Chapter 2
Opening STEM Careers to Women

Abstract This chapter examines the history of higher education for women, as well as the history of careers for women in science and engineering, in the United States. The first section discusses women's matriculation in college generally from 1900 to the present day. The next section presents a statistical overview of women in science and engineering from the early twentieth century to the present. The third section provides a qualitative analysis of the history of women in science since 1820. The final section provides a qualitative analysis of the history of women in engineering since 1918.

This chapter examines the history of higher education for women, as well as the history of careers for women in science and engineering, in the United States. The chapter relies heavily on a few sources, principally Margaret Rossiter's three-volume history of women in science and Amy Sue Bix's book on the history of engineering education for women. (Rossiter 1982, 1995, 2012; Bix 2013) Those readers who are familiar with the history of higher education for women or the history of science and engineering careers for women in America might not find much new in this chapter. However, many of the computer scientists, education specialists, and other social scientists who study women and the STEM disciplines, including computing, are not familiar with this material. The selection, slant, and augmentation of these two major authors have been designed to appeal to these readers who are carrying out research or interventions related to women and STEM (including computing).

2.1 College Matriculation of Women – A Brief History

In this section, we discuss women's matriculation in college generally. For many of the higher-level professional positions in the STEM and computing disciplines, a baccalaureate degree is necessary, typically with a significant amount of course instruction in the STEM or computing disciplines. A study by three Harvard

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economists (Goldin et al. 2006) provides a useful place to start this account, by tracing the history of the college matriculation of women in the United States.[1]

The numbers of women and men attending college were at approximate parity in the period from 1900 to 1930. However, women's enrollment was suppressed somewhat in the 1930s in part because of an increase in the number of so-called "marriage bar rules", which barred married women from working as teachers. These rules made less valuable the completion of a degree in education – one of the most common majors available to and chosen by female students. The number of men attending college began to increase at a faster rate in the 1930s and grew especially rapidly after the Second World War ended in 1945 (on account of the GI Bill) and during the Viet Nam War of the late 1960s and early 1970s (as a means of exemption from military service). For example, in the year 1947 there were 2.3 men attending college for every woman. Beginning in the 1970s, the trend began to reverse. Women began to attend college at a higher rate than they previously had, and gender parity in college attendance was once again achieved in 1980. Since that time, there have been more women than men enrolled in college. As of 2003, there were 1.3 female undergraduates for every male undergraduate.

Until the early 1970s, most female students selected (or in some cases channeled towards) college majors in traditional female-intensive disciplines such as teaching, English, and literature and regarded college primarily as a way to prepare for a traditionally female-intensive occupation such as teaching or social work, or as a means to find a husband.[2] This pattern changed radically in the 1970s and 1980s, and during this time the mean age of a woman's marriage rose significantly and contraceptive technology meant greater choice in when to have children. During these two decades, the women's labor force increased substantially and high school girls began to take more math and science courses in preparation for college.

The authors report gender difference in academic performance and subject area selection over time by reporting on national surveys conducted in the years 1957, 1972, and 1990. In all three of these surveys, high-school girls had significantly higher grades than boys, but in the first two of these periods, boys took more math and science courses in high school. No separate records on twelfth-grade math and reading achievement scores are available for 1957. In 1972, however, these breakouts are available: boys did better than girls in math, while girls did better than boys in reading. By 1992, girls had narrowed the lead of boys in math scores and had widened their lead in reading scores – and had a composite score that was higher than that of the boys. As for high school courses taken, in 1957 boys took far more courses in math and science than girls – and the differences were especially strong in advanced math, chemistry, and physics. Between 1972 and 1982 there was a strong increase in the number of girls taking math and science courses, and by 1992

[1] Other books on the history of women in higher education in America include Newcomer (1959), Graham (1978), Soloman (1985), Gordon (1992), Nash (2005) and Lucas (2006).

[2] I am following Goldin et al. (2006) here on the common intent of using college to find a husband. I do not know, for example, if it was any more common for women to seek a husband in college than for a man to seek a wife – not to mention homosexual or other relationships.

there was rough parity between boys and girls in the math and science courses taken (while girls still maintained a large lead in taking foreign language courses).

In the early postwar years, the socioeconomic background and parental education level mattered. In 1957, families in which the parents were more highly educated or of higher socio-economic status were gender-neutral about sending their children to college; however, in families with less-educated parents or lower socio-economic status, male children were much more likely than female children to be sent to college. By 1992, however, this pattern had completely changed, and at every socio-economic level parents sent more female children to college than male children. Interestingly, the gap between female and male children sent to college was greatest for those in the lowest half of the family socio-economic status distribution.

2.2 A Statistical Overview of Women in Science

We next present some statistical information about women in science. This material is drawn mostly from Margaret Rossiter's authoritative, three-volume history of women in science (1982, 1995, 2012).[3] Much of her data is compiled from the publication *American Men of Science*. Culling data from the 1906, 1910, and 1921 editions, Rossiter (1982, Table 1.1) found that only 439 women had received science baccalaureate degrees prior to 1920. The largest numbers of science degrees women received were awarded in botany (80), zoology (80), and psychology (67), with fewer than 50 degrees given in mathematics and every other scientific discipline. Engineering was not even listed. The top four producers of women scientists (i.e. where these scientists received their undergraduate degree) were all women's colleges: Wellesley (36), Vassar (34), Smith (29), and Mount Holyoke (26). The other schools that graduated 10 or more female students on their way to science careers were several additional women's colleges (Bryn Mawr, Barnard, and Goucher) and five coeducational universities (Cornell, Chicago, Michigan, Pennsylvania, and Nebraska). The leading messages from this data are the overall low numbers of female science graduates, the emphasis on the biological sciences, and the importance of the women's colleges.[4]

[3] Also see Rossiter's earlier research on women scientists in America, e.g. Rossiter (1974).

[4] Rossiter (1982, Table 2.1) also considered doctoral education of women. By the year 1900, 228 women had received doctoral degrees in any field in the United States. 56 had received science degrees, with the largest numbers in chemistry (13), math (9), and psychology (9). Bryn Mawr and Yale were tied with the largest number of doctoral degrees awarded to women in scientific fields, at four apiece. By the 1938 edition of *American Men of Science* the number of doctorates awarded overall and the number to females had increased significantly. The data is not reported in a way to make precise numerical comparisons, but Rossiter (Rossiter 1982, p. 152) infers from the literature that the largest producers of female scientific doctorates at the time were Chicago (strong in botany, mathematics, medical sciences, biochemistry, and nutrition) and Columbia (strong in nutri-

Comparing the 1938 publication with the 1921 version of *American Men of Science*, Rossiter (1982, Table 6.2) found that the number of female scientists had more than quadrupled over this period. The only scientific fields with more than 200 female practitioners in 1938 were zoology (281), psychology (277), and botany (256). Engineering shows up for the first time in the 1938 edition, with a total of eight female engineers. There is little change in the undergraduate institutions from which these female scientists receive their degrees. The same women's colleges are prominent, but among coeducational universities, Wisconsin and UC Berkeley climb into the top ten. (Rossiter 1982, Table 6.5)

Just after the Second World War, in 1946–1947, Rossiter (1995, Table 2.1) finds that women comprise 2.7 % of the science and engineering workforce, with only 0.3 % of engineers being women but 20.1 % of mathematicians being women. Over the period from 1954 to 1970, the percentage of women overall in the science and engineering workforce increased from 6.67 to 9.37 % of the workforce.

Considering advanced higher education, Rossiter (1982, Table 4.4) finds that, between 1947 and 1961, only 0.3 % of the engineering doctorates are awarded to women. The 5.5 % of the mathematics and statistics doctorates awarded to women is a surprisingly low number, given the active participation of women in the mathematical sciences workforce during the war.

Between 1970 and 2000, the total number of female scientists and engineers in the United States in all fields grew from about 80,000 to just under 200,000. (Rossiter 2012, Figure 3.1) The vast majority were scientists, not engineers. The number of baccalaureate degrees in engineering awarded to women increased from a few hundred (less than 1 % of all these degrees) in 1970 to approximately 12,000 (approximately 20 %) in 2000. (Rossiter 2012, Figures 3.2, 3.3) In computer science, the number of baccalaureates offered to women increased from just a few hundred in 1970 – with a steep rise between 1980 and 1987 – to approximately 14,000; and then they began to decline, stabilizing in the mid-1990s at around 8000. (Rossiter 2012, Figure 3.11) This pattern of decline in the late 1980s has perplexed many scholars and is the subject of continuing discussion.

2.3 Science Education for Women – A Brief History

Now that we have shared a few of the statistics from Rossiter's three-volume historical survey of American women in science, we selectively summarize from her narrative. Women participated in science in the United States in small numbers, beginning in the 1820s. Throughout the nineteenth century, gains were made in secondary and college education for women, thus preparing more women to pursue scientific careers. However, many of these women were channeled into the "nurturing sciences", especially domestic science and the medical sciences. In the late

tion, zoology, anthropology, and psychology) – followed distantly by Cornell, Johns Hopkins, and Yale.

nineteenth century, a new barrier to women's participation in science arose: the requirement of a doctoral degree to pursue a scientific career in the academy. This was a barrier because of the lag of 20–30 years before most doctoral programs began to admit women. As professional scientific societies were formed in the second half of the nineteenth century, women were often excluded from being members or were restricted to lower categories of membership. The number of women employed in scientific positions in the federal government increased between the two World Wars, but the hiring patterns showed gendered occupational differentiation, with most women working in jobs involving home economics, botany, microbiology, statistics, or clinical psychology.[5] Individual women scientists during the years before the Second World War often experienced isolation. As of 1940, women scientists, even if they held doctoral degrees, experienced significant barriers to scientific career advancement.

Although the 25 years following the end of the Second World War comprised a period of rapid scientific development, it was a low period for women, who often departed early from their scientific education or careers or were marginalized or underutilized in their scientific careers. Women experienced low pay compared to men in these scientific jobs and were often forced out if they got married; and there was little legal protection for their jobs or compensation. According to Rossiter, claims about the advancement of women in science during the Second World War are often exaggerated. Her data shows only a marginal increase in the participation of women in science created by the Second World War. Approximately 100 women scientists found temporary appointments in government and industrial war projects. Some women scientists who had been unemployed during the 1930s found temporary college teaching positions to replace men who were off at war. The total size of the scientific workforce almost doubled during the war years, but the percentage of scientists who were female grew only from 4.0 % in 1941 to 4.1 % in 1945. Rossiter argues that public opinion about women's proper role in society, even among some of the women scientists themselves, dampened growth in the number of women scientists.

The situation for women scientists deteriorated after the war was over. Overwhelming demand for a college education, paid for by the GI Bill, led to the rapid increase in college enrollment of male veterans. Partly to meet this demand, colleges set quotas or other restrictions on women's enrollment, beginning in 1946. The restrictions were especially widespread for graduate education.

If women had difficulties in studying to be scientists, there were also barriers to women scientists becoming faculty members in the 1950s and 1960s. Many of the places where women had traditionally taught – women's colleges, teachers colleges,

[5] Mathematics was one route into computer science, especially in the 1950s through the 1970s. Green and LaDuke (1989) describe the production of women receiving doctorates in the mathematical sciences prior to the 1940s. There is a surprisingly large literature on women mathematics through history. For an extensive bibliography, see the webpage entitled "Biographies of Women Mathematicians" created by Larry Riddle and colleagues at Agnes Scott College, https://www.agnesscott.edu/lriddle/WOMEN/women.htm (accessed 21 March 2016).

and home economics departments – were closing their doors to women faculty, and the newly created or expanded coeducational institutions did not hire women in large numbers. Some of the middling-quality teachers colleges tried to build institutional prestige in the first decades after the war by taking actions that were often antithetical to the interest of women scientists: getting rid of the "old girls" on their faculties, raising salaries and reducing teaching loads (to attract highly qualified male applicants), hiring more PhDs, and rebranding themselves as universities. The reinstatement of anti-nepotism laws after the war (focused primarily on husband and wife appointments), especially in the public universities, led to married women being forced to leave their current faculty positions or not being considered for faculty positions. Even single women were affected by these laws because university administrators worried that these women would eventually marry. At Smith College, historically one of the most important and most feminist-minded of the women's colleges, the percentage of women on the faculty dropped from 60 to 49 % between AY47-48 and AY 56–57. When women were hired as faculty members, it was often at a lower rank or to visiting professor or research assistant positions; typically at low pay; and in a number of cases the women faculty were not given full access to university facilities, e.g. not being permitted to use the faculty club where intellectual and power networks were built on campus. Few women received appointments as department chair or dean in the 1950s and 1960s, except occasionally at women's, junior, or teaching colleges.

In the early 1950s there was some interest in increasing opportunities for women in science to make sure the United States had enough experts to staff its national defense needs, but this interest subsided after the Korean War ended in 1953. Some limited interest appeared again in training and hiring women scientists in 1957, after the launch of Sputnik, on the basis of a need for more teachers in higher education for national defense purposes. In the late 1950s and early 1960s, while the government mildly encouraged young women to pursue science and engineering careers, graduate schools and employers did not show the same enthusiasm. Although the number of women entering graduate school increased in the 1950s and 1960s, women wanting to attend graduate school were at a disadvantage compared to men; they were severely limited in the set of schools that would admit them (often the most prestigious schools were not open to them), the fields open to them (in the sciences, women were often channeled to psychology and home economics), and the range of professors who would agree to supervise their studies.[6]

Career opportunities for women scientists were somewhat better in other nonprofit organizations during the 1950s and 1960s than in the universities. A significant number of women scientists found employment in federal labs, although leadership positions were seldom open to them. While opportunities for women scientists in industry grew during the 1950s and 1960s, most of the jobs available were in feminized occupations such as routine testing, home economics, and chemical librarianship – although there were also jobs for women as computer programmers. Women scientists were often underutilized in their work in industry.

[6] For more information on this topic, see Bix (2002).

In the 1950s, the American Association of University Women (AAUW) protested against the marginalization of women in the academy, but it had limited influence at the time due to complaints from the political Left that some AAUW chapters did not accept African American women, and from the political Right that AAUW members were Communist sympathizers. Betty Friedan, who had an undergraduate degree in psychology and a year of graduate study at UC Berkeley, was an inspirational figure in the 1960s for a number of the women (and a few men), agitating for a better situation for women scientists. In the late 1960s, increasing numbers of, and more strident, voices began to be heard.[7] 1972 was a watershed year for American women scientists with the passage of the Equal Employment Opportunity Act, the Educational Adjustments Act (including, most famously Title IX), and the Equal Rights Amendment – the last of these passed by Congress but not yet ratified by the states. Unfortunately, it became apparent at about the same time that the universities had produced a glut of science doctorates in the United States, reducing the opportunities for women newly entering the scientific workforce.

In the 1970s there was a growing infrastructure for women in science in the United States. A number of professional organizations became active, including the Association for Women in Science (discussed in Chap. 6), Association for Women in Mathematics, Association for Women in Psychology, and Sociologists for Women in Society. There were also women's committees within existing scientific societies such as the American Chemical Society and the American Physical Society, which were created or became more active in the 1970s. Also created in this decade was the low budget, but effective Office of Opportunities in Science, co-located with the American Association for the Advancement of Science. This Office produced reports and registries of women scientists. In 1975 the National Science Foundation created a Women in Science program, which by 1981 had supported 51 re-entry programs for women.

The politically well-connected chemist Lilly Hornig from the Higher Education Resource Service (HERS), a placement service, was highly critical of NSF's initial efforts concerning women in science.[8] She argued that the NSF program supporting women was buried in the education directorate and not associated with the more powerful research directorates; and that this program mainly sponsored remedial programs for women at the bachelor's and master's levels and did not address the problems found in the leading research universities. Her criticisms reached the ears of Senator Edward Kennedy, and he persuaded the NSF to convene a conference in 1977 of 60 young female scientists in the hopes of identifying new steps the federal government might take in improving the situation for women scientists. As part of

[7] One of the more strident voices was that of psychology professor Naomi Weisstein, who wrote a satirical piece entitled "How Can a Small Girl Like You Teach a Class Full of Big Men, and Other Things the Chairman Said" (Weisstein 1974, most readily found as a 1977 reprint) as well as "Woman as Nigger, or How Psychology Constructs the Female." (Weisstein 1969). This latter piece was reprinted in the *Congressional Record* as part of hearings on discrimination of women in higher education.

[8] For an excellent but dated (ending in the mid-1990s) account of women scientists and engineers at American research universities, see Part II of Hornig (2003).

this same story, the White House's Office of Science and Technology Policy provided funding to the National Research Council's Committee on the Education and Employment of Women in Science and Engineering, which was chaired by Hornig, to write two reports: *Climbing the Academic Ladder: Doctoral Women Scientists in Academe* (National Research Council 1979) and *Women Scientists in Industry and Government: How Much Progress in the 1970s?* (National Research Council 1980) These reports spelled out how poorly women scientists were faring in both the academic and industrial realms.[9]

During the 1970s, women scientists enhanced their political acumen and political power. The principal organization through which this happened was the Federation of Organizations for Professional Women, which represented more than 100 women's groups interested in Washington science policy. The organization was active from 1972 until the early 1990s. Perhaps the most important figure involved with this organization was the political scientist Janet Welsh Brown from the Office of Opportunities in Science. One of the largest political goals of women scientists in the 1970s was ratification of the Equal Rights Amendment. It had been introduced into every Congress since 1923 and was passed by both the House and Senate in 1972, but it needed to be ratified by 38 states. Getting approval from the final three states needed for ratification turned out to be a major political challenge. The National Organization of Women boycotted states that had not yet ratified the Amendment. The American Association for the Advancement of Science followed suit in 1979, when it broke a hotel contract in Chicago in 1979 and moved its annual meeting to Houston in support of the NOW boycott. Nevertheless, the Amendment was never ratified by the required 38 states.

Instead, the major political success for women scientists of that era was the passage in 1980 of the Science and Technology Equal Opportunity Act. The bill had failed to achieve passage in 1978, and the 1980 version was a weakened version. It created the Committee on Equal Opportunities in Science and Technology (CEOST) to advise the NSF director and provided modest funds for visiting professorships for women and some other programs.[10] (For more information on CEOST, later renamed CEOSE, see Aspray (2016).)

Political action was supplemented by legal action during the 1970s. While there was some modest voluntary improvement in the employment practices concerning women faculty at some universities, change in the 1970s came primarily through a series of lawsuits against universities under the Equal Employment Opportunity Act, which generally had lax enforcement until there was pressure of legal action. The three most significant cases of the 1970s were *Johnson v. University of Pittsburgh* and *Lamphere v. Brown University*, which both involved female assistant

[9] There was far from total sympathy for the plight of women scientists. One highly public example was the book published in 1979 by sociologist Jonathan Cole, entitled *Fair Science: Women in the Scientific Community*. (Cole 1979) Cole argued on the basis of a citation analysis that women deserved their second-tier status in science because of the quality of their work.

[10] For more information about the Women in Science and Technology Equal Opportunity Act, see Puaca (2014), Sheffield (2005) and National Research Council (2007).

professors being denied tenure as the universities practiced what came to be known as the "revolving door policy," and *Rajender v. University of Minnesota* in which Shymala Rajender was underemployed (denied a tenure-track appointment) on the basis of sex. These and other court cases moved universities to change their personnel policies. The 1970s also witnessed several lawsuits over equal pay for women academics.

Government support for women academics deteriorated in the 1980s during the Reagan Administration, when its fiscal conservatism limited funds that might have been used for improving the situation and because it relaxed enforcement of the equal opportunity laws and, in particular, gave a narrow interpretation of the Title IX provisions of the Educational Amendment Act as applying mainly to athletics. For all of these reasons, and for the fact that tenure-track positions turn over slowly, increases in the number of women in tenure-track positions increased slowly in the 1970s and 1980s. Change was particularly slow in the fields of chemistry, math, physics, economics, and engineering.

Another factor that affected women in academic positions in science and engineering were changing patterns in higher educational institutions. Between 1968 and 1985 approximately 40 major men's colleges and universities, including for example Bowdoin and Princeton, began admitting women. Since many of these schools offered strong programs in the STEM disciplines, this coeducation movement created a new opportunity for women students to obtain a STEM undergraduate education. However, in most of these schools there were only a few women majoring in the STEM disciplines, perhaps because of an environment that favored men over women, such as professors calling more frequently on men than women in class.[11]

Historically Black colleges and universities had been under duress during the late 1960s and early 1970s, when many African American students elected to attend majority institutions. But in the period 1978–1994, with strong federal support, the HBCUs began to grow again. Typical undergraduate enrollment at an HBCU was more than 50 % female, and about half of all African American women who earned science and engineering doctorates attended HBCUs as undergraduates. Spelman and Bennett Colleges, in particular, were important feeders into this system.

The number of women's colleges in the United States dropped from approximately 200 in 1970 to only 90 in the 1990s. However, the top women's colleges made concerted efforts to strengthen themselves in order to survive in these years – with stronger student recruitment, better salaries to attract more qualified faculty members, and improvements in the physical plant including science facilities. Although the women's colleges enrolled only about 2 % of college students, a disproportionately large number of these students attended graduate school and entered science careers.

[11] For more on why undergraduate women remain in or depart from science majors, see Seymour and Hewitt (1997).

Between 1970 and 2000, the number of women completing doctoral degrees in science and engineering rose from 1648 to 9396.[12] There seem to be many reasons for this increase: more women actively seeking professional careers, some improvement in the academic climate for women at least at some universities (although there was great variation by both institution and discipline), more equitable distribution of fellowship funding, a slightly larger number of women faculty members to serve as role models, increasing sizes of female cohorts in some schools and some disciplines (e.g. in the psychological and biological sciences, not so much in engineering) that helped reduce student feelings of isolation, creation of women in science programs on campus, and establishment of local campus chapters of national organizations to support women such as SWE and AWIS – as well as, of course, equal opportunity laws. Despite all of these changes, many graduate programs continued to have chilly climates or outright discrimination, and most scientific and engineering departments remained overwhelmingly male.

2.4 Engineering Education for Women – A Brief History

We now turn to the history of engineering education for women, relying heavily on the writings of Amy Sue Bix (especially 2013, but also 2000, 2002, 2004). The first engineering departments were formed in the United States in the 1810s and 1820s – at West Point, Norwich University, and Rensselaer Polytechnic Institute. Civil, mining, and mechanical engineering developed first among the engineering disciplines. The first electrical engineering departments were formed in the 1880s at MIT and Cornell. By the end of the nineteenth century, each of the major engineering fields had formed its own professional organization in the United States.

The first efforts to organize women in the engineering disciplines came in the 1910s.[13] The earliest identified group is a local group of women engineers, the T-Square Society, at the University of Michigan. It was formed in 1914 by the thirteen female students then enrolled in engineering and architecture, with the intention of providing a meeting place for these students to socialize and discuss topics of mutual interest.[14] According to a survey taken in 1919, there were 43 women engineers at the University of Michigan at that time – possibly the largest concentration of women engineers on any American campus. This survey of women engineering students and graduates was conducted by women engineers at the University of Colorado at Boulder, who in 1918 had founded what they called the American

[12] For more on the graduate education of women in science and engineering, see Sonnert and Holton (1995a, b) and Long (2001).

[13] The leading scholar of the history of women in engineering in the United States is Amy Sue Bix. She has consolidated a number of her earlier studies into a book (Bix 2013). For those who want to read an article-length version of the material in her book, see Bix (2004). The account in this section relies heavily on Bix's writings.

[14] See Bix (2013) for additional information about the T-Square Society.

Society of Women Engineers and Architects. They polled twenty universities and identified approximately 200 women enrolled in the study of engineering across the nation. The American Society of Women Engineers was never able to build a national membership, but two of the women from the University of Colorado involved with the survey, Hilda (Counts) Edgecomb and Elsie Eaves, helped to create the Society of Women Engineers after the Second World War.[15]

The timing of the survey is perhaps not coincidental. During the First World War, in which the United States participated during 1917 and 1918, there was "a sudden influx of women into such unusual occupations as bank clerks, ticket sellers, elevator operator, chauffeur, street car conductor, railroad trackwalker, section hand, locomotive wiper and oiler, locomotive dispatcher, block operator, draw bridge attendant, and employment in machine shops, steel mills, powder and ammunition factories, airplane works, boot blacking and farming" (*Seattle Union Record* (1918) as quoted in Kim (2003)). Women worked during the war in munitions factories, and there are occasional references to women holding engineering jobs. The war work done by women, as nurses on the war front and in offices and factories on the home front, was recognized by President Woodrow Wilson when he addressed the U.S. Senate in September 1918 to urge it to join the House in approving the 19th Amendment, which gave women suffrage. (Gavin 1997; Goldstein 2001) However, these women were treated as replacements for the men away at war and were expected to surrender those jobs to returning servicemen. Opportunities for women in engineering were uncertain in 1919, when the University of Colorado women sent out their survey.[16]

Until after the Second World War, the number of women who studied or practiced in any of the engineering fields remained small.[17] During the Second World War there was a shortage of engineers to work in the factories building guns, tanks, aircraft, and other devices for the war. A number of companies, such as General Electric and the Curtiss-Wright aircraft company, hired women with basic math and science skills and trained them to work as engineers. For example, Curtiss-Wright provided intensive 10-month training to its Cadettes on college campuses (Cornell, Iowa State, Minnesota, Penn State, Rensselaer, and Texas) to prepare them to move

[15] More detail about the University of Colorado activities can be found in Bix (2013).

[16] The situation for women working during the First World War was similar in Britain and the United States. For an insightful and detailed account of the British situation, see the keynote lecture by Patricia Fara of the University of Cambridge (Fara 2014). Human computers had been used in astronomy research since 1750, when Alexis Claude Clairaut had used Newton's laws of motion to calculate the return of Halley's comet in 1759. Most of the "computers" as these human calculators were called were men until the Harvard University astronomer Edward Charles Pickering employed a team of women to do his computations. It is possible that the First World War gave women a chance to serve as computers, taking up jobs that had been by men who had gone off to war. For information about human computers, see Grier (2005).

[17] Another organization, the American Society of Women Engineers and Architects, was founded in 1920 as a support network for practicing female engineers. It also encouraged and advised young women who wanted to be engineers. Membership was always small, and the organization had become largely inactive by the entry of the United States into the Second World War in 1941.

into the company's research and production facilities. But just as in the First World War, when the war ended most of the jobs reverted to the returning veterans.

A number of women who had practiced as engineers, plus a few supportive men, agitated for opening up the engineering professions to women in the postwar years. Female students on the campuses of Iowa State, Syracuse, and Cornell created women's groups or honorary societies to support women wanting to study engineering. In 1952 Georgia Tech opened admission to women, despite considerable opposition from students, faculty, and alumni.[18] The most important response perhaps was the creation of the Society of Women Engineers (discussed in Chap. 6).

During the 1950s and 1960s, although admission to some of the leading engineering schools in the United States was open to women, the numbers of female engineering students remained small and public sentiment was skeptical about whether women could be good engineers. In the 1950s, female engineering enrollment in the United States grew from approximately 700 to 1700 – thus growing in this time period from 0.35 to 0.60 % of all engineering students.[19]

Change started to occur at a faster pace in the mid-1960s. A major symposium on American Women in Science and Engineering was held at MIT in 1964.[20] That same year, Congress passed the Civil Rights Act barring discrimination on the basis of sex (as well as race, color, religion, or national origin), and the National Organization for Women pressured the Equal Employment Opportunity Commission to enforce the law. While major companies complied with the law and actively recruited women engineers, both the engineering educational system and the engineering workplace remained overwhelmingly male. As of 2000, university engineering departments had few female students and few female faculty members, especially at the higher ranks; while engineers in the workforce remained predominantly male, and female engineers were not promoted as rapidly or given advances in compensation as rapidly as males.[21]

[18] For more information about admission of women engineering students at Georgia Tech, as well as at Cal Tech, MIT, and RPI, see Bix (2000).

[19] These statistics are summarized from McGreaham (1963) as reprinted in Bix (2013).

[20] In fact, events had almost gone the other way at MIT: "in 1960, a fundamental change of course had occurred. An MIT faculty committee majority report recently had recommended that MIT cease admitting women, which would have placed MIT on the wrong side of history and counter the changes occurring at other technical universities where women were being admitted to engineering programs for the first time. Happily it was a minority report by Kenneth Wadleigh which won support by President James Killian and his Chancellor Julius Stratton, and the decision was made not only to continue to admit women, bit to actively work to improve the environment and resources available for women students." (http://1964.alumclass.mit.edu/s/1314/2015/club-class-main.aspx?sid=1314&gid=55&pgid=11879)

[21] On the choice by women of an engineering education or career, see Frehill 1997.

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