

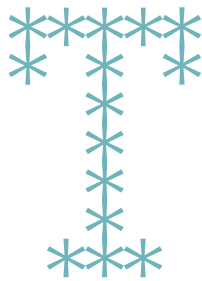


by CLAUDIA GOLDIN

a brief  
history  
of the quiet  
revolution  
that transformed  
women's work

# from the valley to the summit

**We can have a  
meaningful  
discussion  
today about  
“women at  
the top”  
only because  
of a quiet  
revolution  
that took  
place 30  
years ago**



THROUGHOUT RECORDED history, individual women have reached summits, and their accomplishments have been touted as evidence that women could achieve greatness. But it has taken considerably longer for substantial numbers of women—more than a token few—to reach the peaks. Until recently, the vast majority of women—even college graduates—occupied the valleys, not the summits. They had jobs, not careers.

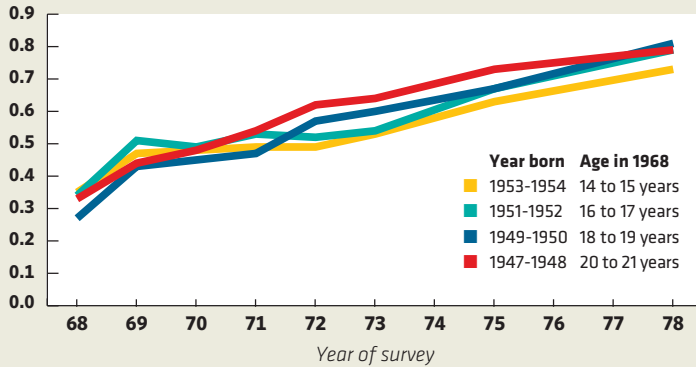
The only reason we can have a meaningful discussion today about “women at the top” is because a quiet revolution took place about 30 years ago. It followed on the heels



## Changing expectations about paid work...

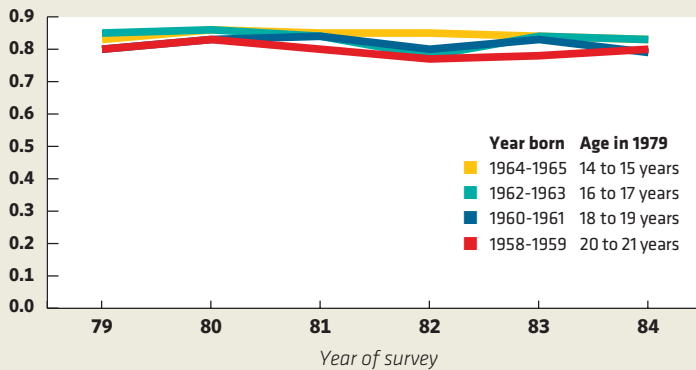
During the 1970s, the fraction of young women who expected to be working for pay at age 35 rose sharply, climbing to between 70 and 80 percent.

Fraction of women who expected to be working for pay at age 35



By 1979, the shift was in place, with virtually no further change during the 1980s.

Fraction of women who expected to be working for pay at age 35



Note: Data using the 1979 NLSY (lower panel) include in "expect to be working at age 35," individuals who said they would be married and raising a family at age 35 but, when questioned further, said they wanted to be working. Excluding this group reduces the average answer to around 0.65 to 0.70.

Sources: National Longitudinal Survey of Young Women, 1968 (upper panel) and National Longitudinal Survey of Youth, 1979 (lower panel)

of a noisier revolution, although the quiet one had greater long-run impact. The revolution was accomplished by many who were unaware they were part of a grand transformation that would deeply affect women and their families for decades to come. They were the unwitting foot soldiers of an upheaval that transformed women's employment and the workforce.

This transformation was startlingly rapid, thus the term "revolution," not evolution. The break occurred over a relatively brief period from the late 1960s to the early 1970s, and for women born during the 1940s and later. We can see the abruptness of the transition in a number of social and economic indicators: young women's expectations about their future work life, their college graduation rates, attainment of professional degrees, age at first marriage, and labor force participation rates all show sharp breaks and turning points during this short interval. Women's choice of college major and occupation also exhibit evidence of a shift during these years.

Perhaps it is not surprising that these factors would change around the same time, since they are all interrelated. When young women have expectations of high labor force participation, they are likely to alter their college programs and college graduation rates. Advanced degree programs, for example, are necessary for certain occupations. Particular college majors are required for certain advanced degree programs. Career aspirations will encourage women to marry and begin their families later; in turn, a later first marriage will serve to facilitate women's career development.

In the sections that follow, I present and discuss these factors. In the last section, I explore some of the explanations for why the quiet revolution occurred.

### The revolution in expectations about labor market work

In 1968, when young women 14 to 21 years old were asked by the National Longitudinal Survey (NLS) about their future labor force plans, their answers reflected the current labor market activity of their mothers, their aunts, and possibly their older sisters. Only about 30 percent said that they expected to be in the labor force at age 35. Most had mothers born between 1922 and 1929—a group with labor force participation rates at age 35 of about 30 to 35 percent. Yet the future labor force participation rates of these young women (of those ever-married born 1951 to 1954) would in fact be about 65 percent at age 35. That is, young women's expectations were more in line with what older women were currently doing rather than with what their own futures would actually hold.

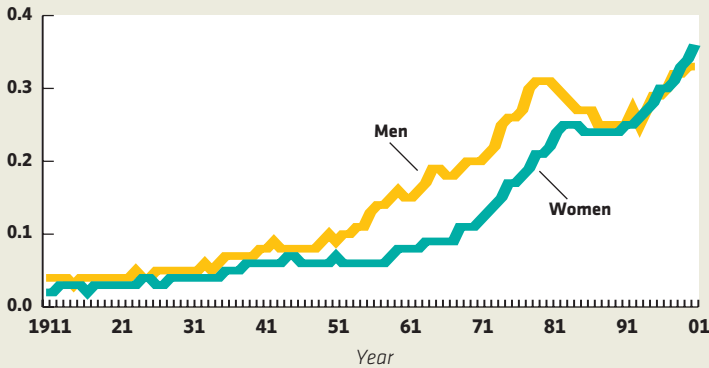
But in the late 1960s and the early 1970s, something began to change. In 1975, the fraction of young women who expected to be working at age 35 reached 65 percent, more than double the response seven years earlier and more in line with their future rates. Even comparing 21-year-olds in 1968 with 21-year-olds in 1975 shows an increase in expected participation of about 35 percentage points. In fact, the expectations of all cohorts increased at the same time and by about the same amount. Furthermore, this period of rapid change in expectations ended by around 1980. Responses to similar questions asked by a later version of the NLS, begun in 1979 with a group of young women 14 to 21 years old, reveal virtually no change either by age or by year from 1979 to 1984—a very different picture from the sharp increase in expectations of future employment by young women from 1968 to 1978.

Thus, by the mid-to-late 1970s young women's plans were considerably different from a decade earlier, with the turning point in the late 1960s and early-to-mid 1970s. Expectations about participation in paid work no longer mimicked the experience of their mothers, but were in line with, if not somewhat higher than, the levels they would eventually achieve.

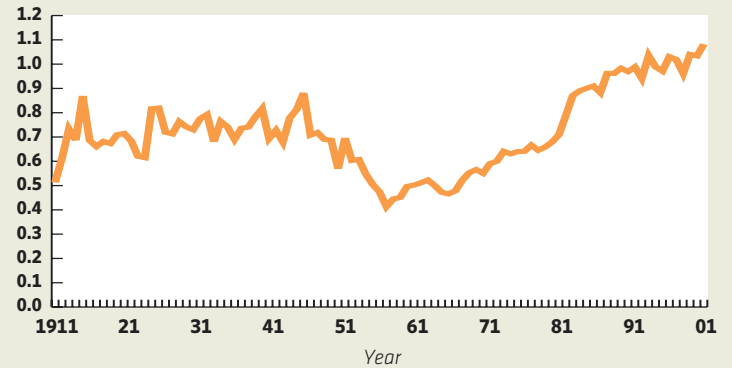
## ...lead women to greater investments in career-oriented education

As the revolution in expectations begins, women are already increasingly attending and graduating from college.

Percentage of population at age 35 that are college graduates

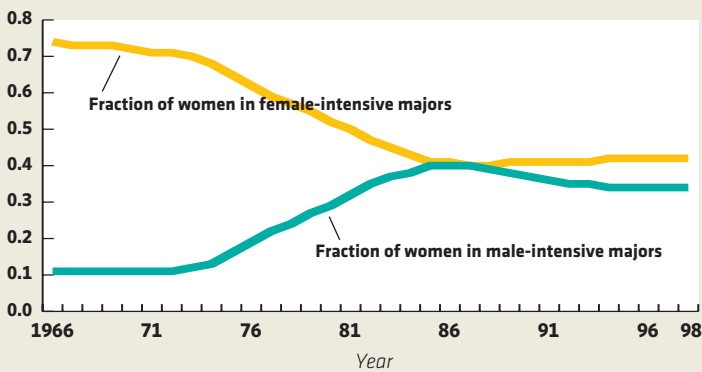


Ratio of female to male college-graduate shares of the population at age 35

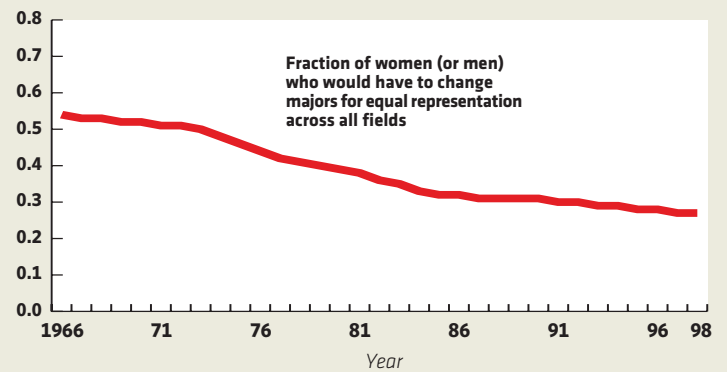


Their choice of college major becomes more similar to their male counterparts.

Fraction in gender-typical majors

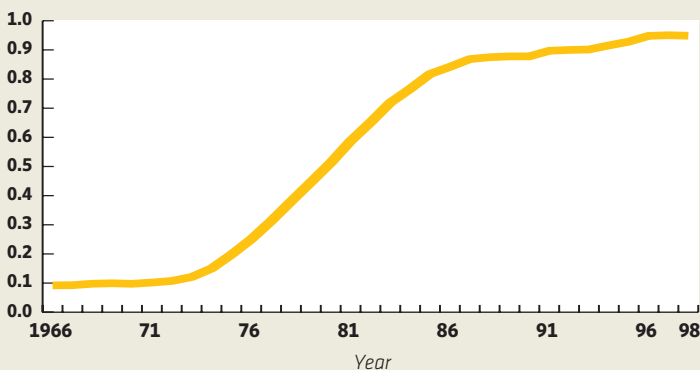


Dissimilarity index

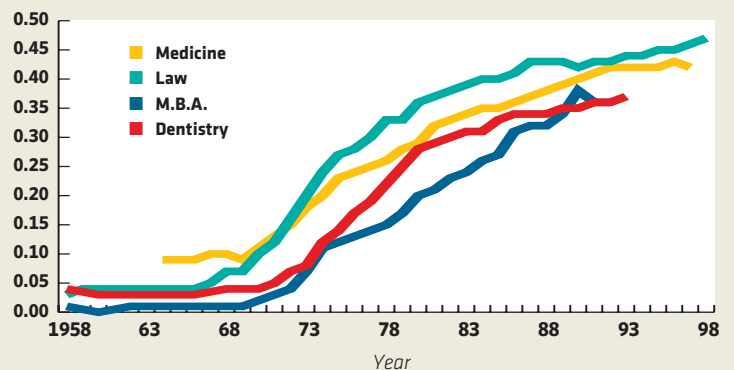


Especially notable is the sharp rise in the share of women majoring in business and management and enrolling in professional programs that had previously been entirely male.

Ratio of women to men in business and management major

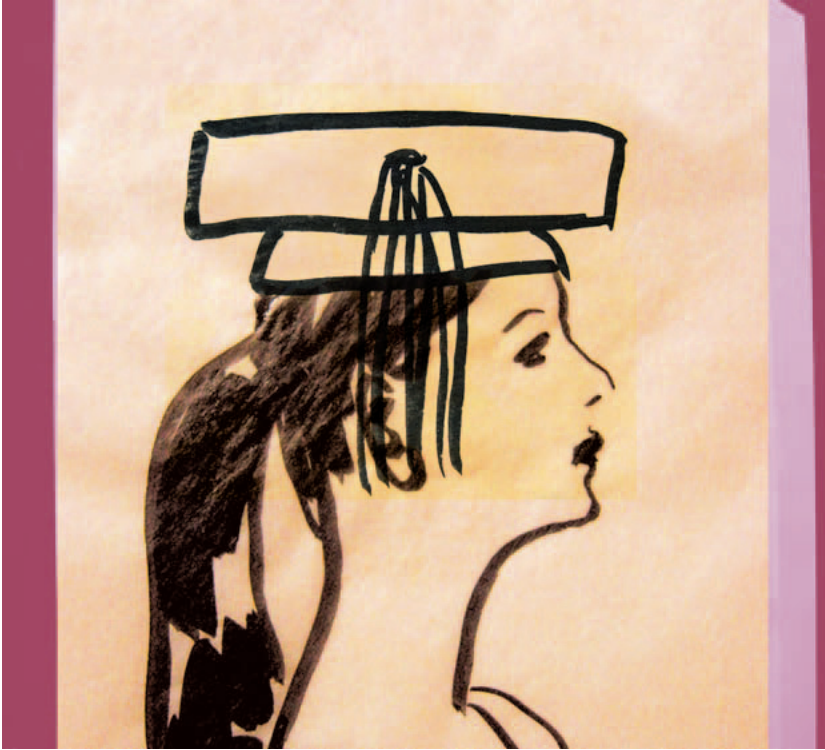


Share of women among first-year students in selected professional programs



Notes: Upper panel: College graduate is 16 years of schooling or more through 1980, and a bachelor's degree or higher in 1990 and 2000. Middle panel: Female-intensive (or male-intensive) majors are those in which the share of women (or men) is 0.5 standard deviations above the mean in 1970, using 1970 weights. Out of 53 majors, 11 were female-intensive, 31 were male-intensive, and 11 were neither. Female-intensive majors were anthropology, arts & music, non-science education, English & literature, foreign languages, health technologies, linguistics, other life sciences, social services professions, sociology, and vocational studies & home economics.

Sources: Integrated Public Use Microdata Series of the U.S. Censuses, 1940-1990; Current Population Survey, 1990 and 2000; National Center for Education Statistics, U.S. Department of Education; *Journal of the American Medical Association*; American Bar Association; and *Digest of Education Statistics*, U.S. Department of Education



### The shift in education from consumption to investment

Although not all the young women surveyed above would attend or graduate from college, the implication for professional advancement is clear. Young women (and men) who have a more accurate assessment of their future labor market involvement will invest more wisely in education and training, whether attending and graduating from college, choosing a college major, or enrolling in a professional degree program.

**COLLEGE MAJORS.** In 1966, almost 75 percent of women graduating from a four-year college majored in subjects in which most of the students were female. About 10 percent specialized in a subject for which most of the students were men, about the same fraction as in 1960; and about 15 percent majored in gender “mixed” fields, such as math, psychology, sociology, anthropology, linguistics, history, and arts & music.

Moreover, fully 40 percent of women college undergraduates majored in education—at a time when that major was 78 percent female. About 17 percent concentrated in English literature or foreign languages (combined, 68 percent female). And 3 percent were in home economics and social services professions (92 percent female). Thus, 60 percent (40 + 17 + 3) of all female undergraduates majored in one of three female-dominated concentrations (or combined concentrations).

By contrast, 50 percent of men in 1966 majored in either science (except “other life sciences”), engineering, or business & management. Most of the women’s concentrations could be classified as “job” or “consumption” oriented (e.g., education and literature), whereas those of the men as “career” and “in-

### Women increasingly chose career-oriented majors that often led to advanced degrees

vestment” oriented (e.g., engineering, and business & management).

Another way to show the separation of the sexes is to compute a standard index of dissimilarity. The index uses the full range of the 50-plus concentrations for which we have data and measures the percent of women (or men) who would have to change concentrations for equal representation across the fields. This calculation shows that more than half of all women (or men) would have had to change concentrations to create equality by sex in all fields in 1966.

But in the early 1970s, the sex segregation of undergraduate majors fell markedly. The break is especially sharp for the fraction of women in male-intensive majors, but it is also apparent for the fraction of women in female-intensive majors and in the sex segregation index.

The proximate reasons for this change can be found in the enrollments in two large concentrations: education and business & management. The relative decrease in women’s enrollment in education depressed the fraction of women in female-intensive majors, while their relative increase in business & management boosted the fraction in male-intensive majors. By 1980, only about 20 percent of women were majoring in education; by 1998, the figure had dropped to 12 percent. Because of the increase in women’s college participation rates, the number of women majoring in education continued to rise from 1966 to 1973. But it has declined

steadily since 1973, despite the continued increase in the fraction of young women attending and graduating from college.

The reverse trend can be found in business & management. Only 2 percent of all women college graduates majored in these fields in 1966; the figure rose to 22 percent in 1988, the height of its relative popularity among all undergraduates. Because women also increased their numbers as undergraduates relative to men throughout the period, the ratio of women to men majoring in business & management majors increased at an even greater rate, climbing spectacularly from 0.12 in 1973 to 0.84 by 1986.

Therefore, beginning in the early 1970s, female undergraduates radically changed their concentrations. They moved out of majors that led to traditionally female occupations. They moved into those that were career-oriented and often led to advanced degrees. And their majors shifted to subjects that were more similar to those of their male counterparts. Differences in the college majors of men and women still exist but are considerably less significant than they once were. In 1998, about 27 percent of women (or men) would have to change majors for equality

across the fields, about half the rate in 1966.

**COLLEGE DEGREES.** The fraction of women graduating from four-year institutions of higher education increased greatly for women born from 1941 to 1951. This coincided with an increase for men due, at least in part, to Vietnam War draft deferments. But enrollments for men decreased substantially for those born from 1946 to the early 1950s, while enrollments for women continued to rise. Thus the ratio of women to men graduating from college soared for those born from 1946 to 1956, rising from 0.65 to more than 0.95.

This ratio began to rise for precisely the same women that underwent the change in college majors described above—women born in the 1940s, and graduating college from the late 1960s to the early 1970s. Such a change was not unprecedented—the ratio of female to male college graduates increased from a low point for those born in 1924 to those born in the 1940s. But that increase mainly made up for the large decrease caused by men returning from World War II and taking advantage of the GI Bill to attend college. The rise in this period was due to something else, and it echoes the breaks for college majors and labor force expectations.

**PROFESSIONAL DEGREES.** Women's enrollment in professional degree programs also reveals obvious turning points in the early 1970s. Women's share of first-year students in medical school, business school, and dentistry turned up around 1970; the share in law school increased sharply a year or two earlier. Similar trends can be observed in the number of women entering professional degree programs expressed as a fraction of all female four-year college and university graduates in that year. This fraction began to increase in about the same year as did the ratio of women to men among first-year professional students. However, almost all the growth in the fraction of female B.A.s continuing on to professional school occurs from 1970 to 1980, whereas the ratio of women to men in graduate programs increases throughout the period considered. Both these data series exhibit among the clearest and sharpest breaks of any shown in this paper.

### **The shift to careers and delayed marriage**

Changes in women's choices about career and family closely mirrored the changes in their labor market expectations and in their educational investments.

**OCCUPATIONS AND LABOR FORCE PARTICIPATION.** The shift in the occupations of college-graduate women, 30 to 34 years old, closely follows that for college majors. Traditional female occupations (e.g., K through 12th grade teachers, nurses,



**The age when college-educated women married rose 2.5 years for women born from 1950 to 1957**

librarians, social workers) show a sharp decrease starting around 1970 and bottom out around 1990. Nontraditional occupations (e.g., doctors, lawyers, managers, college professors) show essentially the opposite trend. The largest increase in the fraction of women in nontraditional occupations occurred in the 1980s, a bit after the change in college majors, probably because advanced degrees are needed to enter these professions.

As more women majored in career-oriented subjects and entered professional and advanced degree programs, they also increased their labor force participation during their late twenties and early thirties. Participation rates among young women (under 35 years) with college degrees or more show the greatest increase for women born during the 1940s. Whereas rates for young college-educated women born in the 1930s were around 50 percent, participation rose to 80 percent for women born in 1950. That is, the greatest change in labor force participation occurred in the 1970s.

As noted above, these women college graduates were the first group to correctly anticipate that their future labor force participation would be considerably higher than that of their mothers. Furthermore, their expectations changed when they were young enough to alter their educational investments. It is likely, therefore, that their actual labor force participation was high precisely because their educational investments made their employment more lucrative and desirable.

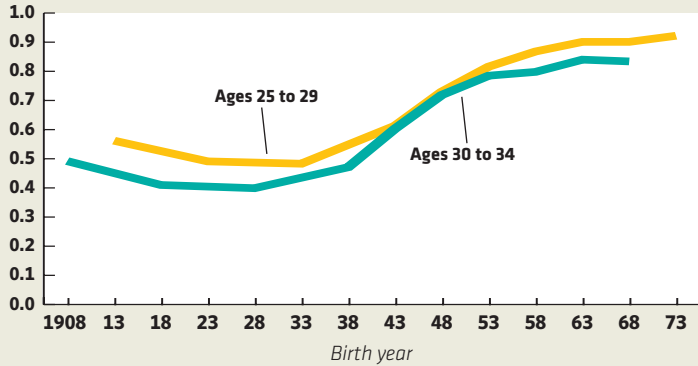
**AGE AT FIRST MARRIAGE.** A host of demographic changes also occurred for this group of women. One of the most important was the trend toward delaying the age at which they married.



## Postgraduate

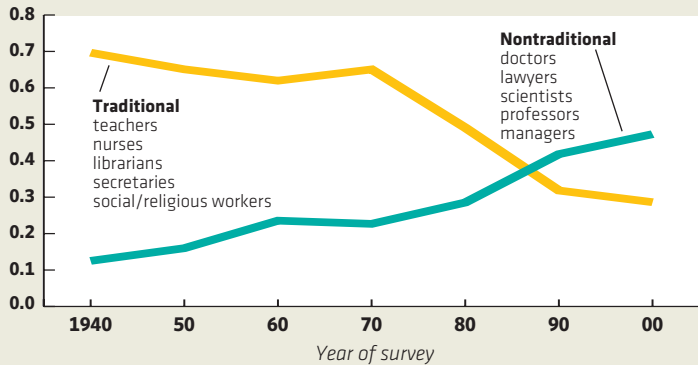
Beginning around 1970, young college-graduate women (under 35 years old) are far more likely to remain in the labor force...

Labor force participation rate



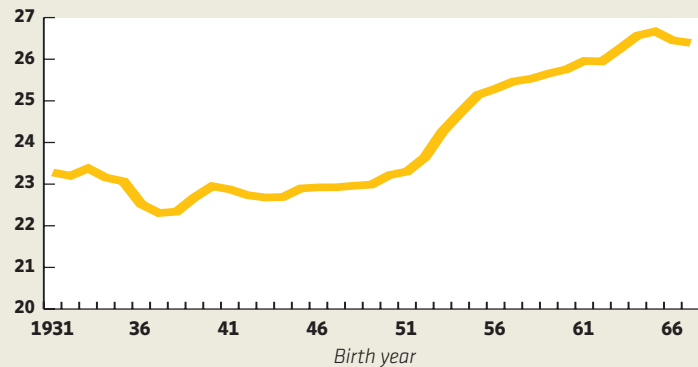
...work in nontraditional occupations...

Fraction of working college-graduate women, 30 to 34 years old, in occupation type



...and delay the age at which they first marry.

Median age at first marriage for white, college-graduate women



Notes: Upper panel: Data are for white, non-Hispanic, college-graduate women, except for 1970, which includes Hispanics. College graduate is 16 years or more of schooling, except after 1990 when it is a bachelor's degree or higher. Middle panel is civilian workers. Nontraditional occupations include all professional and managerial occupations except teachers, librarians, nurses, and social and religious welfare occupations.

Sources: Integrated Public Use Microdata Series of the U.S. Censuses, 1940-1960; Current Population Survey, 1970-2000, and CPS Fertility and Marital History Supplement, 1990 and 1995

The age at first marriage for college-graduate women began to increase for those women born around 1950. Women born in 1949 had a median age at first marriage of 23 years, about the same as for the previous two decades. But women born in 1957 had a median age at first marriage of 25.5. Because so many college-graduate women born in the two decades prior to 1950 married directly out of college, college had functioned, in large part, as a marriage market.

By the time the women born in 1957 married for the first time, their median age had increased by 2.5 years, a large increase in only seven years; and the median age at first marriage continued to climb, although more slowly, rising to 26.5 years for women born in 1965. The age at first marriage also increased for other education groups, but the increase was somewhat smaller than for college women.

### What caused the revolution?

The transformations in women's work roles—from jobs to careers, from “consumption” majors to “investment” majors, and from early to later marriages—took place in an astonishingly short period of time. Labor market expectations of young women were altered beginning in the late 1960s; and by the late 1970s, the transformation was completed. Undergraduate fields of concentration began to change around 1972, and the conversion was mostly finished by the mid 1980s. Similarly, enrollment in professional schools shifted up markedly around 1970, with the largest relative gains occurring by 1980. Changes in occupations and in labor force participation echoed changes in college majors and enrollment in professional schools. The mean age at first marriage began its upward climb with women born in the early 1950s and was completed with women born in the mid 1960s. The only reason that we are able, today, to speak about a significant group of women who are “leaders” and who are “at the top” (or who should be “at the top”) is because these changes allowed women to begin their climb from the valley to the summit.

What can explain why the changes occurred?

Any set of social changes as wide-ranging as those just mentioned is not likely to be explained by a single factor, so it would not be surprising to find several contributing circumstances.

The first important clue is that the process described above was episodic rather than continuous. This suggests seeking explanations in factors that also changed discontinuously. Among the likely contenders are: (1) government mandates such as Title VII of the Civil Rights Act of 1964 that prohibited discrimination in employment practices such as in hiring and promotion, and Title IX of the Education Amendments of 1972 that required equal treatment of the sexes in educational programs, including colleges and universities; (2) social change spurred by the

resurgence of feminism that followed the Civil Rights movement and was reinforced by the anti-war movement; and (3) the contraceptive innovation, known as “the Pill,” which gave young women the ability to delay marriage and child-bearing and plan for a career. Other candidates include abortion reform, which was decided in some states before *Roe v. Wade*; the Baby Boom which, by producing a surplus of women (relative to men) of marriageable age (since women marry younger than men), may have forced some women to postpone or forgo marriage; and the declining economy of the mid 1970s, which may have produced the same effect.

I focus on the Pill, not because government mandates and larger social change made no contribution, but because their importance has been hard to assess. To statistically prove the impact of social change, one must find a factor that is related to the resurgence of feminism but unrelated to the choice of college major, college graduation, and enrollment in professional programs—a difficult, if not impossible, task. As for government mandates, various research papers have not yet uncovered a meaningful effect of antidiscrimination laws on women’s employment and earnings, although they do point to a strong impact with regard to race. (For a discussion of this evidence, see Blau and Winkler, page 38.)

The Pill, by contrast, has proven amenable to empirical exploration and appears to have made an important contribution in changing women’s careers and the age at first marriage. How did the Pill affect the expectations of young women or their desire to pursue college, male-dominated majors, and professional degrees? It lowered the costs to young, unmarried women of pursuing careers, particularly careers involving substantial, upfront investments of time.

A young college woman in the mid 1960s who was considering whether to enter a professional degree



### Access to the Pill delayed marriage and increased the share of women seeking professional careers

program or make other substantial career investments had to consider the impact on her personal life. Sex was highly risky in a world without effective, female-controlled, and easy-to-use contraception—and pregnancy could derail a career. The Pill was more reliable than other methods of contraception and its use was controlled by women. Thus, it might have had a *direct effect* in fostering women’s careers by reducing the risk and cost of having sex.

The Pill also could have had an *indirect effect* by increasing the age at first marriage, which may in turn have influenced other decisions advancing women’s careers. The Pill virtually eliminated one potent reason for early marriage and for many of the social trappings (e.g., going steady, engagements) that led to early marriage. With more men and women delaying marriage for many years after college graduation, the decision of any one woman to delay marriage meant that she would reenter a marriage market that would not be as depleted of eligible men. Thus, the Pill *could* have influenced women’s careers, college majors, professional degrees, and the age at first marriage.

What are the facts? The FDA approved the Pill for contraceptive use in 1960. Married women began to use it immediately, and their use peaked within about five years. But young, single women did not gain full access until the late 1960s or early 1970s, as most were minors and needed parental consent to obtain non-life-threatening medical care. Eventually, age-of-majority laws and mature minor cases at the state level lowered the age at which a woman could legally receive family planning services by a doctor without her parent’s consent. These changes were driven in large part by agitation during the Vietnam War to

further reading



**“From the Valley to the Summit: A Brief History of the Quiet Revolution That Transformed Women’s Work,”** by Claudia Goldin, National Bureau of Economics Working Paper 10335, March 2004.

**“The Power of the Pill: Oral Contraceptives and Women’s Career and Marriage Decisions,”** by Claudia Goldin and Lawrence F. Katz, *Journal of Political Economy*, August 2002.





lower the voting age. ("Old enough to die, old enough to vote," was the slogan at the time.)

Using these variations in state law and judicial rulings, Lawrence F. Katz and I were able to look at their impact on the age at first marriage and on women's careers. We find that laws allowing for greater access were strongly and positively related to the age at first marriage and strongly and positively related to the fraction of women pursuing professional careers. The availability of the Pill to young, single women does appear to have been a substantial factor in the quiet revolution.

While the Pill was an important factor, it was only one contributing factor; and it functioned within a larger changing social and economic environment for young women. Labor force participation rates had already been rising for some time, although until the late 1960s young women had not built the increases into their educational investment calculus. The appearance of the Pill may have enabled young women to view early investments in time-intensive careers as less risky. The resurgence of feminism may have awakened young women to the social changes around them and also contributed to their use of the Pill. Antidiscrimination laws affecting hiring, promotion, and education may also have contributed, on the margin, to protect women workers and to encourage schools to admit them.

Other factors appear to have been less important. Abortion reform may have mattered somewhat; but in our statistical analysis, abortion reform runs a distant second to the Pill in explaining the changes discussed above. Similarly, because women tend to marry men who are somewhat older than they are, the Baby Boom created a sex ratio bulge. But this does not explain much of the increase in the age at first marriage for the group of women analyzed here, nor can it explain the enormous increase in professional degrees for women.

Whatever the precise reasons, a great divide in college-graduate women's lives and employment occurred about 35 years ago. Before this change, women who reached the peaks made solo climbs. They became symbols and tokens demonstrating that women could achieve greatness. But real change demanded a march by the masses from the valley to the summit. That march began with women born in the late 1940s. \*

*Claudia Goldin is the Henry Lee Professor of Economics at Harvard University and Director of the Development of the American Economy Program, National Bureau of Economic Research.*

by MARCIA BRUMIT KROPF

# inspiring girls to be strong,



IRLS INCORPORATED, a nonprofit organization that serves girls aged 6 to 18, has been dramatically influenced by the transformation that Claudia Goldin describes. The group began in 1864 in Waterbury, Connecticut, as a place for girls to gather while their mothers worked in the factories. An early statement of purpose (1937) was explicit about its mission of preparing young women to be wives and mothers. "Little girls of today are the homemakers of the future,



# smart, & bold

the mothers of the next generation of citizens. Opportunities given to them now for cultural background, for healthy minds and bodies, for training in homecraft and a basic knowledge of motherhood—these determine the standards of our future homes.” As late as the 1950s, the Girls Incorporated mission remained essentially unchanged. In 1952, it inaugurated a Homemaker of the Year Award. In 1955, with funding from a shampoo manufacturer, it published *The Handbook of Charm*. The book covered topics such as hair, skin, posture, and wardrobe, and offered pointers on manners including,

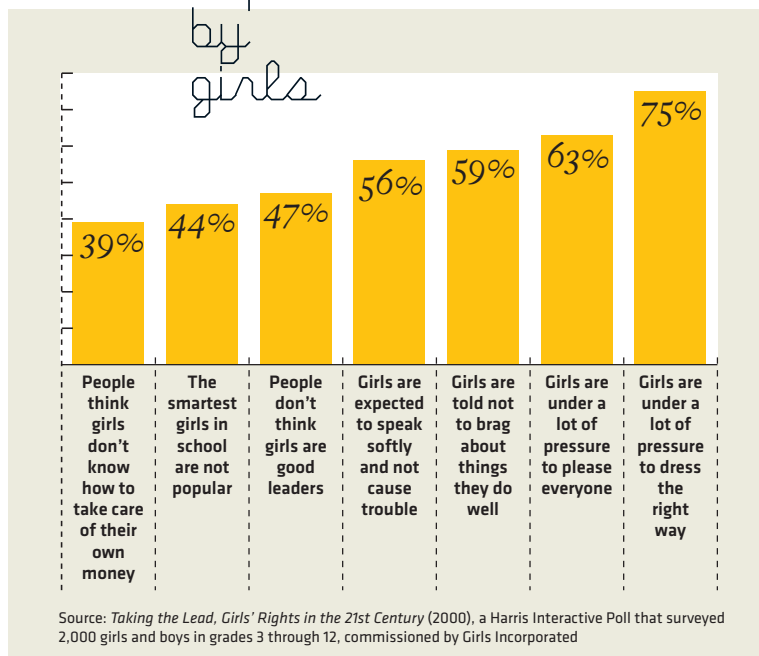
“Don’t monopolize a conversation. Don’t interrupt when others talk. When at any public gathering, conduct yourself in a ladylike, considerate manner . . . don’t be conspicuous and call a lot of unnecessary attention to yourself.”

During the 1960s and 1970s, Girls Incorporated completely rethought its mission and purpose. With changing times came a new focus on preparing girls for interesting work and economic independence. In 1984, its first identity program, focused on adolescent pregnancy prevention, was introduced. In 1998, the current mission statement was adopted: to inspire all girls to be strong, smart, and bold. Today seven additional identity programs are offered, including math and science education, media literacy, violence prevention, economic literacy, leadership development, substance abuse prevention, and sports participation, all designed to help girls think about themselves in new ways.

But while Girls Incorporated and other organizations have evolved with the changing times, many of the old problems remain, leaving Goldin’s revolution unfinished. A recent Girls Inc./Harris Interactive survey of 2,000 girls and boys in



## Stereotypes experienced by girls



grades 3 through 12 found that three-quarters of the girls agreed that girls are under pressure to dress the right way; 63 percent agreed that girls are under pressure to please everyone; and 59 percent agreed that girls are told not to brag about things they do well. This raises troubling questions about the influences that girls face when they’re preparing for their futures. Boys recognized the stereotypes, too, but girls were twice as likely to be highly dissatisfied with them: 47 percent of girls compared to 23 percent of boys as measured by an index Harris created.

It’ll end with another thought-provoking Girls Inc./Harris study on the potential influence of “girls’ communities.” The study defined participation in a girls’ community very loosely, including playing on a girls’ sports team or being in a Girl Scout troop; it didn’t have to be as intensive as attending a girls’ school. Nonetheless, girls who participated in such groups were more likely to plan to attend college, more likely to feel safe, more likely to play sports, and more likely to read books than girls who did not. The study can’t explain exactly why these differences occurred, and it cannot sort out the extent to which girls who join girls’ communities are different—perhaps more motivated—to begin with. But it does raise interesting questions about what will most help girls make progress and to find a comfortable place in the economy and the world in the future. ✱

*Marcia Brumit Kropf is Chief Operating Officer of Girls Incorporated.*

by IOANNIS N. MIAOULIS

# encouraging

## women in engineering, math, & science

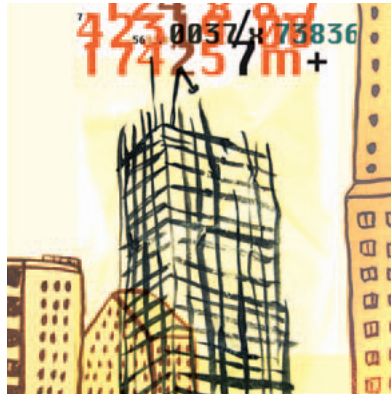


COME AS AN EMISSARY FROM one of Claudia Goldin's "male-intensive" majors. I am a mechanical engineer by training and, before I joined the Museum of Science, I was Dean of the School of Engineering at Tufts University. In these jobs, I have looked to promote women into leadership positions, and it has often been very difficult to find candidates. Thus I have spent a significant part of my career trying to increase the number of women studying engineering, science, and math.

My interest in encouraging young people to study engineering began in the mid 1980s when my wife and I moved to Boston. One day, I was trying to find my way to Tufts when I made a wrong turn and ended up in the parking lot of the local middle school. As I was looking around, it occurred to me that it would be fun to show the students some of the new materials we had made in the laboratory. IBM researchers had been working on new superconducting materials; magnets placed on them would float. Many of us thought this might lead to superconducting roads and magnetic cars, like in the TV cartoon show, *The Jetsons*. I got out of the car and met with the principal, who invited me back to talk with his eighth graders.

During the presentation, I planned lots of hands-on activities. To make the concept of electrical resistance understandable, I used the analogy of drinking a milkshake through a straw: the thicker the straw, the easier to drink the milkshake; the longer the straw, the more difficult to drink the milkshake. As I was giving my talk, a blonde girl with frizzy hair sat right in front of me, glued to everything I had to say.

At the end of my visit, I noticed the



teacher encouraging his "science boys," as he called them, to lobby me to help them build a superconductor. The little frizzy-haired girl cut right in front of them. "Dr. Miaoulis, I would love you to help me with my Science Fair project," she said. She wanted to investigate the fluid mechanics of milkshakes. As I was negotiating with her, the teacher pulled me aside and whispered in my ear, "Don't waste your time with her. She's a mediocre student. Why don't you work with the guys?" I was shocked.

I spent the next 15 years at Tufts focusing on making science and mathematics more exciting for young people in general, and young women in particular. The first hurdle: rethinking the K-12 curriculum, which had been set in 1892 when there were no airplanes, cars had just been introduced, and technology and engineering weren't on the radar screen. Today's curriculum focuses on the natural world but covers little about the human-made world where we spend most of our time. Inspiring today's students—women and men—would require a new approach.

I thought engineering would be a good way to get young people excited about math and science. Engineering makes math and science relevant to

people, and it uses project-based and collaborative learning in which women tend to thrive. In an engineering project, you identify a human need and come up with a solution. For example, suppose a second-grade classroom has a pet bunny, but one student is allergic to rabbits. An engineering project would be to design and build an outside habitat. Students use math to make measurements and science to understand that insulation is necessary since heat travels from hot to cold. They have to communicate verbally and in writing—to collaborate with each other *and* to convince the janitor to let them put the bunny house outside!

But success would take more than an "add women and stir" approach. Other schools had tried to improve the representation of women in math and science by simply accepting more women students or hiring more women faculty, and expecting the rest to follow. Yet, retaining women was the real problem and this required a larger transformation.

Tufts engineering students tended to drop out before taking a single engineering course—because they said engineering wasn't interesting. So we decided to introduce engineering from the first year and in a playful way. Professors took their passions and developed engineering courses around them. My two passions are fishing and cooking. I taught a fluid mechanics course called "Life in Moving Fluids," which focuses on the physics of motion of fluids but from the point of view of a fish. I also taught "Gourmet Engineering," a heat transfer course, with the experiments done in a kitchen. We also introduced design courses early to even up the experience gap that boys have over girls prior to college. Traditionally, women have had more difficulty than men in

by PAUL F. LEVY

# teamwork

## on the field & at work

visualizing things in three dimensions. Research suggests this is the result of the toys that girls play with compared to the toys that boys play with, and that early design courses can bridge the gap.

Along the way, we instituted other measures. We established a national web database ([www.wieo.org](http://www.wieo.org)) for women-in-engineering programs. We created innovative summer programs for high-school girls, and a program that pairs middle-school girls with Tufts engineering students and faculty to work at a local museum. We increased the representation of women on Tufts faculty to serve as role models and mentors. We also paid attention to things which are sometimes overlooked, like creating more women's bathrooms in buildings built when only 3 percent of engineering students were women. We changed the culture in a fundamental way.

And an amazing thing happened. Tufts became the only engineering school in the country that attracted more students from liberal arts than it lost to liberal arts. Today, 32 percent of Tufts engineering students—about twice the national average—are women; and 16 percent of the faculty are women, about four times the national average.

And in case you're wondering, the little girl with the frizzy hair won the science fair that year; in fact, she was the first of five girls in a row to win at her school, an unprecedented event. She eventually attended Haverford College and majored in history and biology, graduating with honors. Today, she works in Tanzania for her own nonprofit foundation that raises money, and designs and builds science laboratories for children. \*

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*Ioannis N. Miaoulis is President and Director of Boston's Museum of Science.*

ONE WAY THAT PEOPLE LEARN TEAMWORK, informal mentoring, and other workplace skills is through participating in sports. Yet, many women of my generation did not get a chance to develop these talents since they had fewer opportunities to participate in organized athletics when they were young. I came to understand the importance of sports from my own experience: My passion—all the rest is a hobby—is coaching girls' soccer, something I have done for the last 15 years.

My goal as a coach is to create an environment that rewards risk-taking, discourages criticism, and acknowledges the girls' desire to have social relationships while they play. In this environment, the girls gain prowess and confidence, and their individual satisfaction rises. They become more and more creative—trying out different approaches, fresh moves, new ideas—because they know they are not going to be criticized. Over time, what I would call the “explicit social intercourse” also grows, as girls from a variety of backgrounds become at least friendly, if not real friends.

But here is the magic. Imagine 22 kids moving around on the field. Eventually, the girls learn to place themselves as play develops during a game in a way that reflects their relative strengths and weaknesses as players. They do not have to be told to do this. They do it on their own, on the field. They talk to one another occasionally, but mostly it happens intuitively.

The result: a team that is truly greater than the sum of its parts. The players function as a cohesive group—going from offense to defense, left to right, one side to the other—and the team works as an organic whole. When mistakes are made, you hear, “Good try.” Or, “Don't worry about it. It'll be better next time.” And when successes happen, players are covered with compliments from everyone. And, most important, the girls are smiling when they leave the field, win or lose.

These lessons from the playing field also apply to companies and institutions. Mentoring works best when it happens informally with the person who happens to be standing next to you when you need it. A work environment that encourages risk-taking, discourages criticism, and supports social relationships will allow and encourage women to develop their skills and achieve high-level satisfying careers. And, the interesting part is that men like it, too. \*

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*Paul F. Levy is President and Chief Executive Officer of the Beth Israel Deaconess Medical Center.*