCES projections made in 1978 for 1980, we find that although the total number of science and engineering doctorates projected for 1980 (18,030) is close to the actual number awarded (18,171), the projection for men was overestimated by 0.9 percent and that for women was underestimated by 7.0 percent. This error will intensify in the 1980's if women continue to increase their participation at the rate now indicated by graduate enrollments and enrollment trends.

In those undergraduate fields (principally engineering and computer science) where a bachelor's degree is the professional entry level, available information indicates a continuing increase in the proportion of women enrolling and graduating (*11*). The number of undergraduate women enrolled full time in engineering grew from 3569 in 1970 to almost 49,000 in 1980, an increase of 1271 percent in 10 years. The increase for men over that decade was 38.6 percent. Women were 13.4 percent of total full-time engineering undergraduates in 1980, up from 1.5 percent in 1970. The 358 women who earned bachelor's degrees in engineering in 1970 were 0.8 percent of the graduating class, and the 6545 women who earned this degree in 1981 were 10.4 percent of the graduates. The 1984 class (from estimates based on freshman enrollments) should be more than 14 percent (10,800) women.

In computer science, women earned 14.5 percent of the baccalaureates in 1971 and 30.3 percent in 1980. With continued high demand for these graduates, the proportion of women should continue to rise, even though a shortage of faculty, facilities, and equipment, both in engineering and in computer science, is expected to impose limitations on undergraduate enrollments in these fields for the next several years.

Table 1. Number of science and engineering doctoral degrees awarded between 1965 and 1980. [Data from (*7*)]

Year	All science and engineering fields	Physical sciences*	Engineering	Mathematical sciences†	Life sciences	Social sciences‡
1965 Total	10,477	2,865	2,073	685	2,539	2,315
Women	744	127	7	50	263	297
1966 Total	11,456	3,058	2,299	769	2,712	2,618
Women	911	132	8	48	326	397
1967 Total	12,982	3,502	2,603	830	2,967	3,080
Women	1,086	161	9	48	401	467
1968 Total	14,411	3,667	2,847	970	3,501	3,426
Women	1,295	185	12	47	483	568
1969 Total	15,949	3,910	3,249	1,064	3,796	3,930
Women	1,472	205	10	56	537	664
1970 Total	17,731	4,400	3,432	1,222	4,163	4,514
Women	1,626	243	15	77	538	753
1971 Total	18,880	4,494	3,495	1,236	4,533	5,122
Women	1,929	244	16	96	656	917
1972 Total	18,940	4,226	3,475	1,281	4,505	5,453
Women	2,101	269	21	96	680	1,035
1973 Total	18,948	4,016	3,338	1,222	4,574	5,798
Women	2,446	257	45	119	795	1,230
1974 Total	18,316	3,696	3,144	1,196	4,407	5,873
Women	2,590	260	34	115	784	1,397
1975 Total	18,352	3,611	2,959	1,149	4,540	6,093
Women	2,838	284	50	110	863	1,531
1976 Total	17,872	3,442	2,791	1,003	4,480	6,156
Women	2,986	296	53	113	870	1,654
1977 Total	17,373	3,410	2,641	959	4,266	6,097
Women	3,103	303	74	128	845	1,753
1978 Total	17,956	3,234	2,423	959	4,887	6,453
Women	3,526	309	53	131	1,082	1,951
1979 Total	18,247	3,321	2,494	977	5,076	6,379
Women	3,854	351	63	145	1,190	2,105
1980 Total	18,171	3,151	2,479	963	5,325	6,253
Women	4,099	386	90	116	1,342	2,165

*Includes environmental sciences. †Includes computer sciences. ‡Includes psychology.

Employment

Once prepared with the necessary education credentials, women have been moving into the science and engineering labor force in record numbers. Available data on the working population are neither as recent nor as complete as those on degree awards, but the data indicate varying levels of progress that are somewhat below the rates of increase in degrees. We can examine labor force participation, unemployment rates, salaries, and in academic institutions such measures as promotions in rank and tenure status.

Because there are many more women in science than in engineering, and because engineers largely enter the labor force only with bachelor's degrees and scientists do not, it is of some interest to examine the degree characteristics of the science and the engineering populations separately. In 1978, according to NSF estimates, women were 18.1 percent of all scientists in the labor force, including 12.2 percent of those with Ph.D.'s, 24.8 percent of those whose highest degree was a master's, and 15.3 percent of those with only a bachelor's degree; among engineers, women were 1.5 percent of the total, 0.6 percent of those with Ph.D.'s, 1.1 percent of those with master's degrees, and 0.2 percent of those with only the bachelor's degree (*4*). Since women earned 35 percent of the science bachelor's degrees awarded from 1960 to 1980 (*6*), their 15 percent proportion in the science population suggests that men without graduate degrees find careers in science more easily than women who are in this category. Although some of the difference is because of differences in field distribution of the sexes, data on recent graduates support this assumption.

The master's degree population, which has been further delineated by the NSF (*5*) was found to include 29 percent women in the science population and less than 3 percent in engineering. Although women with master's degrees make up about half of all women scientists (the figure is 37 percent for men), we know relatively little about the status of women scientists below the doctoral level.

There was a fivefold increase in the number of women with master's degrees in science between 1960 and 1978 and a fourfold increase in the total number of master's graduates. Generally, these increases were most dramatic in fields that had below-average proportions of women in 1960 (for example, earth and agricultural science and engineering).

Labor Force Participation

Because of the recent, rapid increase in the number of science and engineering degrees awarded to women, and because the labor force data lag behind degree information, we must estimate the proportions of women among working scientists and engineers. The doctoral population serves as an example of this process.

Studies of women with doctorates in science and engineering (*12*) have found that at least 90 percent are in the labor force at any time. The NRC found that 90.8 percent of women and 96.2 percent of men with doctorates were in the labor force in 1979, making women 10.8 percent of the Ph.D. labor force in science and engineering (*3*).

Since the 1979 survey an additional 7953 women and 26,465 men have been awarded Ph.D.'s in science and engineering. About 18 percent of these Ph.D.'s were awarded to foreign nationals on temporary visas (predominantly men). For this rough estimate, we will assume that all new science and engineering doctorates from these classes entered the Ph.D. pool and that the number of holders of Ph.D.'s who retired or died approximately equaled the number of foreign graduates who returned home. Thus, the Ph.D. pool in 1981 included 320,845 men and 45,853 women. If 96.2 percent of men and 90.8 percent of women in this pool (41,635 women) are in the labor force, then women make up 11.9 percent of the 1981 Ph.D. labor force of doctoral scientists and engineers. We can also estimate that women are 13.8 percent of Ph.D. scientists and 1.2 percent of Ph.D. engineers in the 1981 labor force. Similar calculations, based on the 1978 population as estimated by the STPCS and adjusted for graduates with lower degrees continuing full-time graduate study, indicate that women are about 18.5 percent of the total science labor force and less than 2 percent of the engineers. How have these women fared?

Employment Status

In each of the four surveys of the Ph.D. population since 1973, the NRC (*3*) found employment rates of women to be two to five times as high as those of men, with some variation by field (Fig. 2). An exception is the computer science field, where no cases of unemployment have been reported by either sex since the field was first surveyed separately in 1977. Although the marketplace for graduates in different fields varies somewhat, unemployment rates for men vary less than a percentage point by field, but those for women are higher in physics and chemistry than they are in mathematics or psychology (Fig. 2). Generally, the higher the unemployment rate for men, the wider the gap in unemployment rates between men and women, suggesting that women are more likely to have difficulty finding jobs in a tight job market than are men.

Some of the differences in unemployment rates between men and women have been attributed to the higher proportion of more recent graduates among

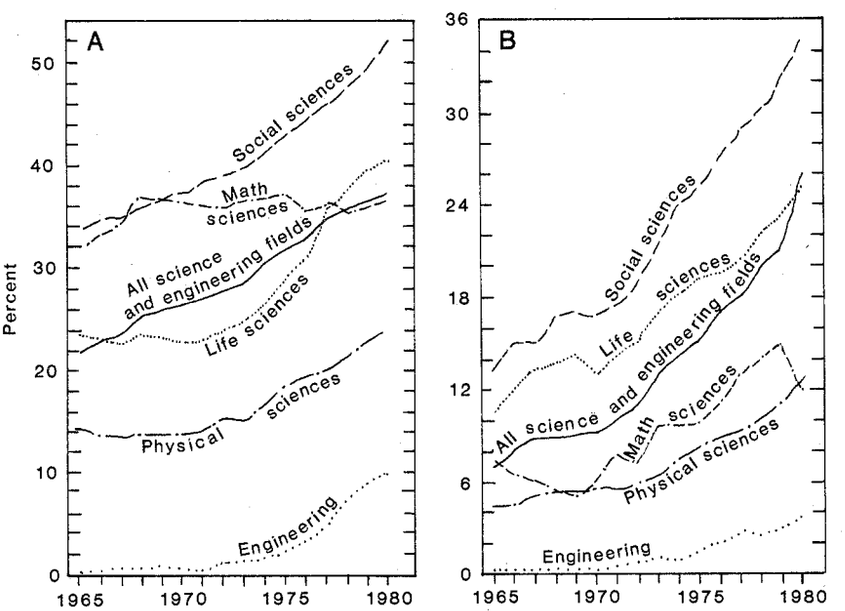

Fig. 1. Percentage of (A) bachelor's and (B) Ph.D. degrees earned by women from 1965 to 1980. Social sciences include psychology, math sciences include computer sciences, and physical sciences include environmental sciences. [Data from (*6*)]

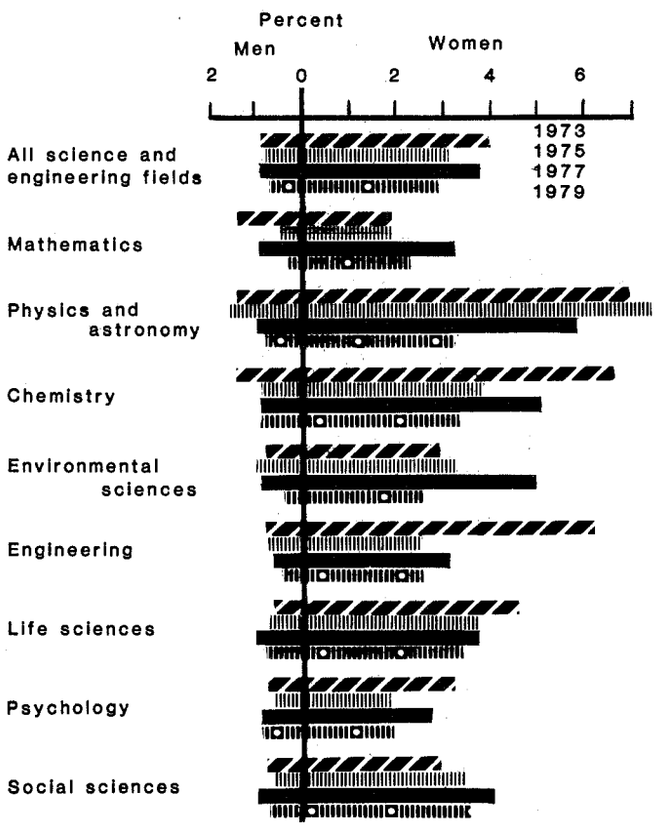

Fig. 2. Unemployment rates of men and women Ph.D. scientists and engineers in four survey years. [Data from (*3*)]

women than among men. However, a study of matched pairs of men and women Ph.D.'s who earned degrees in the 1940's and each succeeding decade found that the unemployment rate rises and the gap between men and women widens among the more recent Ph.D.'s, but the unemployment rate of women is consistently three to four times as high as that of men at the same experience level (*12*). The greater concentration of women in the biological, social, and behavioral sciences does not account for the difference, which occurs in all fields. There is no evidence that single women have lower unemployment rates than married women. None of the explanations tell us why, in the most recent survey year (1979), when women were 10.8 percent of the science and engineering doctoral labor force, they were 32 percent of all doctoral scientists and engineers who were unemployed and seeking jobs (*3*).

According to STPCS figures, unemployment rates among all women scientists and engineers also are higher than those of men: 4.1 and 1.6 percent, respectively, in 1974; 7.4 and 2.8 percent, respectively, in 1976; and 2.1 and 1.2 percent in 1978. Perhaps more illuminating, however, are the unemployment rates of recent graduates with bachelor's and master's degrees. Beginning in 1974, NSF (*2*) sponsored sample surveys of the employment characteristics of graduates of 2 years earlier (Fig. 3). Although unemployment rates of doctoral scientists and engineers are lower than those of recent graduates at the bachelor's and master's levels, the gap in rates between men and women generally is less at the lower degree levels.

Unemployment among recent graduates was highest in 1976, when the 1974 graduates were surveyed, but for every class and in most fields the unemployment rates of women exceeded those of men. Men were also considerably more likely to find jobs in science or engineering than were women. For example, at the master's level, 85 percent of the employed male graduates but only 67 percent of the female graduates of 1978 and 1979 were employed in science or engineering in 1980. Some, but not all, of this difference can be explained by field of degree, since men were more likely to major in engineering, and women in the social and behavioral sciences. In general, women with science degrees are more likely to be unemployed, and less likely to find employment in their field than comparable men. This is the case for recent as well as more experienced graduates, for women at all degree levels and whatever their field.

Postdoctoral appointments. A recent study by the NRC (*13*) found that over the past decade, women were somewhat more likely than men to take these appointments within a year after receiving the Ph.D. The number of women taking postdoctoral appointments rose nearly 80 percent between 1972 and 1978, but the number of men doing so dropped by 15 percent. In the social sciences, for example, women earning Ph.D.'s in 1978 were more than three times as likely as the men with whom they graduated to hold a postdoctoral appointment. Both married men and married women were less likely than those who were single to have taken such appointments, but the difference is wider between married and single women than it is between married and single men.

Women from the 1972 Ph.D. cohort who took a postdoctoral appointment held it longer than did the men from that class and were more likely to have prolonged the postdoctorate "because of difficulty in finding alternative employment positions," the NRC study found (*13*, p. 149). This holding pattern was most apparent in the physical and life sciences.

Although as many as two-thirds of the women graduates of 1972 who had taken postdoctoral appointments were employed in the academic sector in 1979, only one in seven had received tenure; one-third of their male cohorts had tenure. More than 22 percent of the women and 14 percent of the men held positions outside the faculty track. Although women with postdoctorate experience have been more likely than men to take employment in educational institutions, "men have been far more successful than women in pursuing faculty careers," the report states (*13*, p. 153).

Again, the typical explanations do not apply. Perhaps the women were delayed in obtaining tenure because they took time out to begin a family. But 12 percent of the married women and only 7 percent of the single women from the 1972 Ph.D. cohort who had postdoctorate experience held tenured faculty positions in 1979. Differences by field are not the reason, since the differences pervade all fields. Among 328 female life scientists from this 1972 Ph.D. cohort, for example, 70 percent were in academic employment in 1979; 8 percent were tenured faculty, 45 percent were nonten-

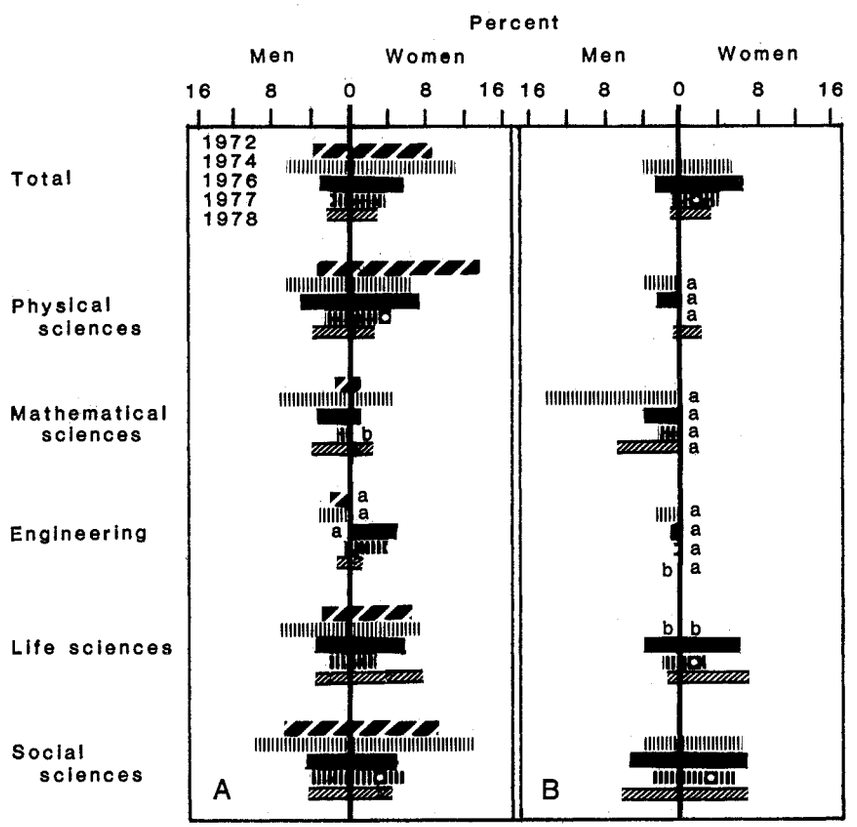

Fig. 3. Unemployment rates of men and women science and engineering graduates with (A) bachelor's and (B) master's degrees, 2 years after graduation in five survey years; *a*, no rate computed (< 1500 in the labor force); *b*, rate < 0.5 percent. [Data from (*2*)]

ured faculty, and 17 percent were nonfaculty staff. Among the 1368 men in the cohort, 62 percent were in academic employment, 14 percent had tenure, 40 percent were nontenured faculty, and only 9 percent were nonfaculty staff.

Employment Sector

Women scientists, particularly at the doctoral level, are more likely to be employed in academic institutions than men and less likely to be employed in industry or in government (*3*, *4*) (Table 2). Much of this difference may be attributable to the preponderance of engineers in industrial employment. However, the proportion of women from almost every field is higher in educational institutions and lower in industry and government.

Regardless of employment sector, women still fare less well than men in terms of status or rank, salary, and promotion, although some lessening of all these differences can be seen among younger scientists and engineers (*3*, *12*, *13*). According to NSF figures, women were 17.4 percent of all scientists and engineers employed at colleges and universities in 1980, but their proportions of faculty positions, tenured positions, and tenure-track positions were much lower. This is due in part to the fact that more of the women than of the men received their Ph.D.'s since 1970.

Among those who earned their doctorates from 1970 to 1974, however, a higher proportion of men than women in all fields had attained the ranks of professor and associate professor in 1979, and proportionately more women than men were in the lower ranks (Table 3) (*3*). It is too soon to tell whether an equalizing of opportunity is occurring among later cohorts, but even if it does, the probability that women will substantially increase their proportion of tenured positions and top academic positions in this decade is not bright. In 1979, 62.5 percent of men with Ph.D.'s but only 35.2 percent of women held tenure, and 15.2 percent of men and 24.9 percent of women Ph.D's were on the tenure track. One-eighth of men and one-fourth of women were not in tenure-track positions (*3*).

A closer examination of one field, chemistry, illustrates some of the difficulties typically confronted by women. Since 1940, 3740 women have earned Ph.D.'s in chemistry (*7*) (7.5 percent of the total awarded) as well as 9500 master's degrees and 58,000 bachelor's degrees since 1948 (*6*). They are as likely as men to have graduated from top-rated departments and are more likely to be academically employed. Indeed, in 1980, 1748 women chemists with Ph.D.'s were 9 percent of all academic employment in chemistry (*3*).

In the more than 180 doctorate-granting chemistry departments, however, there were 60 women faculty at the assistant professor or higher ranks in 1970, or only 1.5 percent of such full-time faculty. In 1980, there were 132 women in such positions, or 3.1 percent of this faculty. Half of these chemistry departments employ no women faculty and only 14 percent employ two or more above the rank of instructor (*14*).

Table 2. Employment sector (percent) of doctoral scientists and engineers by sex, 1979. [Data from (*3*)]

Field	Number employed		Percent employed							
			Business and industry		Educational institutions		Government		Hospitals and clinics	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Physical sciences	56,726	3,109	42.7	25.9	44.8	58.8	8.5	8.5	0.8	2.4
Mathematical sciences	14,145	1,134	9.6	8.2	82.4	84.0	6.1	4.9		
Computer sciences	6,355	363	54.5	56.5	36.6	35.5	6.1	6.1	0.3	
Environmental sciences	13,963	606	29.6	18.8	41.9	53.8	24.2	18.2		
Engineering	49,558	527	52.8	51.4	34.0	34.5	8.8	6.0	0.1	1.3
Life sciences	68,626	11,080	15.4	7.9	64.2	73.5	12.7	9.1	4.0	4.0
Psychology	28,568	9,140	18.6	19.4	53.1	52.4	8.5	6.6	15.8	15.2
Social sciences	40,893	7,191	7.5	6.2	75.1	77.1	11.1	10.3		0.2
Total	279,185	33,150	28.0	13.8	54.5	66.1	10.6	8.6	3.0	4.2

Table 3. Academic position of doctoral scientists and engineers in the 1970–1974 Ph.D. cohort in 1979. Behavioral sciences are psychology and the social sciences. Abbreviation: EMP = engineering, mathematics, computer sciences, physics and astronomy, chemistry, and environmental sciences. [Data from (*3*)]

Position	Field of doctorate (%)							
	All fields		EMP		Life sciences		Behavioral sciences	
	Men	Women	Men	Women	Men	Women	Men	Women
Faculty	83.7	80.8	79.5	72.1	83.6	75.8	88.7	86.9
Professor	9.4	4.3	6.8	2.6	8.4	4.1	13.4	5.0
Associate professor	41.6	28.0	40.6	25.0	35.8	19.5	48.0	34.9
Assistant professor	31.8	44.4	31.4	39.3	37.9	47.5	26.7	43.7
Instructor	0.9	4.1	0.7	5.2	1.5	4.8	0.6	3.2
Nonfaculty staff	7.7	8.4	11.0	14.1	7.1	11.5	4.3	4.5
Teaching staff*	0.8	1.3	0.4	1.2	0.4	0.5	1.7	1.8
Research staff†	6.8	7.2	10.6	12.9	6.6	11.0	2.6	2.8
Postdoctoral appointment	3.3	5.3	3.8	7.1	4.8	8.4	1.3	2.5
Other or no report	5.3	5.5	5.7	6.7	4.5	4.3	5.7	6.1
Total Ph.D.'s	37,000	6,700	13,800	900	11,100	2,400	12,100	3,400

*Includes nonfaculty staff members whose primary work activity is teaching. †Includes nonfaculty staff members whose primary work activity is basic research, applied research, development, or design.

A number of studies (*15*) have provided rich detail on the different treatment of men and women in academic employment. Although women have made some advances, no data available indicate that equality of opportunity for employment or for advancement yet exists.

In industry and government the only clear measure of comparison between women and men is the proportions of women employed (Table 2), and their salaries.

Salaries

Women's salaries are lower than those paid to comparable men in almost every field, but some improvement is apparent since the early 1970's. Comparing salary trends for women and men is one way to measure progress. Many factors affect salary—highest degree, years of experience, type of employer, type of principal activity or job function, and both field and subfield of science or engineering, among other things. Most survey samples are not large enough to provide accurate comparisons over time of all these factors, but some comparisons are possible by combining information from several surveys. Salary information for women has been calculated as a percentage of salary paid to men in the same survey.

One excellent longitudinal survey by the College Placement Council (*16*) provides average annual starting salary offers from business, industry, and government to inexperienced graduates by field

Table 4. Beginning salary offers to women with bachelor's degrees in selected fields are shown as a percentage of men's beginning offers. [Data from (*16*)]

Year	Women's salary offers (percentage of men's) by field of degree									
	Mathematics and statistics	Computer sciences	Chemistry	Biological sciences	Economics	Engineering				
						Chemical	Electrical	Civil	Mechanical	All
1970	93.2		92.7							98.7
1971	89.7									99.6
1972	92.1									100.0
1973	96.0									104.8
1974	99.2	97.3	97.3	88.4		99.1	101.5	100.4	100.3	100.3
1975	98.1	99.4	98.1	92.0		100.1	103.3	103.2	99.5	101.5
1976	98.9	100.9	104.0	96.9		100.4	101.8	104.4	102.6	102.3
1977	98.6	98.8	99.8	96.7		101.1	101.4	105.8	102.7	102.7
1978	98.7	98.9	98.1	88.0	97.2	100.3	101.1	104.3	101.6	101.8
1979	97.3	97.8	98.4	93.0	96.8	100.5	101.8	102.7	101.0	101.5
1980	97.6	98.5	97.1	89.6	97.4	100.2	99.8	102.3	101.5	100.9
1981	97.9	98.4	97.5	92.9	96.2	99.8	100.2	100.3	100.2	100.1

Table 5. Women's salaries as a percentage of men's for graduates with bachelor's degrees in selected occupations at selected intervals after graduation. [Data from (*17*)]

Year	Women's salaries (percentage of men's) by years since degree							
	0 to 1*	2	4	7	10	13	15	24 to 25
				Mathematics and statistics				
1970	93.2	90.2	96.1	95.8	92.7	91.8		105.8
1972	92.1	93.2	92.4	83.7	88.6		92.2	74.2
1974	99.2	96.0	92.6	87.2	94.1	89.2	79.8	74.2
1976	98.9	87.0	101.5	100.5	92.9	80.3	84.9	86.8
1978	98.7	89.2	90.3	84.7	93.6	87.1	87.6	90.0
1980	97.6	89.4	86.9	96.0	91.8	89.2	87.5	66.1
				Chemistry				
1970	92.7	88.1	87.8	92.4	88.5	93.6	90.9	85.1
1972		94.2	84.9	83.8	85.9	73.1	63.7	75.7
1974	97.3	93.4	88.4	89.6	91.5	88.5	70.5	83.5
1976	104.0	95.1	79.8	94.1	87.6	88.6	80.4	75.5
1978	98.1	94.7	97.6	90.6	77.3	92.9	88.3	78.2
1980	97.1	96.3	93.5	90.0	73.6	81.0	79.4	68.6
				Biological sciences				
1970		93.8	91.5	88.9	87.4	74.7	87.2	85.4
1972		86.5	91.5	87.4	74.7	76.8	65.9	82.0
1974	88.4	94.6	86.9	71.6	89.4	62.6	77.9	82.4
1976	96.9	95.1	99.2	80.1	84.7	73.7	64.2	55.4
1978	88.0	93.3	86.7	78.8	89.8	78.0	71.3	79.6
1980	89.6	91.9	90.6	89.5	78.8	65.1	79.9	65.6
				Engineering				
1970	98.7							
1972	100.0							
1974	100.3							
1976	102.6							
1978	101.8	94.4	91.6	94.3	89.3	87.8	94.8	84.5
1980	100.9	95.4	91.9	90.8	86.6	82.5	84.9	78.4

*By field of degree. [Data from (*16*)]

and level of degree. Data from this survey are available by sex from 1970–1981 for some fields and from 1974–1981 for additional science and engineering fields (Table 4).

Although the differences in starting salaries at the bachelor's level has changed only a few percentage points in each field, a surprising finding is that women's salary offers as a percentage of men's peaked in 1976 in science and mathematics fields, and in 1977 in engineering.

The actual dollar differences represented by the salary ratios is not large except in the biological sciences; in 1981 the difference represented $1116 per year. The dollar difference in chemistry in 1981 was about $500 per year, and the women's advantage in civil engineering was only $60 per year. However, the consistent pattern in the sciences of lower starting salaries for women undoubtedly contributes to the widening gap in men's and women's salaries as they move through their careers.

A study of pairs of men and women who earned Ph.D.'s after 1958, matched for field, years of experience, year of Ph.D., and departmental quality of Ph.D. institution, and who were employed full time in academia in 1979, found that women's salaries were significantly below the salaries for men even after such variables as primary activity and type of employing institution were considered. Futher, the study found that salary differences persist for both recent and earlier doctoral pairs. The largest differentials in pay between men and women for post-1975 Ph.D.'s were found in chemistry ($3300) and the biological sciences ($2100).

Because no longitudinal surveys of salaries of the same graduates are available, information from the College Placement Council's (*16*) survey of starting salaries was combined with that from other longitudinal surveys (*17*), which looked at the salaries of graduates with only bachelor's degrees working in nonsupervisory research and development positions (Table 5). After 1976 there is generally a wider gap between the salaries of men and women 2 years out of school than there was in the earlier part of the decade. And almost without exception, the gap in salary between men and women widens with time since degree. The actual annual dollar differences represented by these percentages are, of course, larger in more recent years than those in 1970. The difference in 1980 for men and women with 10 years of experience was $2160 in mathematics or statistics, $6408 in chemistry, $4800 in biological sciences, and $3708 in engineering. But these differences are smaller than those with 10 years of experience at higher degree levels.

Salaries of graduates with master's degrees—almost half of women scientists and engineers are in this category (*5*)—are not available over time for comparable groups. The College Placement Council does not break down starting salaries by sex for either master's or doctoral graduates, nor did the other longitudinal surveys (*17*) report the salaries of master's graduates by sex until 1980. The only other data available are those of the NSF survey of new entrants to the labor force (*2*). This survey of bachelor's and master's graduates 2 years after receipt of the degree gave us information in 1978 on the salaries of 1976 and 1972 master's degree recipients employed full time, and in 1979 on the salaries of 1977 master's degree recipients. Data are provided separately in the 1979 survey for those in science or engineering jobs (Table 6).

The large salary differential between the sexes indicates that the master's degree pays off in salary far more to men than to women. The dollar amounts represented by the percentages are large. For example, among social scientists employed in science or engineering fields in 1979, the difference in men's and women's salaries is $4000, and women engineers employed in science or engineering made $2400 per year less than men in 1979.

Data from the American Chemical Society (*18*) on salaries of its member chemists by degree level and years of experience gives us some trend data in that field from 1974 to 1979 (Table 7). The salaries of women chemists have improved relative to men's at all three

Table 6. Women's salaries as a percentage of men's for recent master's degree graduates. [Data from (*2*)]

Field	Women's salaries (percentage of men's)			
			1977 class in 1979	
	1972 class in 1978	1976 class in 1978	Total employed	Employed in science or engineering
All science and engineering fields	79.2	78.7	76.4	76.1
Physical sciences	85.4	75.1	83.9	86.2
Environmental sciences	66.7	73.9	84.9	
Mathematical sciences	103.8	107.9	83.6	85.3
Engineering	89.7	94.3	91.0	89.2
Life sciences	83.5	90.0	89.3	85.8
Psychology	96.8	106.6	88.8	84.0
Social sciences	83.8	91.5	79.1	76.5

Table 7. Women chemists' salaries as a percentage of men's by highest degree and years of experience. [Data from (*18*)]

Survey year	Women's salaries (percentage of men's) by years of experience							
	0 to 1	2 to 4	5 to 9	10 to 14	15 to 19	20 to 24	25 to 29	30 to 34
				Bachelor's degree				
1974		93.0	85.7	84.8	83.3	78.5	76.5	74.7
1977	104.3	94.3	89.8	94.6	74.3	79.2	88.5	88.7
1979	107.1	103.2	90.2	70.6	93.5	74.8	83.3	88.3
				Master's degree				
1974		88.3	83.3	80.5	77.9	79.1	67.1	71.7
1977	71.4	84.4	94.4	79.2	81.5	77.0	74.1	66.7
1979	87.0	93.3	90.0	83.3	90.6	74.1	78.6	88.6
				Ph.D.				
1974		87.9	76.0	84.9	82.1	81.7	79.5	68.0
1977	76.2	84.0	86.4	74.8	70.9	72.6	77.3	72.7
1979	103.6	87.0	80.0	73.7	73.4	68.0	62.2	71.1

Table 8. Women's salaries as a percentage of men's for doctoral scientists and engineers by field in four survey years. [Data from (*3*)]

Field	Percentage			
	1973	1975	1977	1979
All fields	82.3	80.8	79.6	77.3
Physical sciences	81.4	79.3	79.1	80.0
Mathematical sciences	87.8	85.5	84.3	81.3
Computer sciences	79.4	76.3	79.7	79.2
Environmental sciences	81.6	80.9	75.8	79.3
Engineering	87.0	82.5	79.8	80.1
Life sciences	76.6	83.6	83.7	79.6
Psychology	87.6	86.3	82.7	82.9
Social sciences	84.4	83.1	81.8	84.3

degree levels and virtually every level of experience. However, women with master's degrees have salaries that are farther below those of men than do women with only bachelor's degrees. And salaries of women with Ph.D.'s lag even more behind those of men at every level of experience except the entry level. The differences in salary widen with years of experience at each degree level.

Women chemists appear to be typical of all women scientists. Women with graduate degrees are more likely to be employed by educational institutions than by industry, where more men are employed and salaries are higher (*3*, *4*). However, employment sector alone cannot explain all the salary discrepancies. Only the amount of difference in salary levels is affected by the employment sector, but women earn less than men in almost every category of degree level, experience level, or type of employer, and the salary difference between the sexes widens with years of experience, whatever the degree level or employment sector.

Although we do not have salary data over time, broken out by sex, field of degree, and years of experience, the biennial survey of the science and engineering Ph.D. population (*3*) shows that women's salaries are lower than men's salaries in every field and at every experience level, and the salary gaps are wider in 1979 than they were in 1973 (*3*) (Table 8). Even though part of the difference can be attributed to the higher proportion of women among more recent Ph.D.'s, salary data presented by age (1973) or by years of professional experience (1979) also indicate that the differences may have widened. Women between 30 and 34 years of age in 1973 earned 85.3 percent of the salaries of men that age. Roughly comparable women with 2 to 5 years of professional experience in 1979 earned only 75.8 percent of men's salaries. That salary gap also exists whatever the employment sector.

Other studies of doctoral men and women in academia (*15*) and of those with postdoctoral experience (*13*) verify the continuing inability of women to be as successful as men in pursuing and advancing in science and engineering careers, once they have completed their formal education.

Summary and Conclusions

In the past decade women have made great progress in attainment of degrees in science and engineering, at every degree level and in every field. They are continuing to increase their numbers and proportions in the educational pipeline at both graduate and undergraduate levels, so that the increase in degree awards can be expected to continue at least during the first half of the 1980's and probably into the second half. However, women still have more difficulty than men in finding employment and in advancing in careers. Except for beginning engineers, women's initial salaries are lower than those of men and the difference increases with age. The gap between men and women in salaries and in unemployment rates also widens at succeedingly higher degree levels.

Some progress is apparent. In 1970, no survey found women leading men in salaries, or sharing unemployment rates equally, regardless of field or degree level. Perhaps the most disturbing trend is that the equalization of opportunities is considerably better for women with only bachelor's degrees than for those with either master's degrees or Ph.D.'s. Women are rewarded far less than men for the larger investment in career preparation represented by graduate degrees.

Progress may be slower in the 1980's as the Administration reduces programs to equalize opportunities for women. The provisions of the Women in Science Act, passed as part of the National Science Foundation authorization in 1980, are largely in the deep freeze, without appropriations to carry them through. Title IX of the Education Amendments of 1972, which forbids discrimination by sex in all federally assisted educational programs, is again under attack. Academic institutions, already searching for ways to survive the problems of a waning population of college-age students, heavily tenured faculties, rising costs, and inflationary pressures, can be expected to welcome both college-age and returning women as students. But relatively few tenure-track positions will open for new graduates when they have completed their graduate education, and women scientists already on campus are disproportionately in the fringe groups of temporary researchers, extended postdoctorates, lecturers, and nonfaculty staff. Even among faculty, women earn far less than men. In 1981, the salaries of women faculty in science and mathematics were only 78.2 percent of those of men, and in the social sciences, 81.5 percent. The actual dollar differences were $5300 and $4670, respectively (*19*).

Although more women are being hired by industry in such fields as engineering and the physical sciences, they are not yet represented in industry in the proportions in which they are available. Despite the increases in the number of women graduating in engineering, chemistry, geology, and other fields where their representation has been small and where industry hiring is significant, the largest numbers of women still are moving into the behavioral and social sciences and into the life sciences.

After 1776, women worked for 144 years to obtain the right to vote and for 187 years to get a law in the books requiring equal pay for equal work. By comparison, the progress made by women scientists in the 1970's has been enormous. The rate of progress may slow down in the 1980's, but women's participation in science and engineering will continue to grow.

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