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ABSTRACT

This paper reports the current status of women in science and engineering careers. Statistical data comparing women with men in various subject areas are presented, with graphs at these various levels: (1) precollege; (2) bachelor's degrees; (3) graduate school; (4) master's degrees; (5) doctoral degrees; and (6) labor force. Most of the statistical data show the trend over years. The obstacles on the way to a science career are explored, using the presented data. Encouraging women to participate in science and engineering areas, equal treatment in school and the workplace, shared responsibility for home and family, and a change in societal attitudes towards girls and women are recommended. (YP)

WOMEN IN SCIENCE

Progress and Problems

by

Betty M. Vetter

Occasional Paper 89-1

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Betty M. Vetter
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Adapted from a Presentation to a

AAAS Symposium

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San Francisco, California

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AAAS SYMPOSIUM

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WOMEN IN SCIENCE - Progress and Problems

List of Figures

WOMEN IN SCIENCE - PROGRESS AND PROBLEMS

American women have made remarkable inroads into the community of scientists, particularly over the past decade and a half, but the increase in their participation has stopped, well before they achieved demographic parity or occupational equality with men. Although the obstacles they continue to encounter are formidable, the nation's need for them is growing, and change appears inevitable.

PRE COLLEGE

One of the several pragmatic reasons behind an increasing need to utilize the talents of women in science and engineering is the U.S. birth curve, which fell substantially after 1961, resulting in a 25 percent drop in the number of American babies born over the next 15 years. The number of freshman-age students started down in 1980, and this decreasing population group will continue to affect enrollments of college students in the natural science and engineering fields through the rest of this century (fig. 1).

The problems of getting women into science or engineering also begin at birth, when babies in hospital nurseries are labeled with appropriately pink or blue blankets. We continue to treat them differently throughout their childhood and school years, and into the world of work. Girls are told and shown that they are seen as less competent than boys; with less mathematical ability. Many girls drop out of math as soon as they can, closing their options to a science or engineering career as early as the eighth grade.

The serious deterioration in pre-college education in our public school system during the period of the Vietnam conflict and after illustrates another reason that the nation needs to add women to its roster of scientists and engineers. Although college-going increased markedly during this period, particularly among young men who might otherwise have faced the military draft, high school course requirements in math and science - and indeed most of the other core courses previously required of high school students who sought entry to college - had been dropped. Boys, but particularly girls dropped out of the mathematics course sequence required for engineering and most science majors as early as ninth grade.

By 1982, about a fourth of American 17 year olds of both sexes had ended their formal mathematics training with pre-algebra. At the top end of the scale, only six percent of the boys and five percent of the girls had taken

U.S. 18-YEAR OLDS

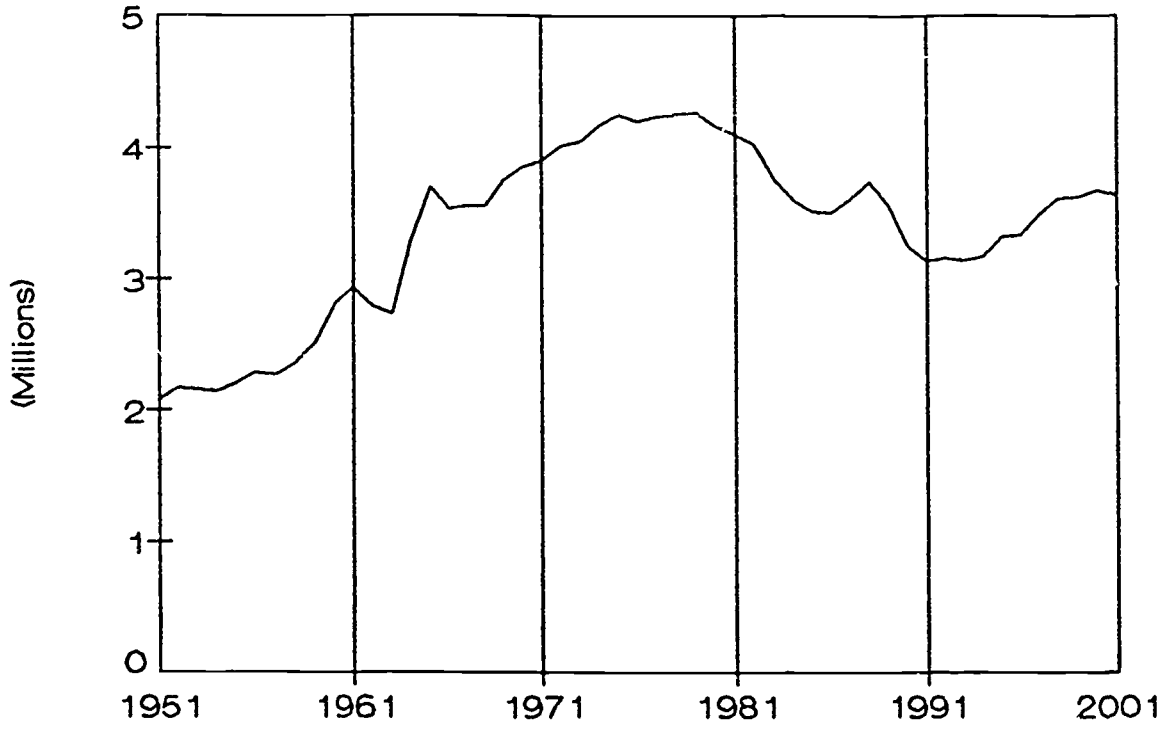
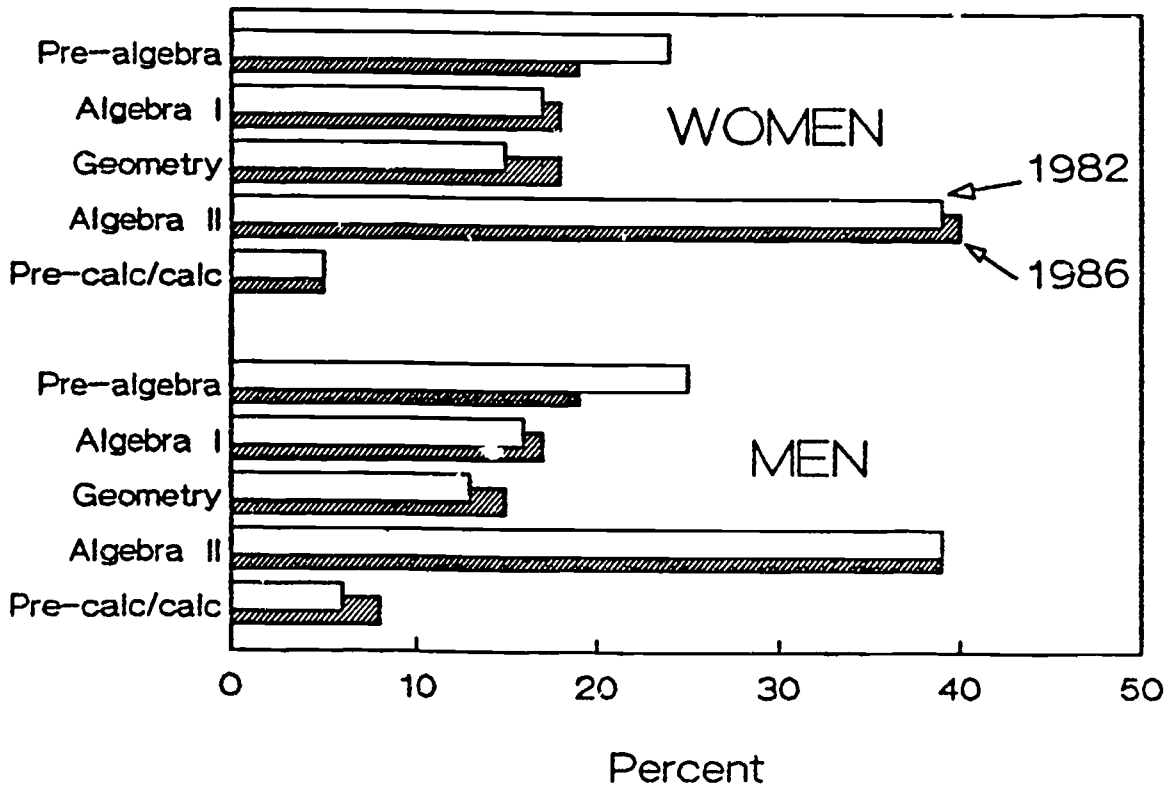


Figure 1

HIGHEST MATH COURSE TAKEN BY 17-YEAR-OLDS, 1982-86



Source: Dossey, The Mathematics Report Card,

Figure 2

pre-calculus or calculus, and less than 40 percent of either sex had completed Algebra II (fig. 2). However, urgent efforts over the past several years have begun to have an effect. By 1986, the proportion of girls and boys who stopped with pre-algebra had dropped by five and six percent respectively, and both sexes showed an increase in the proportion completing each higher math course, until the very top. But even in 1986, only 5 percent of girls - the same percentage as in 1982, had taken pre-calculus or calculus, although the proportion of boys completing this level of training had moved up from six to eight percent.

In science, we now have data from the fifth national assessment of science proficiency among nine, 13 and 17 year old Americans. Although boys at each age level show some improvement in 1986 over the 1982 assessment, following a steady decline since the 1970 assessment, the average science proficiency of girls shows significantly less positive change, so that the already far-too-wide performance gap between 13 year old boys and girls has more than doubled across the five assessments since 1969 (fig. 3).

Children come to school for the first time with a universal curiosity and interest in the natural world around them and how it works. By age nine, girls already have lost some of their interest, and have learned measurably less than boys, and by age 17, the knowledge gap between them is almost unbridgeable. The dropoff of girl's interest in natural science or engineering from the time they enter school to their high school sophomore year is far greater than is true for boys (fig. 4).

Despite a significant increase in the proportion of American women who go to college, their participation in math-based major fields has increased only in proportion to their greater college attendance, and even this gain now appears to be threatened. Among women just beginning college, interest in natural science and engineering majors has dropped steadily since 1982 (fig. 5). And it is not only engineering and computer science that show this declining attraction for freshman women; their interest in the biosciences, mathematics and the physical sciences also is dropping. Instead, they are choosing business majors in substantial and increasing numbers, and there is also a steady increase in the proportion planning to major in education (fig. 6). Unfortunately, this does not mean they plan to teach science or mathematics, for these are areas where participants generally take a major in the field itself rather than in education. It does mean that new elementary teachers, mostly

Ages 9, 13, and 17: Trends in Average Science Proficiency by Gender, 1969-70 to 1986

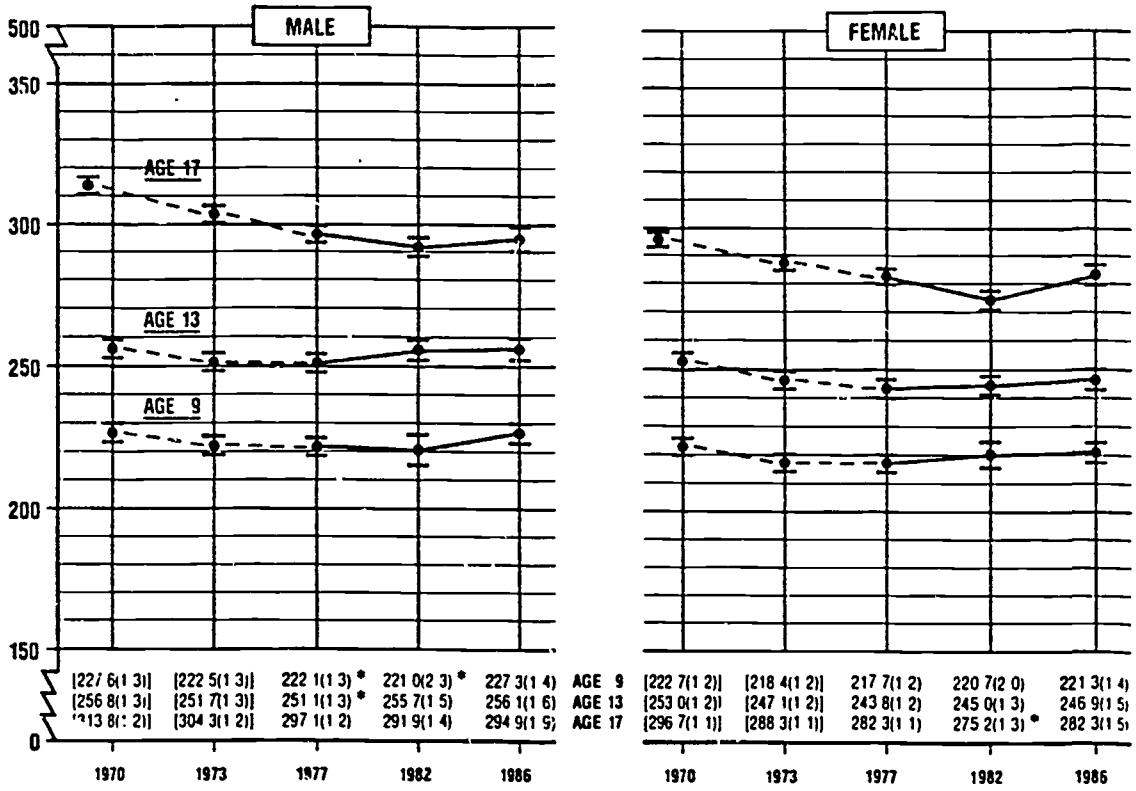


Figure 3

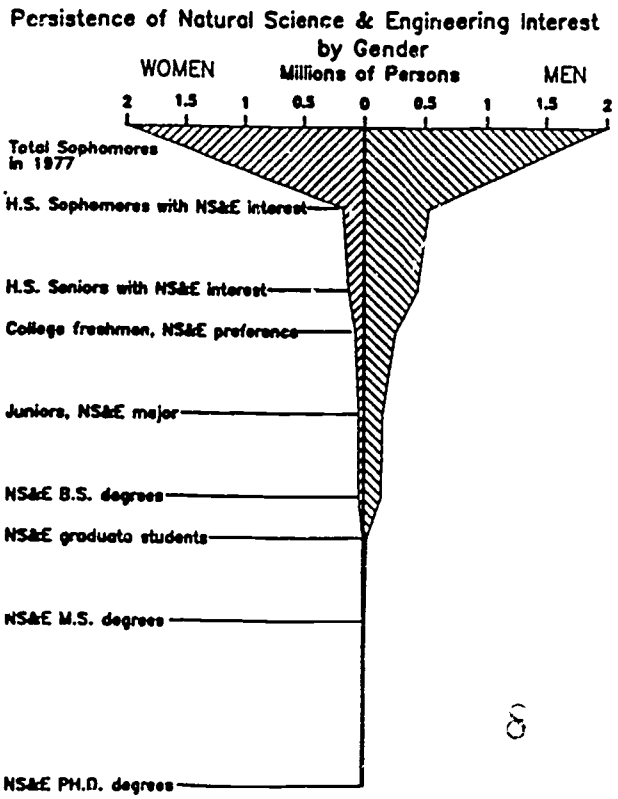
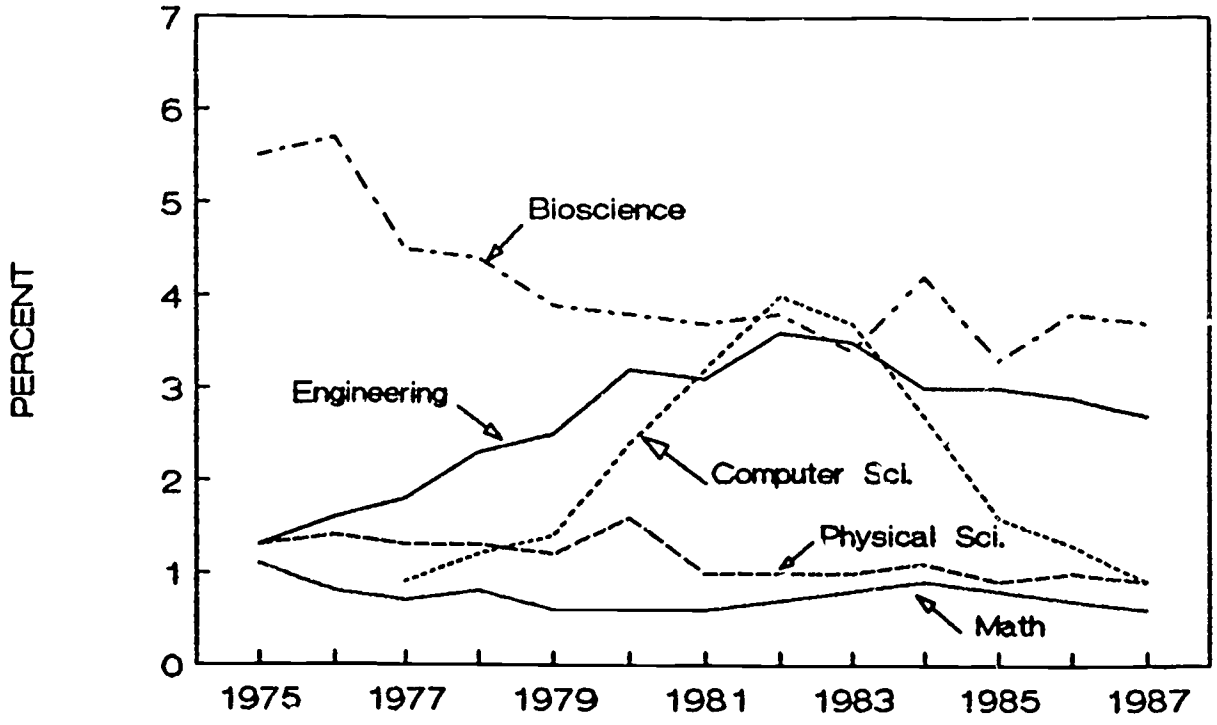


Figure 4

FRESHMAN WOMEN NS/E MAJORS
1975 - 1987



Source: The American Freshman: Fall 1975 – FAll 1987

Figure 5

CHANGING FRESHMAN WOMEN MAJORS
1973 - 1987

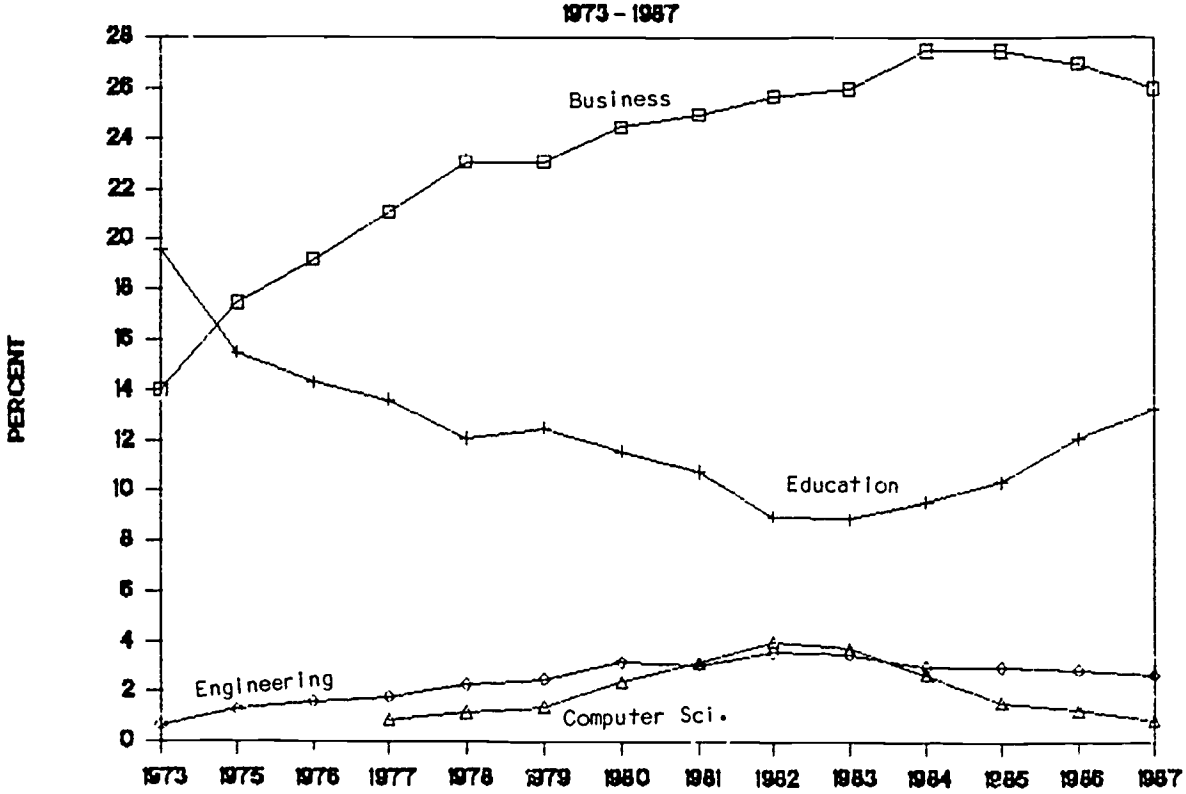


Figure 6

women, probably will continue to fear math and pass this on to the girls in their classes.

It is useful to see whether the stated plans of freshmen correlate with what they actually do, and we can see this only in engineering, where data are available over a long time period on freshman enrollment. Among both men and women, a steady drop in the number of enrolled freshmen has occurred since the 1982 peak (fig. 7). Some drop would have occurred solely on the basis of the smaller number of 18 year olds. However, the clue as to what is happening to women is that after a long and steady increase in their representation among engineering freshmen, from less than three percent to 17 percent of the class in 1983, the proportion of women in the first year class is now dropping along with the number (fig. 8).

BACHELOR'S DEGREES

The number of women earning baccalureate degrees in engineering peaked four years behind the freshman enrollment peak, as expected, and each graduating class for the next several years will be smaller than its predecessor. (fig. 9). Unless some change occurs, it appears that women will not exceed about 15 percent of engineering graduates even at the bachelor's level in the foreseeable future.

The number of women earning bachelor's degrees in all fields of science and engineering together, including the social sciences, has continued to rise slowly for the past 20 years, parallelling an increase in total baccalaureate awards to women (fig. 10). However, we expect to see a leveling off of that curve when the 1987 degree data for all fields become available. Certainly by 1988, the number of women graduates in science will have started down.

A similar relative increase in representation of women among bachelor's graduates has occurred in each broad area of science and engineering since 1960. However, even by 1986, that increase has levelled off or started to decline in most of these areas (fig. 11).

Zooming in even further to examine bachelor's degrees in the physical sciences, the total pattern already shows a drop by 1986, with the decrease occurring in each of the fields that make up the physical sciences group (fig. 12). A significant majority of the physical science graduates are in chemistry. Of course, a bachelor's degree in a physical science field is not necessarily an indicator that the individual recipient will become a professional in that area, but women who earn such degrees are much less likely than men to reach

FRESHMAN ENROLLMENT IN ENGINEERING 1972 - 1987

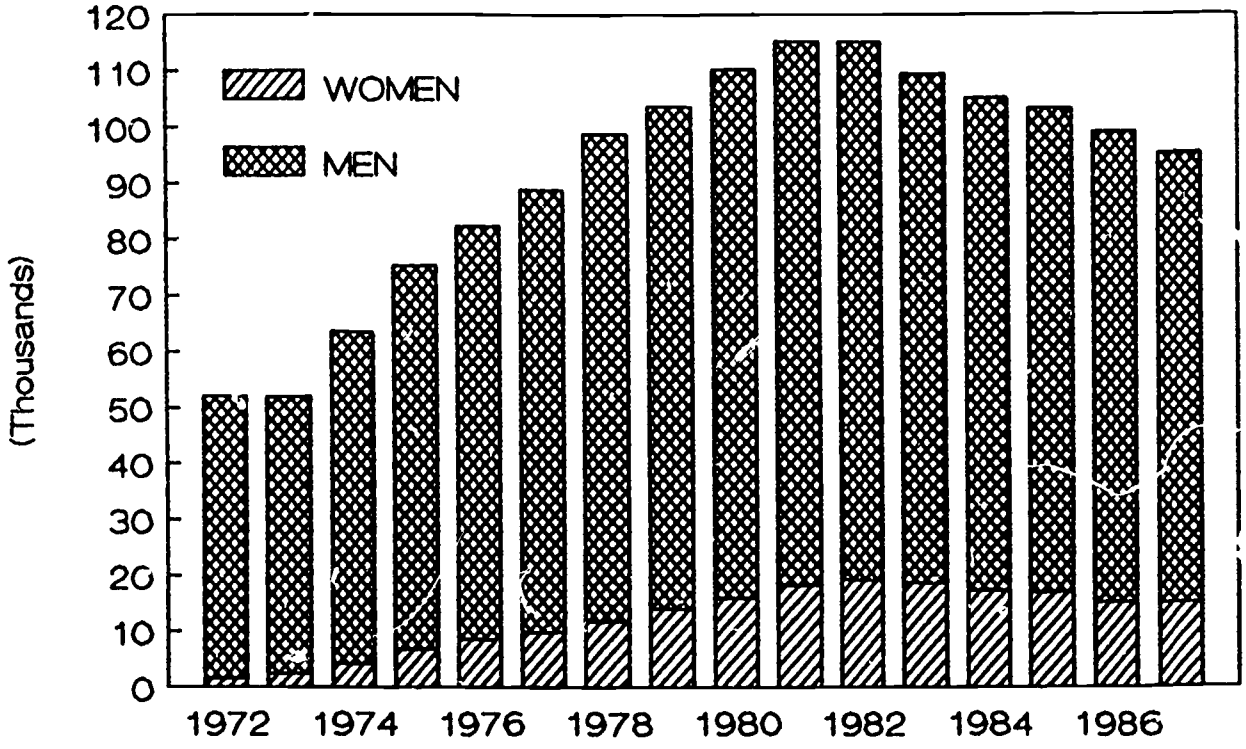


Figure 7

% WOMEN ENGINEERING FRESHMEN

1972 - 1987

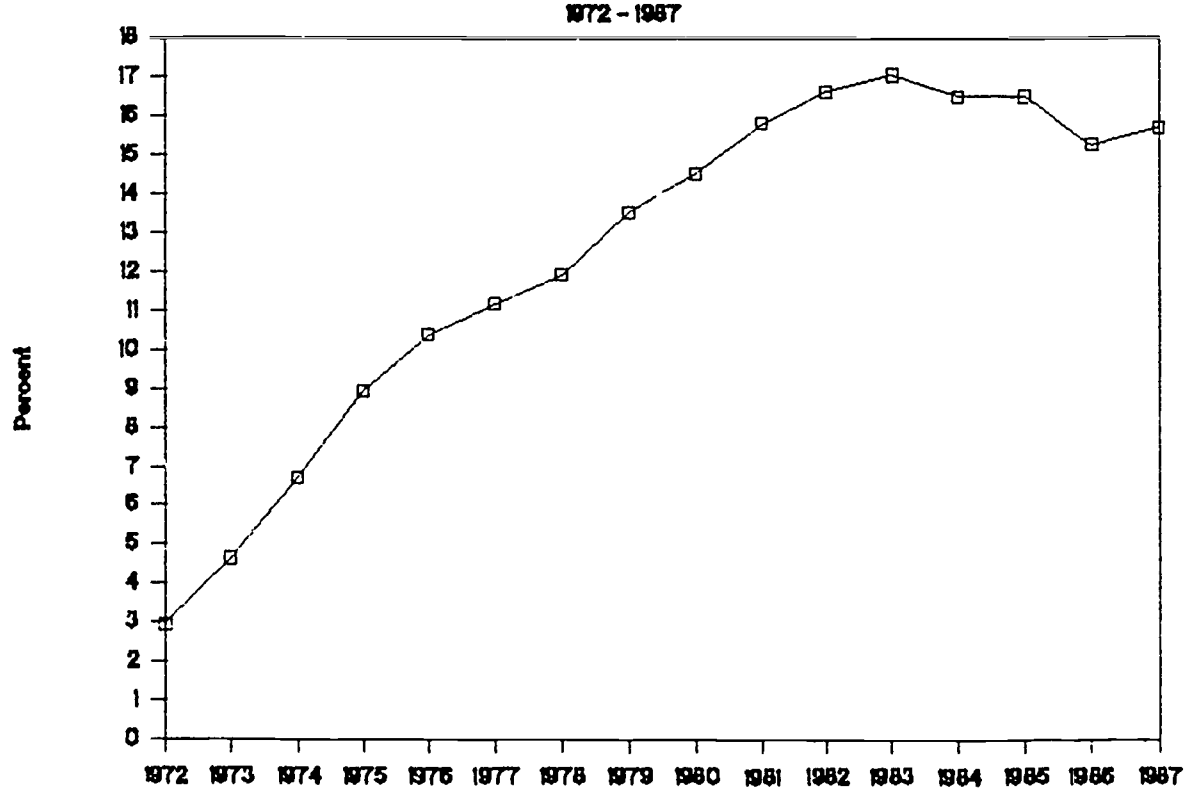


Figure 8

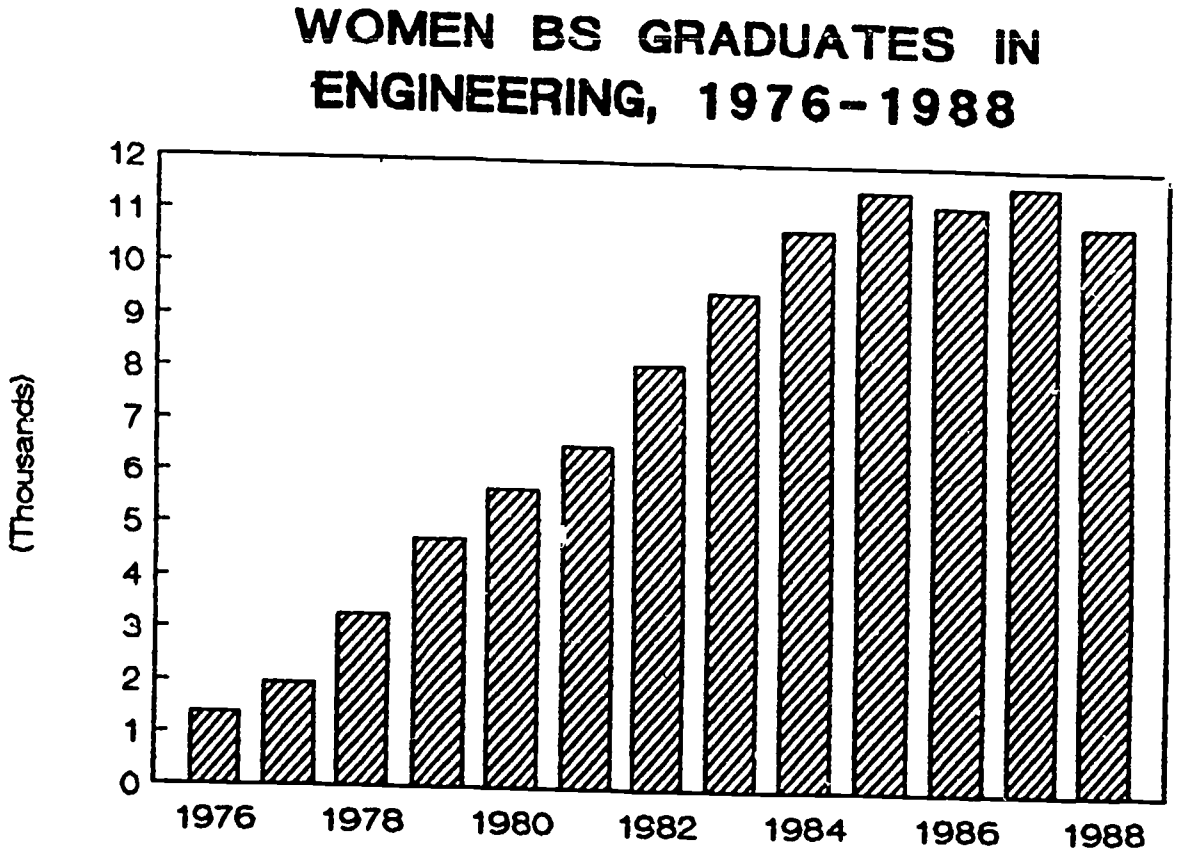


Figure 9

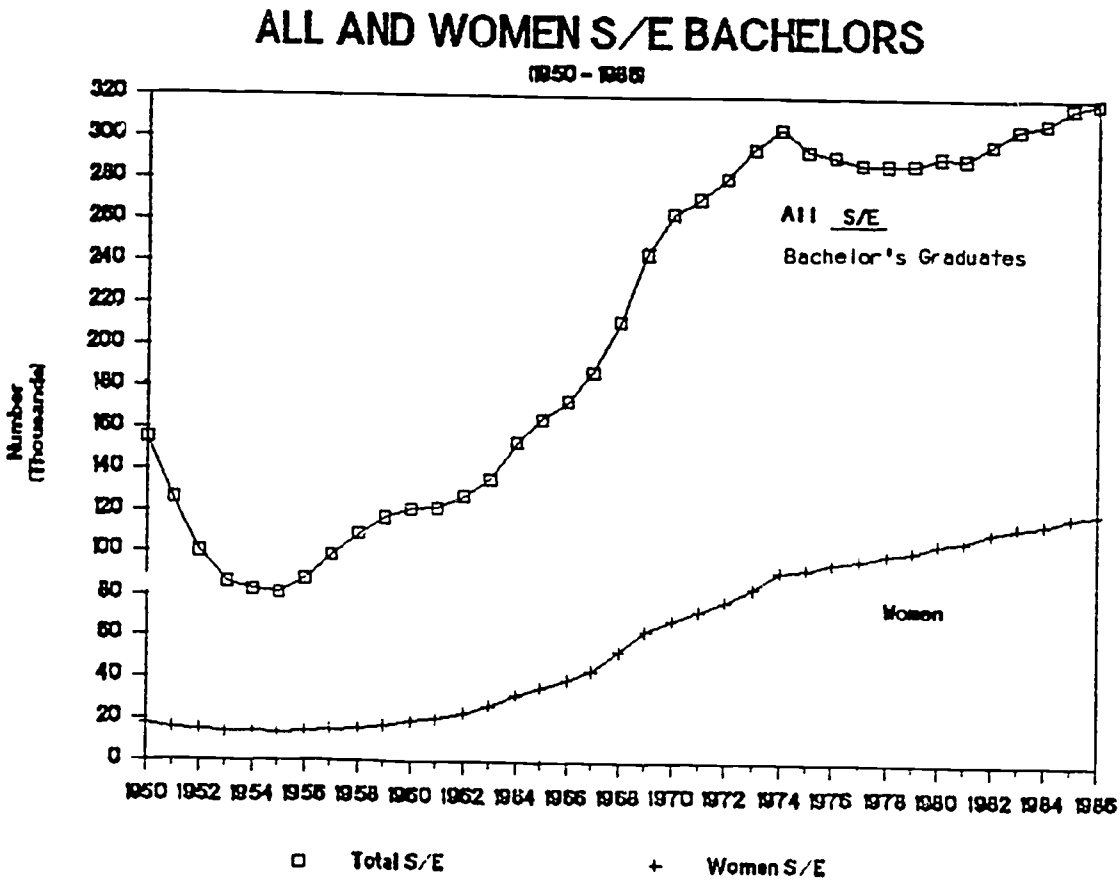


Figure 10

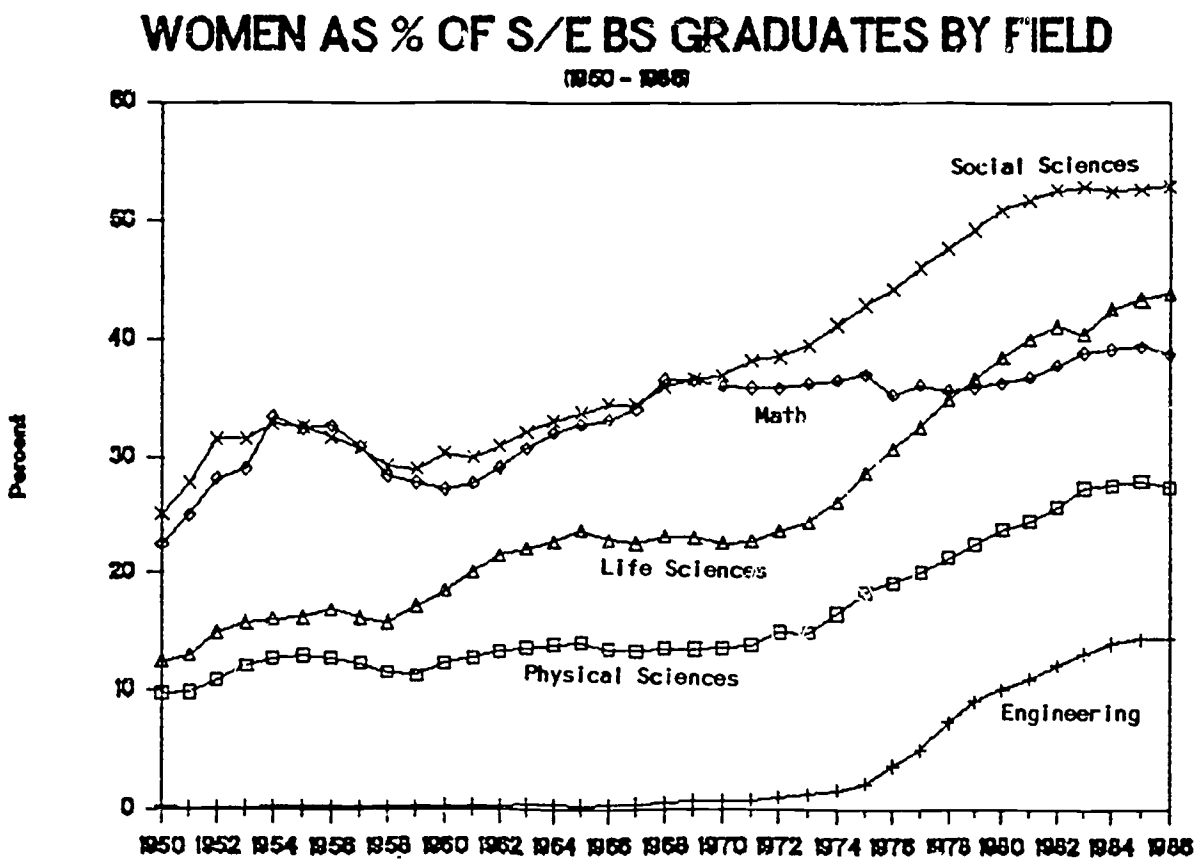


Figure 11

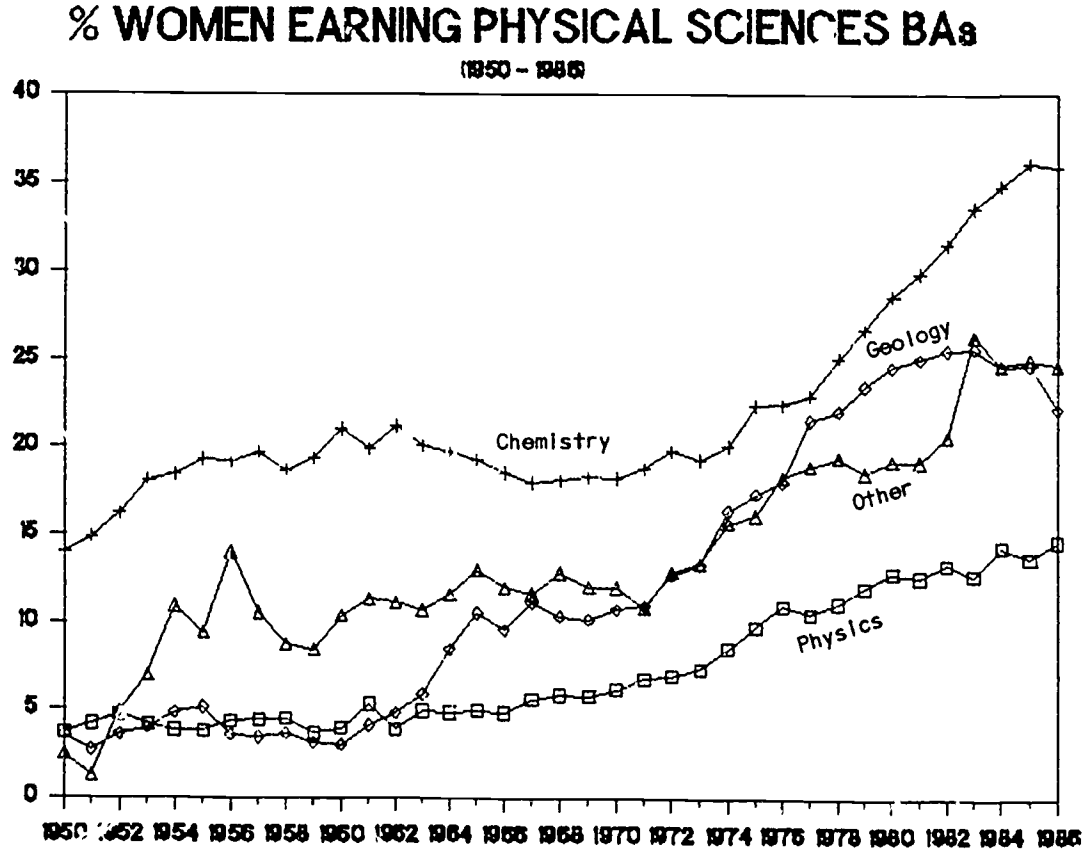


Figure 12

professional status in these fields. Women earned 17.5 percent of all physical science bachelor's degrees awarded between 1950 and 1985, but were only 11.5 percent of the physical science labor force in 1986. It is also of note that despite the steady increase in the proportion of women earning degrees in chemistry, their status as workers shows little shift over recent years. Among federal chemists, for example, women increased only from 20 percent in 1972 to 21.5 percent by 1985.

Starting Salaries of Bachelor's Graduates

Many graduates of both sexes, particularly in engineering, enter the labor force at the end of a bachelor's degree. One of the promising changes that has occured for these graduates is that the gap in starting salaries between men and women at this educational level has narrowed considerably in almost all fields over the past decade. Nonetheless, except in engineering, women still start work with consistently lower salaries than men.

In engineering, not only are starting salary levels higher than for graduates in any other field, but women earn as much as or more than their male classmates in the first job. In the sciences, the gap has narrowed somewhat between men and women, but starting salaries for chemistry, biology, mathematics and particularly physics graduates are significantly lower for women than for men at the bachelor's level (fig. 13).

GRADUATE SCHOOL

In many of the science fields, a bachelor's degree is no longer sufficient for professional employment. Thus, graduate school and a graduate degree have become increasingly important for both sexes. But graduate school also is costly, and ways must be found to pay those costs.

For both men and women, that includes obtaining one of the few fellowships still being provided by federal funds; obtaining a university fellowship, a teaching or research assistantship; or finally supporting themselves while working on a graduate degree. Throughout the past decade and a half, a higher proportion of women graduate students in science and engineering than of men have been principally self supporting. By 1986, this proportion included 36.7 percent of the women and 28.5 percent of the men. Some of the difference is a function of field choice, because students in the social sciences are considerably more likely than those in the physical sciences to be supported primarily by their own earnings. However, except in the physical sciences and environmental sciences, women are more likely than men to be dependent on self support (fig. 14).

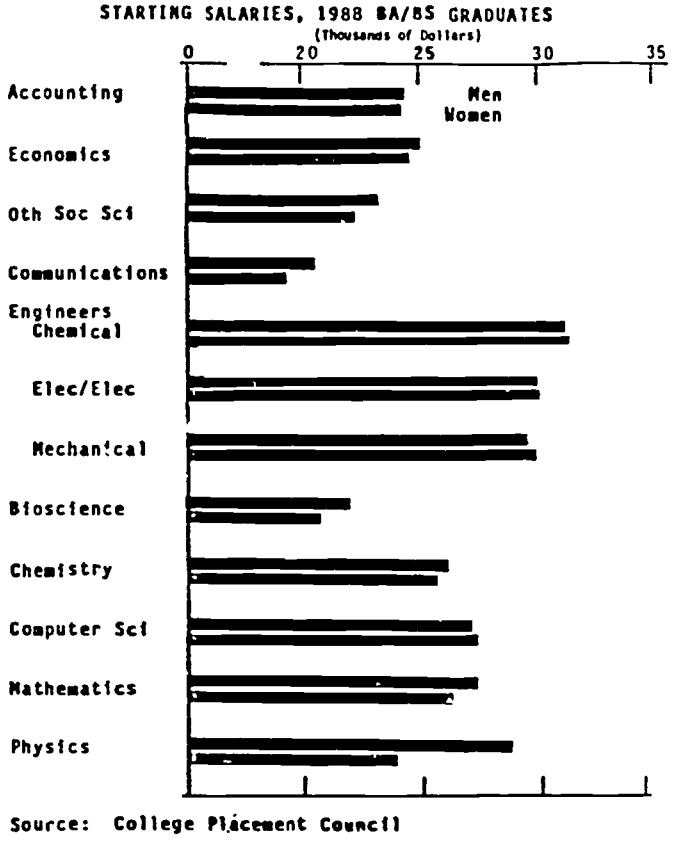


Figure 13

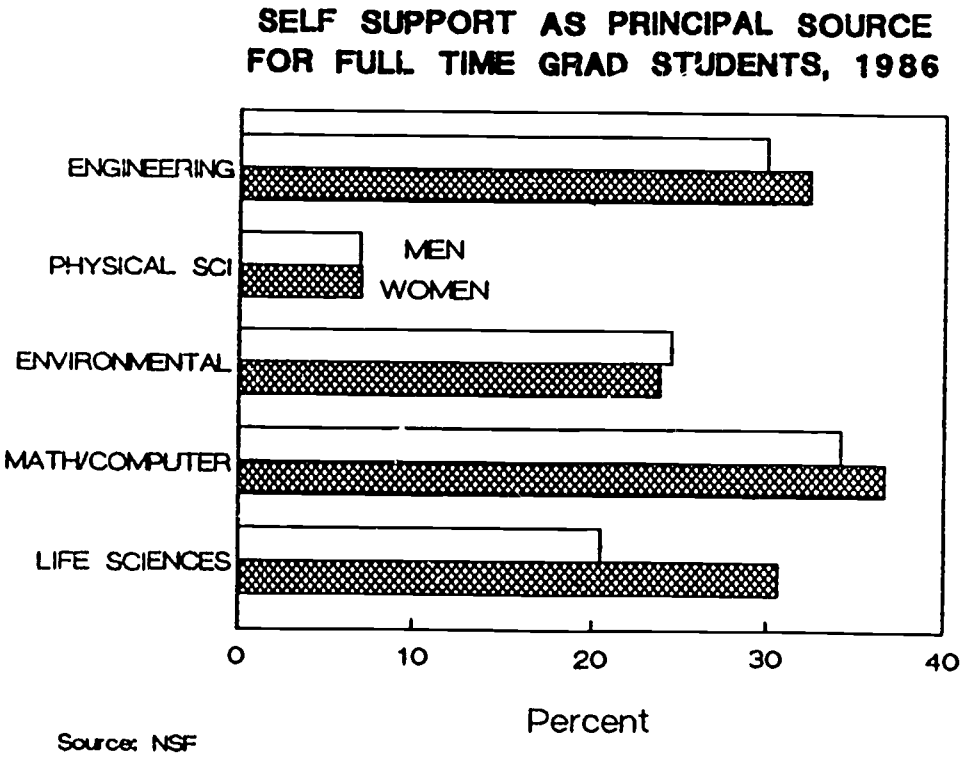


Figure 14

MASTER'S DEGREES

A substantial increase has occurred in both the number and proportion of master's degrees earned by women in all of the natural science and engineering fields (fig. 15). Their proportionate share of master's degrees now approximates their proportion of earned bachelor's degrees in these fields. But women are far more likely than men to stop with the master's degree. This has been variously attributed to lack of funding, lack of self confidence, and lower goals for women. Whatever the reason, men are substantially more likely than women to continue graduate study through a PhD.

Women students in the physical sciences, mathematics, computer science or engineering are particularly likely to have to work under foreign teaching assistants and faculty - most of them from countries with wide cultural differences in their view of women and their place in society. This may create serious difficulties for American women. Not that all American men treat women as colleagues - indeed, sexual harrassment of women is widely persistent. But there are few women faculty available to provide help when problems with male faculty occur.

THE PHD

With some rare exceptions, today's American women are relative late-comers to science. Their representation among doctorate recipients, both in science and engineering and in all fields, was higher in the 1920s than it was again for half a century (fig. 16). In that decade, women earned 16 percent of the doctorates awarded in the life sciences, 8 percent in the physical sciences, 17 percent in the social sciences and one percent in engineering.

Many educational opportunities for women were closed off in the years following World War II. Higher admissions standards for women than for men were established to assure room for the returning veterans, and most of the best universities had quotas for women that eliminated even many of those who met the higher admissions standards. The proportion of women among new doctoral scientists dropped steadily, reaching a twentieth century low in the 1950s, when women earned less than four percent of the doctorates awarded in the physical sciences, only nine percent in the life sciences, 11 percent in the social sciences, and less than half of one percent in engineering.

From 1960 to 1987, women earned more than 68,000 doctorates in science and engineering, including 32,000 in the social and behavioral sciences. Since the early 1970s, the number of American men earning doctorates in science and

NUMBER WOMEN NS/E MS DEGREES BY FIELD, 1950 - 1986

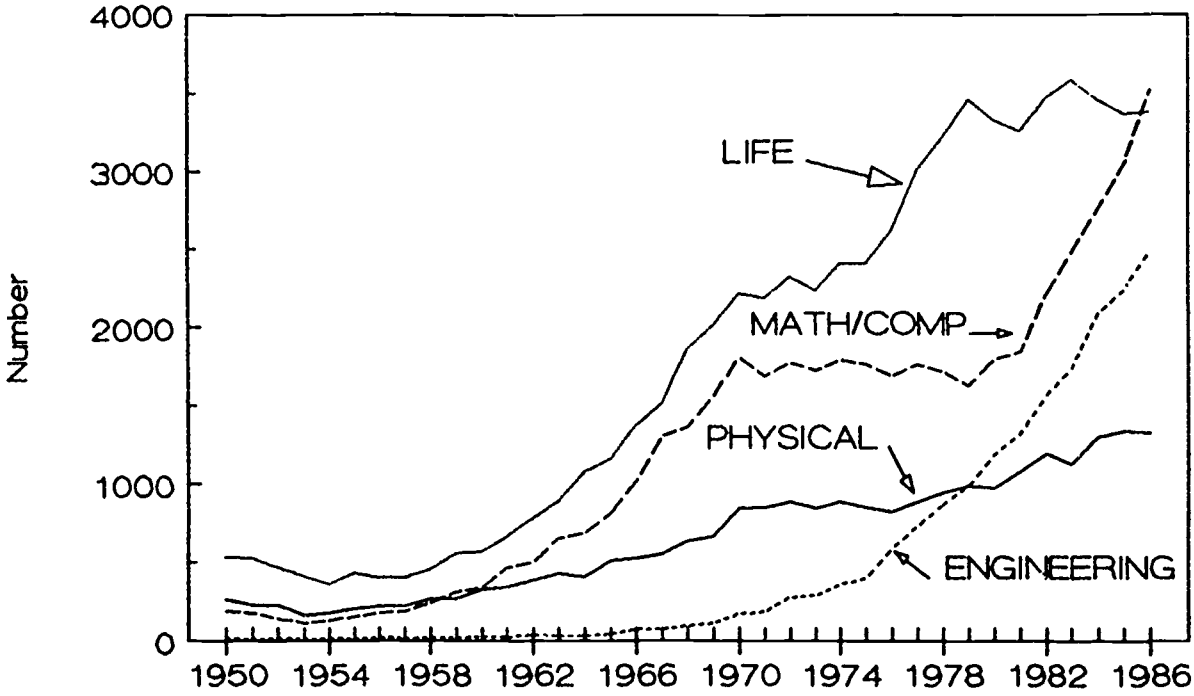


Figure 15

WOMEN AS % OF ALL & S/E PhDs

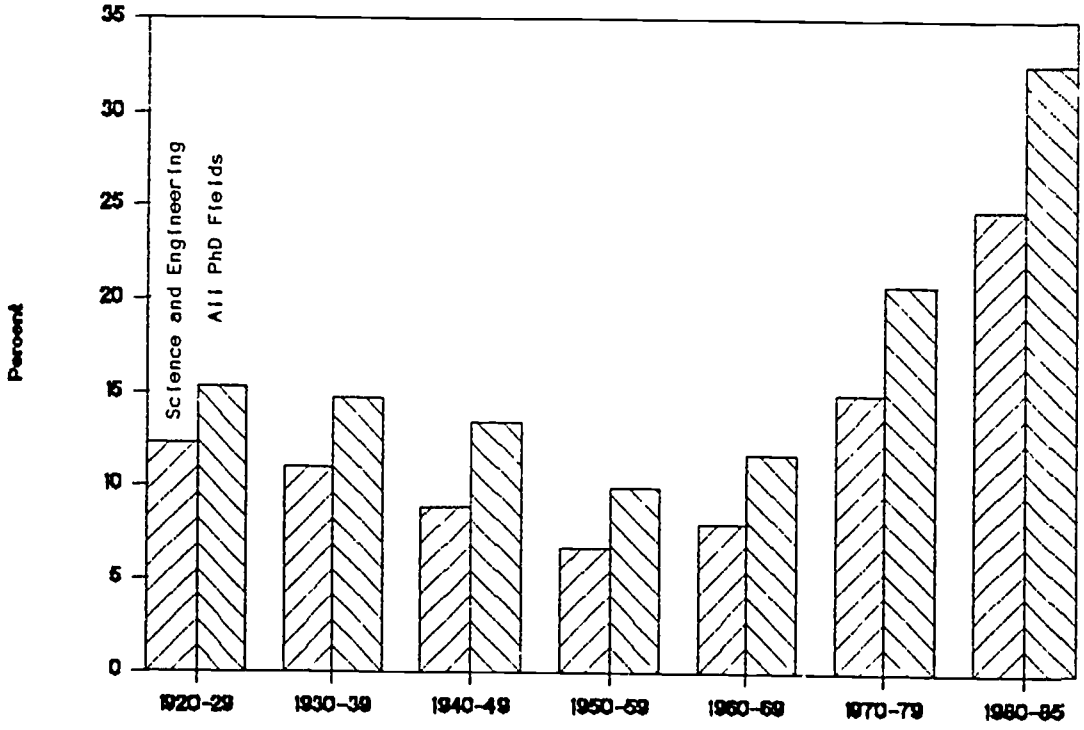


Figure 16

particularly engineering has shown a steady drop, while the number of American women has continued to rise slowly (fig. 17).

Even since the first quarter of this century, however, there has been very little field shifting among women, so that, just as in the 1920s, women earned most of their science doctorates in 1987 in the social and life sciences, and fewest in the physical sciences and engineering (fig. 18).

Looking more closely again at the physical sciences, there is, of course, a substantial increase in the proportion of doctorates earned by women in the physical sciences, and this increase has not yet abated (fig. 19). However, even in chemistry, where numerical representation of women is highest among the physical sciences, women earned less than 21 percent of the new PhD awards even by 1987.

Women now earn half of all bachelors and masters degrees awarded in the U.S., and more than a third of the doctorates. In science, they earn 45 percent of the bachelors degrees, 39 percent of the masters degrees and 27 percent of the Ph.D.s. In engineering, their share of 1987 bachelor's degrees is 15 percent, master's degrees, 13 percent, and Ph.D.s, seven percent.

THE SCIENCE AND ENGINEERING LABOR FORCE

Armed with their new education credentials, women have slowly increased their representation among employed natural scientists over the past decade, except for substantial drops in mathematics and environmental sciences (fig. 20). Of course, these employed scientists represent all degree levels. The fact that the proportions of women have not risen as fast as among degree recipients is a function both of the large population of males into which new graduates were moving, and also a function of differences in employment opportunities for men and women. The unemployment rates of women are consistently two to four times higher than for men; and women are somewhat less likely than men to find a job in science.

Women with doctorates are more than twice as likely as the men in their field to be unemployed and seeking employment, although the ratio has somewhat improved since 1979 (fig. 21). In 1985, for example, women were 17 percent of the doctoral labor force in science, but 35 percent of those who were involuntarily unemployed. Fortunately, the unemployment rate for doctoral scientists is low.

Nonetheless, by 1985, women were seven percent of employed physical scientists with doctorates, ten percent of those in math and computer sciences,

U.S. S/E PhDs BY SEX
1975 - 1987

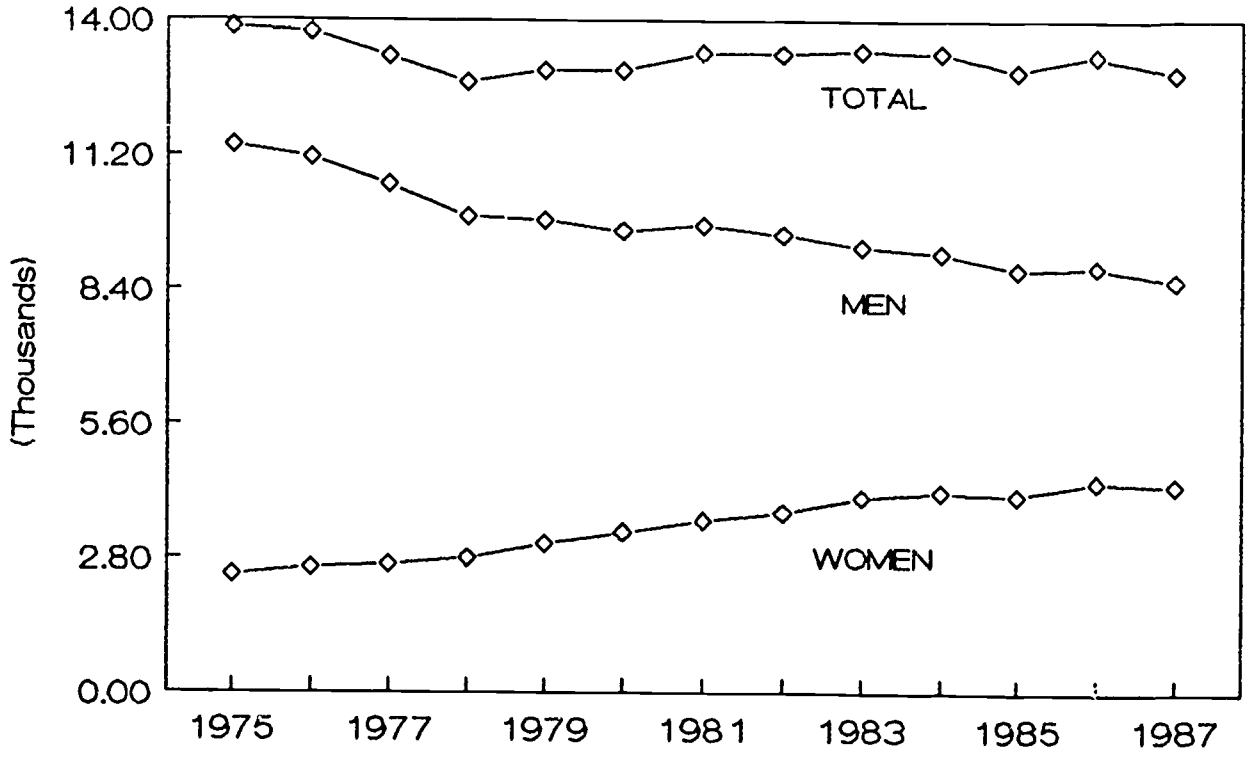


Figure 17

US WOMEN SE PhDs BY FIELD, 1975 - 1987

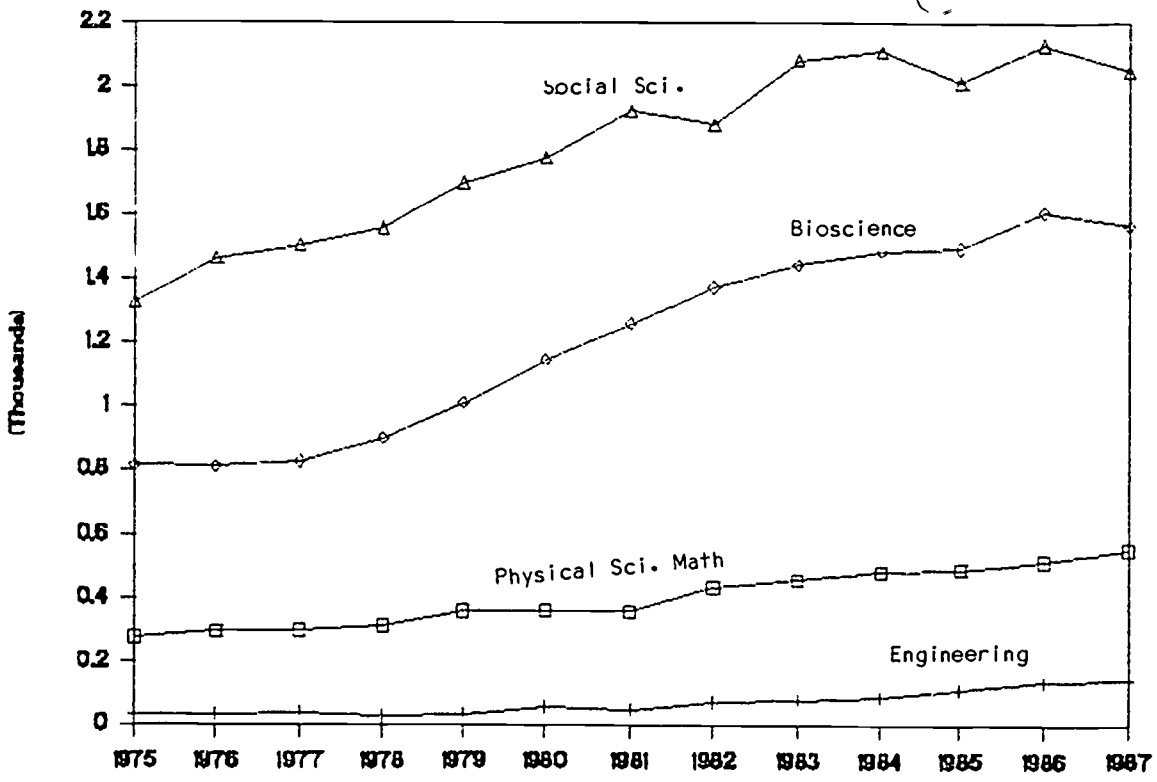


Figure 18

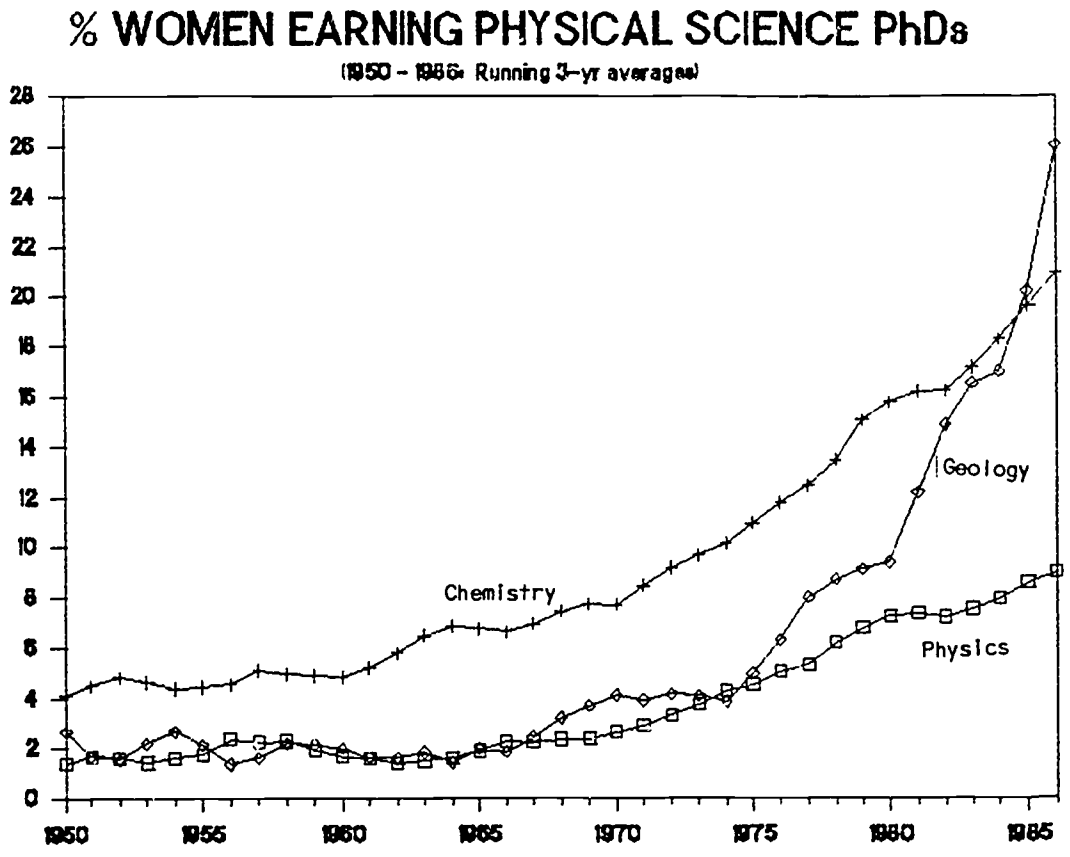
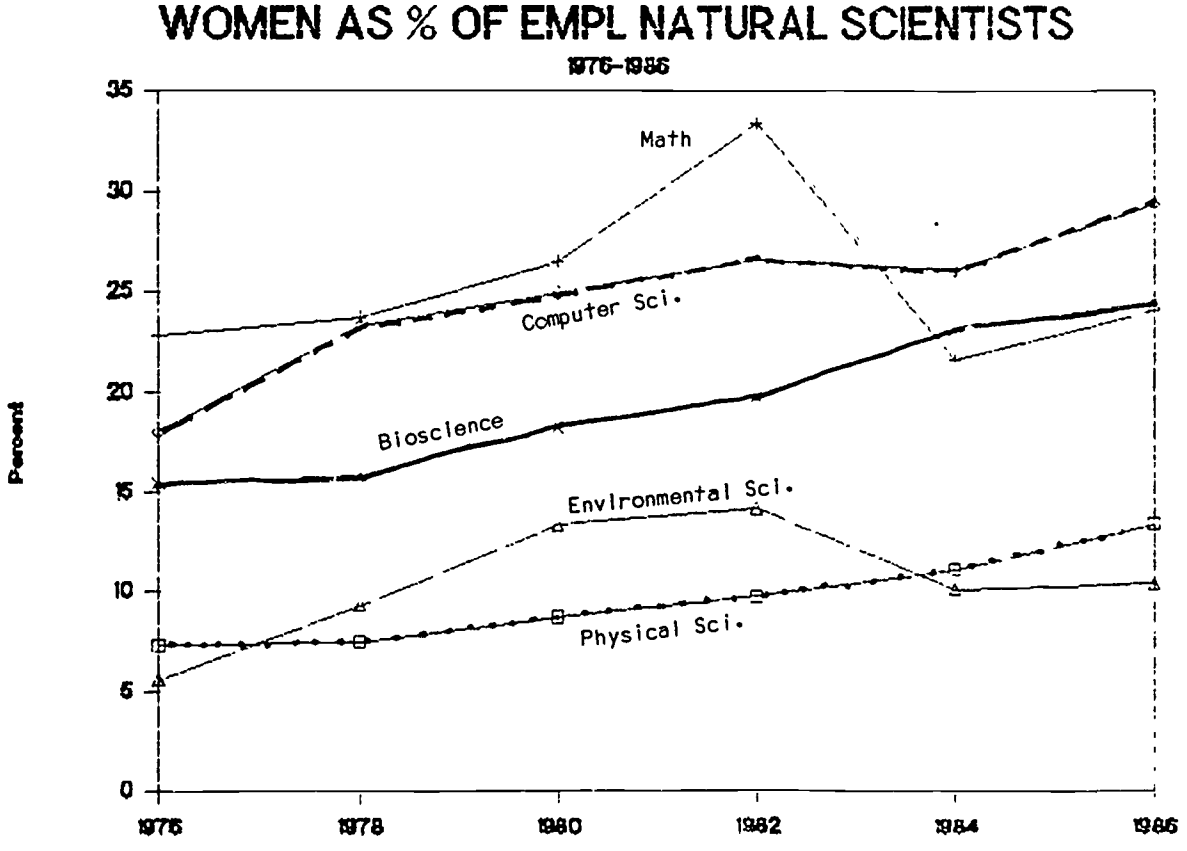


Figure 19



igure 20

PhD S/E UNEMPLOYMENT RATES

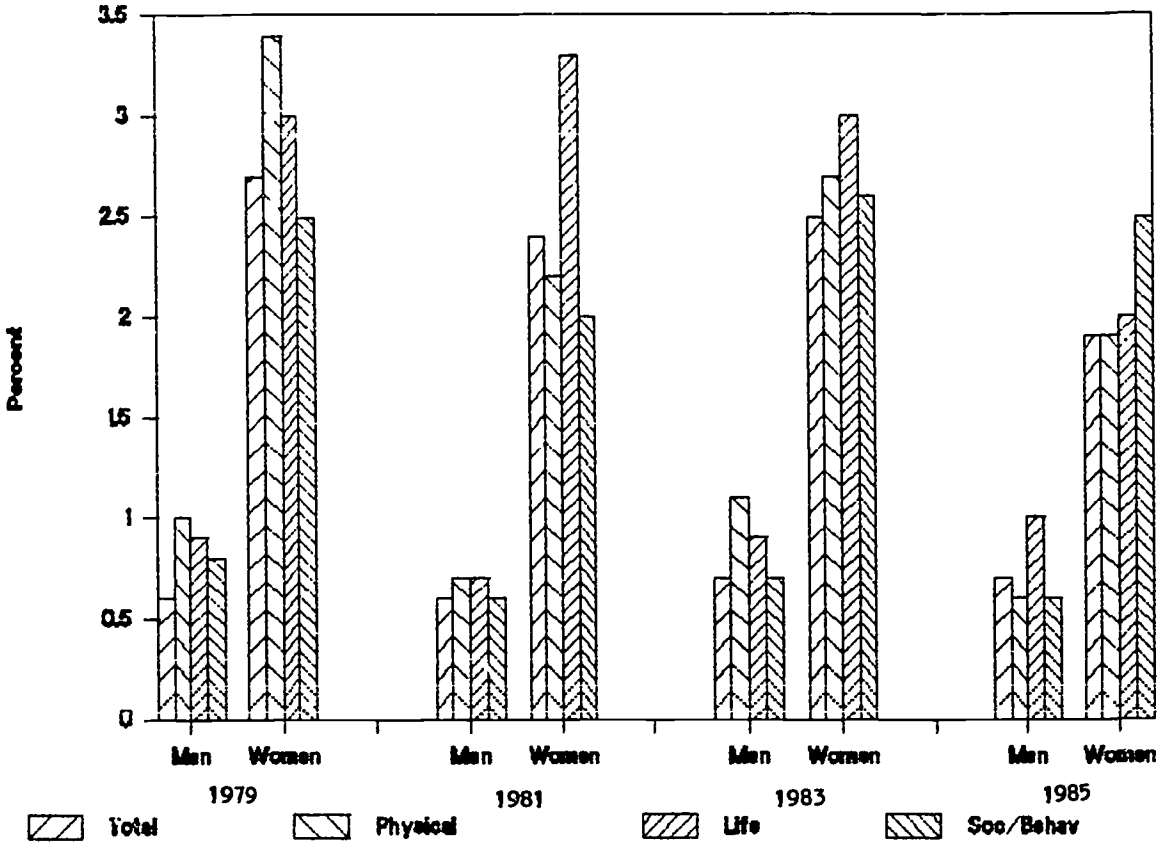


Figure 21

SALARIES OF DOCTORAL SCIENTISTS AND ENGINEERS - 1985

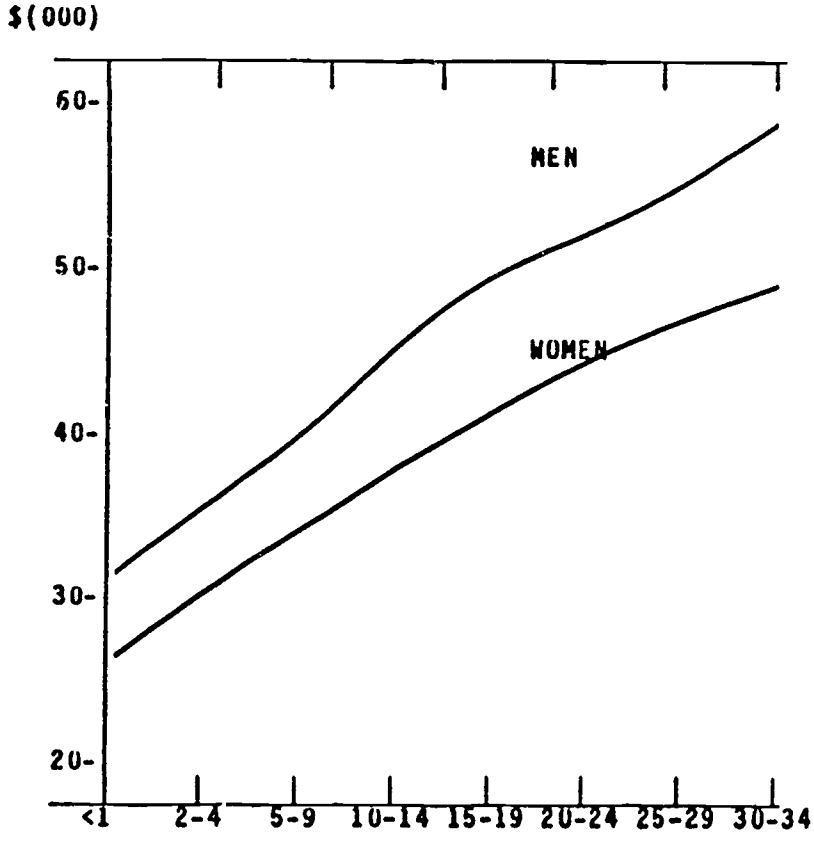


Figure 22

Data Source: National Research Council

six percent of environmental scientists, 19 percent of life scientists, 32 percent of psychologists and 18 percent of social scientists.

Even more than at the bachelor's level, women with doctorates in science or engineering earn salaries that lag those of their male counterparts. The gap widens with years of experience, just as it widens with higher degree level (fig. 22). Even when compared by both field and years of experience, women's salaries continue to average only about 80-90 percent of men's. This is because women are less likely to be promoted and less likely to move into managerial positions than their male colleagues. The penalty for being female ranges from a few hundred dollars per year in the first job following a bachelor's degree to $12,000 or more per year for doctoral women scientists after 20 to 30 years of work. In 1985, among doctoral scientists and engineers, the average salary difference is $10,500 per year - up from $9,100 in 1983 and $8,600 in 1981.

Academic Employment

Among those employed in academic institutions, the contrast between men and women is sharp in terms of salary, tenure or tenure track status and rank. Although the proportion of women among recent academic hires has increased, the number of men has increased far faster than the number of women (fig. 23). The proportion of women among scientists and engineers employed in academic institutions has changed very little since 1979 in engineering, math, computer sciences and physical sciences, where women are only seven percent of all professionals employed, but has increased several percentage points in the life and social sciences (fig. 24).

Even a decade has not been long enough to raise the proportion of women on faculties in engineering, mathematics and physical sciences to one women in ten. In the life and social sciences, however, one faculty member in five was a woman in 1985 (fig. 25). It is when tenure track status is examined that it is apparent how little progress women have made in entering permanent academic positions. In 1979, more than twice as high a proportion of women as of men were neither tenured nor on a tenure track. That was still true in 1987 (fig. 26).

SUMMARY

Although some progress has been made, serious problems continue to exist. Increases both in the number and the proportion of women earning degrees in natural science and engineering fields have stopped, well before

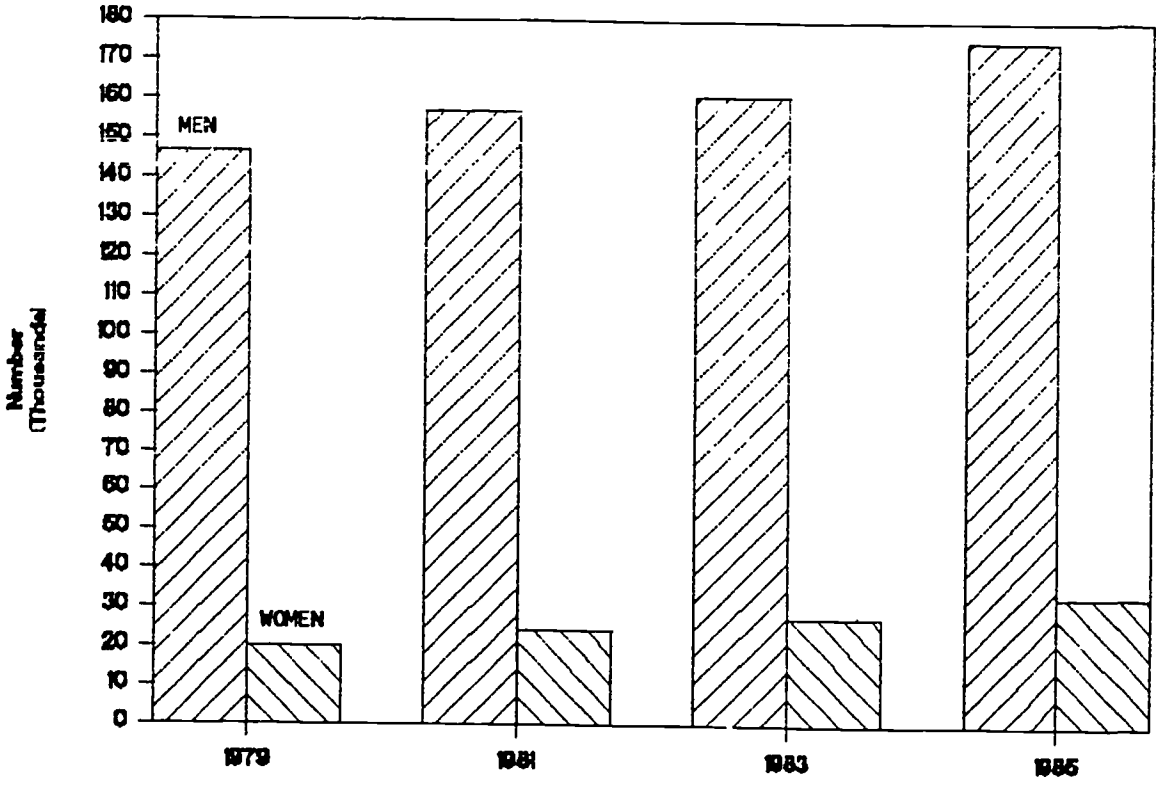


Figure 23

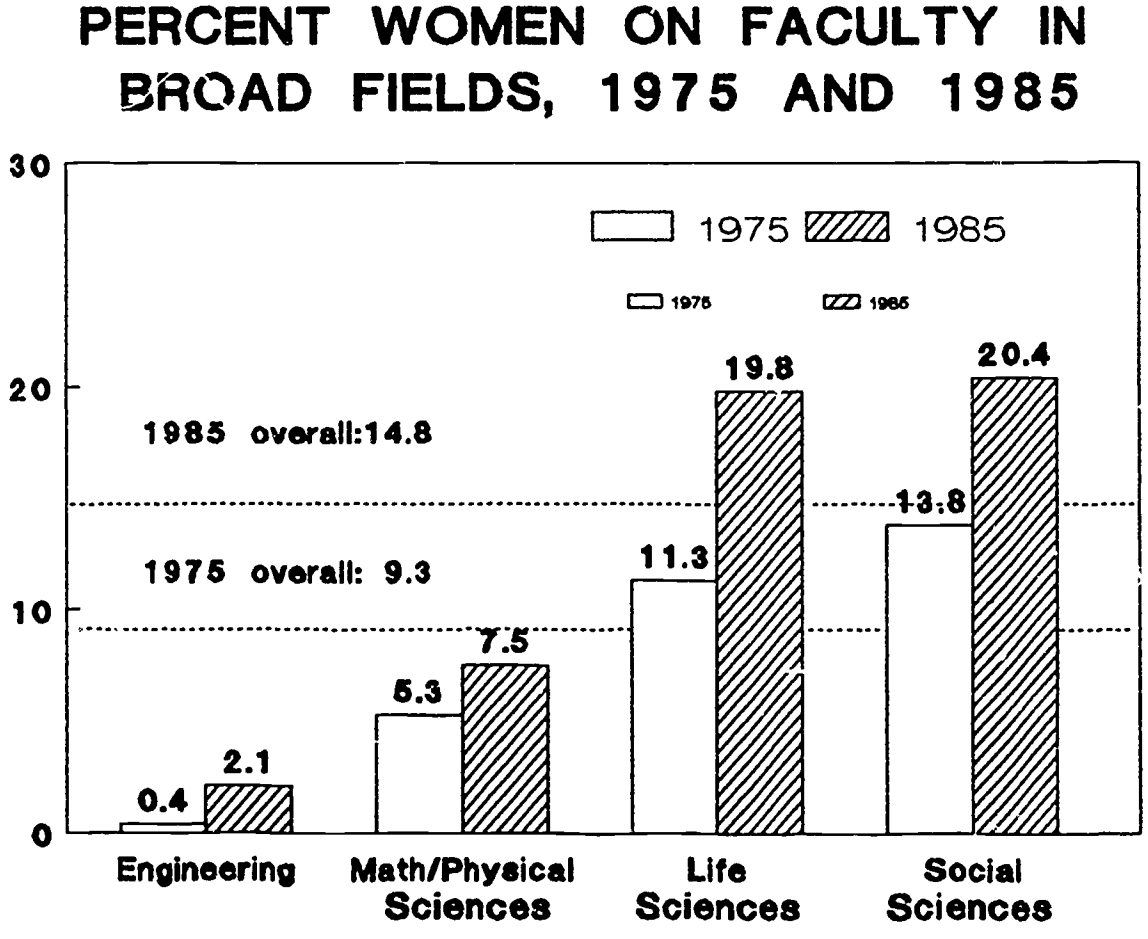


Figure 24

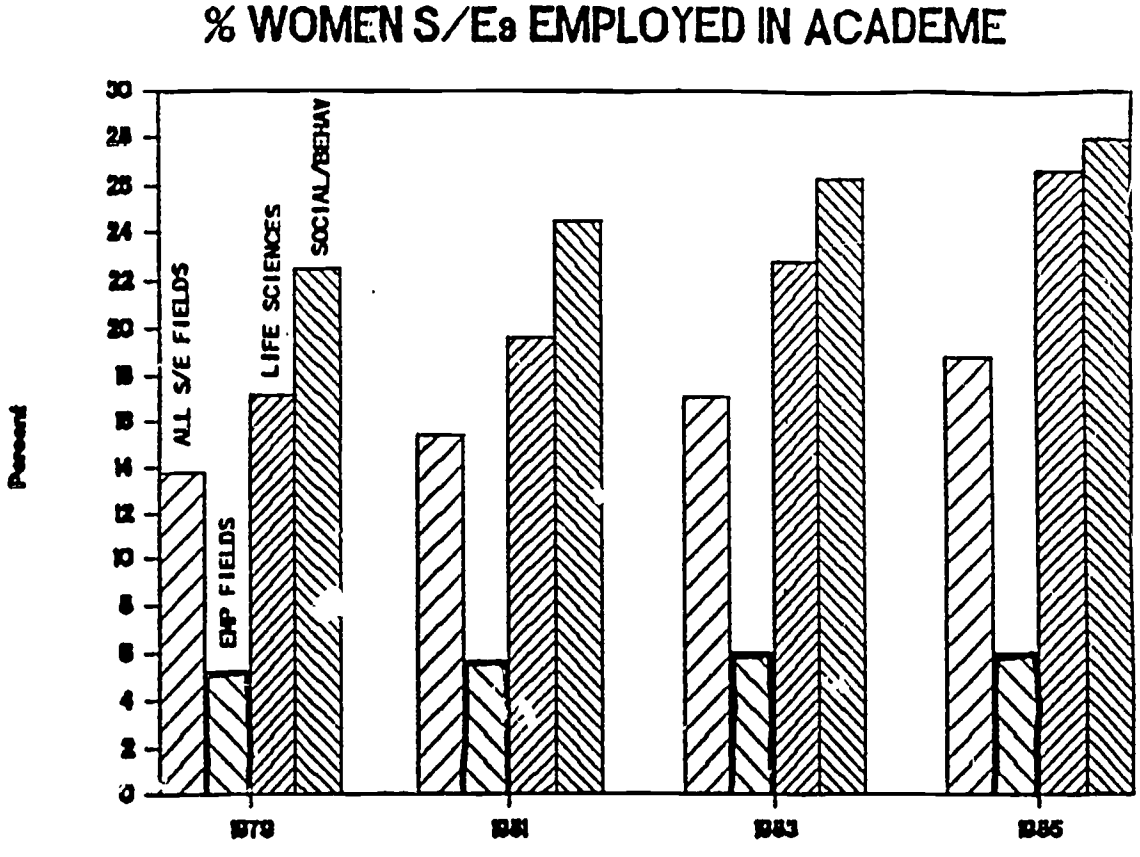


Figure 25

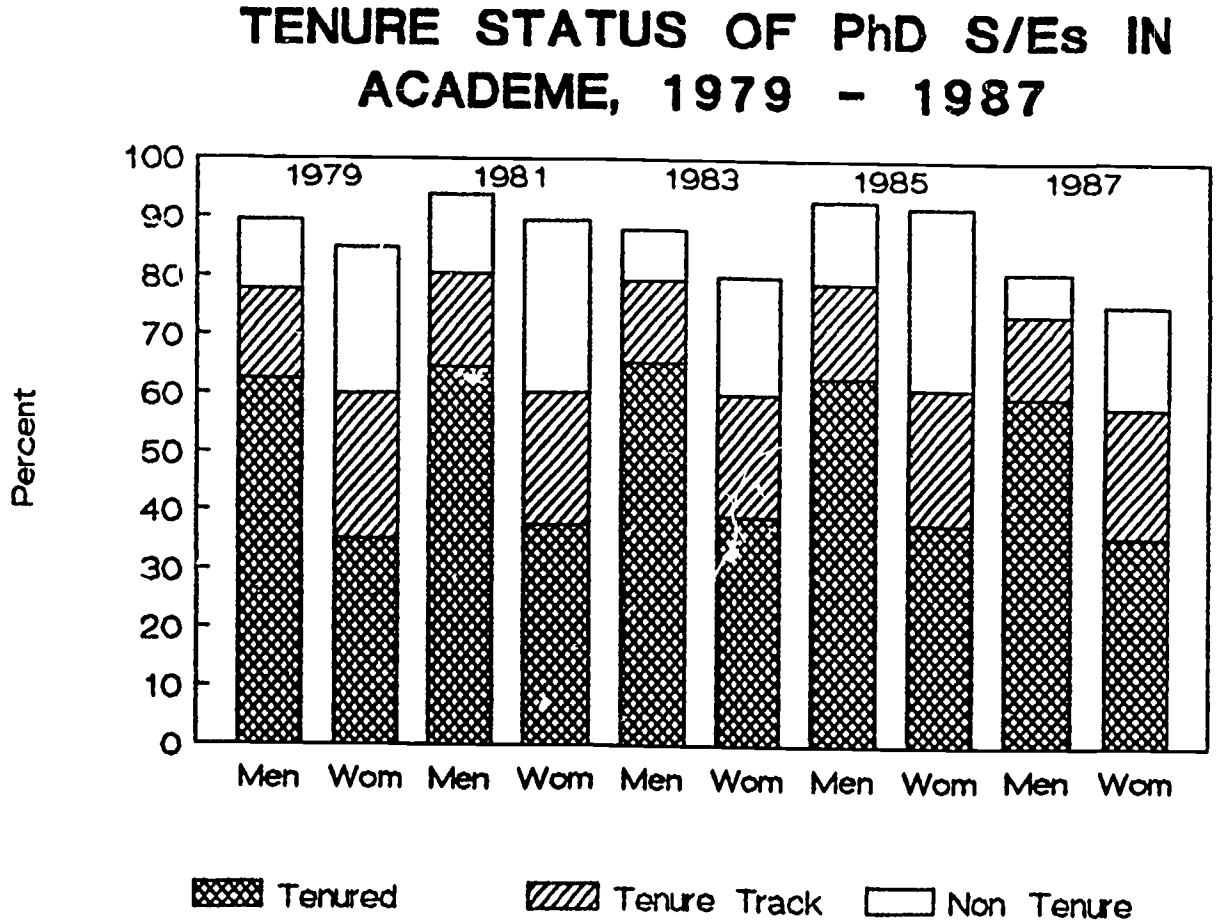


Figure 26

women achieved demographic parity. Although there are some indications that students of both sexes are going farther in high school mathematics than was true five years earlier, women are not increasing their registration in the advanced mathematics courses that may be required for college entry to engineering or some of the sciences. Women indicate a declining interest in majoring in these fields.

At least some of the reason for their declining interest in science careers may be found in their treatment in the labor force. Despite laws and executive orders requiring nondiscrimination, differential treatment of women and men has not disappeared, and equality of opportunity does not yet exist. Some of these problems are economic; others are societal. All have a negative effect on the achievement of women in science.

Women face other obstacles on the way to a science career. As science graduate students, they are less likely than men, including foreign men in the same field, to have either institutional or federal support during their graduate study; and they are more likely than men to be self-supporting.

After completing a doctorate, or even a lower degree, women find more difficulty in attaining a first position than do the men with whom they graduate. Over the past fifteen years, seven biennial surveys of the doctoral population have found that the unemployment rates of women doctoral scientists and engineers are two to five times higher than those of men.

Once they find a job, women are less likely than their male peers to find full time work when that is their choice; less likely to find a job in their field; and less likely to find an academic job in a tenure track. This is not a function of their more recent entry into the labor force, since at least twice as high a proportion of women as of men employed in academic institutions are neither tenured nor on a tenure track, and this difference has not changed in the past decade.

When employed, women continue to be paid less than comparable men, and the gap in salaries which is present even in the first job, widens with age. There is some improvement in narrowing the salary gap, but women still earn less than men in every field of science, regardless of degree or experience level.

It is not really surprising, then, that participation of American women in science has stopped increasing well before they reached demographic parity with men. But the nation can no longer afford to let the loss continue. The college

age population, from which we must draw most of tomorrow's American scientists and engineers, will continue to contract through 1998. The proportion of women within this smaller population who are choosing to major in science also is shrinking, as also is true for men. If this trend continues, America's ability to maintain international technological competitiveness over the next two decades is jeopardized.

Encouraging women and minorities to participate in science and engineering is no longer a matter of "affirmative action", to be carried out as a moral responsibility - it is a matter of national survival. America's talent pool includes equal numbers of males and females, who come in all skin colors. White males are a rapidly decreasing proportion of our population, who can no longer be expected to carry the total burden of responsibility for research, for government, and for most of the other leadership posts which must be filled. Women must be encouraged to continue to work toward attainment of their rightful place, in science as in other fields, as partners with men, recognized for their individual talents and contributions without regard to their sex. Equal treatment in school and the workplace, shared responsibility for home and family, and a change in societal attitudes toward girls and women are needed to achieve this goal.

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