Tools for Understanding

Gender Codes
Defining the Problem

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Women have passionately programmed computers for many decades. Ada Lovelace wrote abstract programs for calculating Bernoulli numbers on Charles Babbage's mechanical computer, and six women mathematicians, known as human "computers," created working programs for the ENIAC computer during the Second World War. In the 1950s the pioneering generation of computer science featured a surprising number of prominent women who led research teams, defined computer languages, and even pioneered the history of computing. The annual Grace Hopper celebration, named for the most prominent of these pioneering women computer scientists, offers "a four-day technical conference designed to bring the research and career interests of women in computing to the forefront"[1]. More recently, Elizabeth "Jake" Feinler defined the top-level domain names—.com, .gov, .org—for the Internet. In 2006, Fran Allen, already the first female IBM Fellow, was the first woman to win the prestigious Turing Award from the Association for Computing Machinery, for her work in optimizing computer code. Two years later, Barbara Liskov was awarded the Turing Award for her foundational work on programming languages. The list of notable women in computing is sizable and expanding. It's strange anyone would think that women don't like computing.

Since the 1970s women have made impressive gains in professional life, but these gains did not extend evenly into the fields of engineering and the physical sciences. Greater gender parity has typified most professions in the past two decades or so, with women making up half or more of all graduate or professional students: this is true for law schools and medical schools as well as most fields in the social and biological sciences. Engineering and physical

sciences started with rather few women, at all levels, and have been making slow if steady progress in enrolling more women students and hiring more women faculty and scientists. Retaining women scientists and engineers at mid-career remains a challenge. But when you look at the college enrollments and workforce figures for computing, a strikingly different picture emerges.

There's no way of putting it except to say that computing is unique among all the professional fields. You can see this most clearly when looking at the "big picture" across the last 40 years and identifying which of the technical professions women opted to enter and when they did so. The first distinction for computing was an early upside in women's participation. Beginning in the mid-1960s, women entered the emerging computing profession and eventually did so in unusually large numbers (Fig. 1.1). In the United States, women went from being roughly one in ten in the undergraduate computing cohort to being nearly four in ten. At the peak in the mid-1980s women earned 37% of all U.S. bachelor degrees in computing, and across these decades women entered the computing workforce in large numbers. In the late 1980s, women constituted fully 38% of the U.S. white-collar computing workforce. This was a significant success for computing and for the women's movement. Chapters in this volume describe why, for roughly two decades, computing attracted so many women.

Figure 1.1. Woman studying linear programming. For recruiting, Honeywell created a positive image of women programmers in 1969. Women, such as Christine Johnson, composed one-third of the opening class of 40 at Honeywell's Wellesley Hills, Massachusetts, education center. (Courtesy of Charles Babbage Institute.)

We need to better understand why women elected to study *computing* in such large numbers. Why not chemistry or physics or engineering or one of the other technical professions? Men through the 1960s soundly dominated all of these fields. In this book we explore why large numbers of women experienced programming and other computer-related jobs to be more congenial than working in science labs or in engineering offices. We show that women worked

as programmers, as systems analysts, as managers, and as computer executives. In the mid-1980s, while women flooded into computing education and from there into the computing workforce, there were proportionately more women in computing than anywhere else in the engineering world. Medical school was to a large degree still a boy's club, with sizable increases in women medical students just beginning. (Only psychology and certain of the social sciences had equal numbers of women and men; and, of course, the professions of nursing, teaching, librarianship, and social work were, from their origins earlier in the 20th century, distinctively hospitable to women.) This book tells the stories of women computing professionals, including accounts of their struggles and celebrations of their successes. The chapters also give visibility to the many women who worked in lower-status and lower-pay computer occupations, such as operators and data-entry clerks (Fig. 1.2).

Despite these early successes, something unprecedented in the history of the professions hit computing in the mid-1980s: not merely did women stop entering computing in large numbers, but the proportion of women studying computing actually began falling—and it has continued to fall, steadily, all the way through to the present. No other professional field has ever experienced such a decline in the proportion of women in its ranks. The latest figures from the National Science Foundation (NSF), the Computing Research Association,

Figure 1.2. Women as computer operators. Publicity images often used attractive women models to sell computer systems. But many women actually worked as computer operators, here on an OCR data-entry system, a decided step up from data-entry work (compare Fig. 1.6). (Courtesy of Charles Babbage Institute.)

the Department of Education, and the Bureau of Labor Statistics using various measures and methodologies all tell the same story: women are staying away from computing education and the computing workforce. The most recent NSF figures suggest that women may account for just one in seven undergraduate computing students, or around 15%: a catastrophic drop from the peak of 37%. The Taulbee survey of top-ranked North American computer science and engineering programs puts the recent figures even lower [2]. A minuscule 0.4% of first-year women college students list computer science as a probable major, while as recently as the early 1980s it was fully ten times higher. Even when combining computer science with information science, which has more women students, the trend is unmistakable—and it is down [3].

We initially thought this drop was "only" a problem for academic computer science, but closer inspection of the data indicates there has been a gender-specific tail-off in the computing workforce as well. Recent figures from 2005 indicate that women composed just 29% of the white-collar computing workforce, down nearly 10 percentage points from the 1980s. Clearly, this is not merely an academic problem. Of course, not all practicing programmers have computer science degrees, and indeed only around two-thirds of working programmers and systems analysts have 4-year college degrees of any sort. A large number of computer professionals enter the workforce with associate degrees or other vocational training. (Gender statistics for these vocational programs are not carefully scrutinized by national policymaking bodies; the same goes for proprietary courses offered by Microsoft, Oracle, and other companies.)

A recent report from the Harvard Business School anatomizes the sharp falloff of women in science, engineering, and other technical companies. Most women continue work in these technical fields, including computing, for approximately 10 years—and then fully half of them leave the workforce. This mid-career exodus is not the result of women's "choices" or "preferences" (as some commentators suggest) because, after all, these women actually chose those professions. Rather, "more than half of these women [working in science and technology fields] drop out—pushed and shoved by macho work environments, serious isolation, and extreme job pressures" [4]. This loss of women's talent is alarming. Figures that we obtained from the U.S. Bureau of Labor Statistics indicate that women's presence in the computing workforce is falling off as well. Worse, the falloff in workforce closely follows the downturn in undergraduate computer science graduates—with perhaps as little as a 3-year "lag." If women were leaving the computing workforce after 10 years, that would be bad enough. It appears that the fall in enrollments, number of graduates, and computing workforce numbers are closely related. Indeed, we suspect that the educational and workforce tail-offs together actually reflect some broader, as-yet-unrecognized social or cultural shift. If the employment figures continue to fall as abruptly as the enrollment figures might forecast, then the computing workforce will soon become one of the most gender-segregated professional environments. Computing might return to its gender composition of the 1960s, but the rest of the world has moved forward.

A pressing question that this book addresses, and for the first time with historical data and analysis, is how and when and why women's participation

in computing fell so dramatically. This lopsided change in computing's gender balance in the past two decades is entirely without historical precedent. Some of the technical professions appear historically to be resistant to women's entry, such as surgery or civil engineering; yet no other profession has seen the upswing and downturn of women that is strikingly evident in computing. There have been wide swings in the enrollments and employment of varied branches of engineering, as one field or another comes into fashion or falls from favor; these swings are not accompanied by any similar long-term decline in women.

FRAMING THE GENDER GAP

The dramatic falloff of women in computing is hardly a secret. In 1991 Ellen Spertus, then an MIT graduate student, wrote a paper asking, "Why Are There So Few Female Computer Scientists?" The problem was not so much formal discrimination or overt barriers to women, but rather gender biases encoded in professional culture. Among her findings, Spertus reported a professor introducing robotics to a graduate artificial-intelligence class by telling this would-be joke: "Pretty soon we'll have robots that are sophisticated enough to wander around in shopping malls and pick up girls." Unsurprisingly, the female graduate student who related the episode hardly heard the rest of the lecture. In the years since Spertus's report, the situation has not gotten better. "What Has Driven Women Out of Computer Science?" was one recent headline. "Lack of Women in Computing Has Educators Worried," goes another. The *IEEE Spectrum* [5] warns that the "gender gap is widening."

The gender gap in computing now concerns professionals in the field as well as educators concerned about the composition of their classrooms. Women's absence has contributed to a sharp contraction in U.S. computing enrollments: in 2001 there were 400 majors in each computer science (CS) department, while today there are just over 200. In recent years, the National Science Foundation has put around $20 million annually into various research and demonstration efforts aimed at increasing the participation of women in computing and other science and engineering fields [6]. Educators from K-12 through graduate school encourage young women to study math and science as well as to major in engineering fields, including computer science and electrical engineering. Professional associations mobilize high-level committees of educators and practitioners. Some researchers examine gender as an important variable in designing software and human–computer interfaces, addressing a gender bias broadly similar to medical researchers' past assumption that men's bodies were the normal ones [7]. And science museums, science-fair mentors, Girl Scout leaders, and many others present positive views of science and technical fields as approachable, exciting, and relevant to young women as they plan careers. It's difficult to assess their impact, but it's a safe bet that absent these wide-ranging efforts the worrisome figures on women in computing might be even worse.

We believe that there is some "missing piece" to this picture. Our book is aimed—in three distinct ways—at assisting these reform efforts and, we hope, changing the culture of computing. First, we offer forceful *historical data* documenting the gender gap in computing. It's very clear that smart people have

devised many intervention strategies, based on intuitively plausible models of the underlying problem [8]. Yet, surprisingly, not enough is known about how and when and why the gendered culture of computing emerged. This book addresses these very questions. We hope historical insight can improve the outcomes for the wide-ranging efforts at change. Richly textured case studies of women's struggles as well as their own strategies for success, in gaining computing education as well as working for and even running computing companies, can help evaluate and refine these intervention strategies. While we know that women flooded into the computing professions in the 1960s and 1970s, we know all too little about why they did so and what they found there. Women's experiences in the computing workforce are similarly underdocumented and poorly understood [9]. In this book we present fresh evidence of women's striking successes as computer scientists and as entrepreneurs in the computer services industry. This book also documents women's exclusion from high-level computing positions and marginalization within the computing professions. These stories, too, give a more complete picture of the problem.

A second contribution of this book is to offer *tools for grasping the dynamics* of the gender gap. The computing profession changed dramatically across the past three or four decades. We need to record the stories but we also need tools for understanding what was going on, what might have gone wrong, and, for those early decades, what clearly went right with women in computing. Historians, by our disciplinary training, are ideally equipped to understand complexity and change across time. Historians study social processes as well as cultural dynamics; as a profession we deal centrally with language, representations, cultural forms, institutional practices, social and political processes—and power. "The study of computer science education can be seen as a microcosm of how a realm of power can be claimed by one group of people, relegating others to outsiders," as Margolis and Fisher argue in *Unlocking the Clubhouse*. There are "weighty influences that steal women's interest in computer science away from them" [10]. Historians' contributions frequently involve not merely accurately reporting the facts, but also unpacking complex terms at play. Here, it is certain that we need to unpack the terms "women" and "men" and "computing" and to set these into a dynamic framework. Women faced different expectations about gender roles and career paths in the 1960s compared with the 1980s, while computing during these decades was transformed from large mainframe-based installations to the profusion of personal computers. It is worth noting that women flooded into computing during the mainframe era as well as that the sea change in gender occurred during the rise of personal computers in the 1980s.

This book profiles the astonishing diversity of women's experiences in the "computing profession" as well: they worked as highly paid programmers and systems analysts and managers, as well as lower-status operators, data-entry clerks, and maintenance workers. Some of these women, especially ones with managerial or executive responsibilities, are at the upper scale of white-collar work, while the lower-status jobs are squarely blue-collar ones. A key process that we document and analyze is the "feminization" of work as well as the "masculinization" of the professions. This book highlights how computing is understood in gendered terms and how it is represented in popular culture.

Figure 1.3. "Computing = Development" for Ivory Coast women. Ivory Coast stamp from 1972 surrounds a woman with computer images, including an IBM mainframe, punch cards, and core memory. In French, *informatique* can be either computing or the discipline of computer science. (Courtesy of Charles Babbage Institute.)

It is probably happenstance that the movie "Revenge of the Nerds" (1984) appeared just as women's enrollments in computer science were peaking, but there is some relationship between popular culture and the computing culture. We believe it is no coincidence that the sea change in gender of the 1980s closely paralleled the emergence of male nerds in popular culture as well as the rise of distinctly gendered computer gaming, now a multibillion dollar industry (see below). All the same, the mass media's amplified masculine image of computing is clearly a misleading one. Media images of computing are even less gender balanced than the actual practices of computing (see Chapter 12).

Finally, this book frames the problem of gender and computing in *international and comparative terms* (Fig. 1.3). Much thinking about the gender gap so far has taken the United States to be the normative case. Certainly, in the global economy of today, any uniquely national perspective is increasingly irrelevant. A recent CRA-Taulbee survey indicates that students from outside North America make up 59% of entering Ph.D. students in computing at North American universities. Computing professionals increasingly work in thoroughly international and multicultural environments, whether for large multinational companies or even in smaller entrepreneurial start-ups. We need to know how divergent perceptions and expectations regarding gender interact in this multicultural environment: this is the daily work experience for thousands of computing professionals today. This book presents historical cases and contributions

that begin a much-needed international and comparative analysis of gender and computing. The chapters include substantial material on Britain, Germany, Greece, Norway, and the United States as well as briefer comparative reflections on other countries. It's a modest step to a more thoroughly global picture [11].

STRATEGIES FOR REFORM

Before turning to the detailed contributions of this book, we should give an overview of the reform efforts underway today. The favored intervention strategies aim at increasing the number of women in the computing professions, at both the undergraduate and graduate levels as well as in the ranks of faculty and in the wider workforce. The results of reform are not always easy to determine, especially with the persistent, long-term decline of women in computing. Social scientists and educators have identified five "explanatory factors" that underpin most existing interventions and experiments [12]. First, who feels welcome in the computing classroom or workplace—and who feels out of place—is shaped by experiences and even more strongly by entry barriers. When undergraduate computer science programs began requiring prior programming experience for introductory level classes, they did not intend to send a negative message to women but all the same that is exactly what occurred. It so happened that young men interested in computing had frequently done extensive after-hours programming at school or at home, but relatively few young women interested in computing had done so. The requirement of prior programming experience constituted a gender-selecting entry barrier. Indeed, recognizing this problem, some computer science programs have restructured introductory courses to focus less on programming prowess and more on conceptual issues.

Second, the topics treated in a computing curriculum as well as the examples used to illustrate them can be more or less gender-specific. For years, programming assignments did computations with professional football scores or baseball statistics. At one high school a woman student using football statistics in a programming exercise "was ridiculed because she used the name of a baseball team instead of a football team" [13]. (Some have suggested knitting diagrams as an alternate way of studying algorithmic thinking [14].) Some recent research suggests that women as well as men respond positively to course assignments that show how computing can make a difference in the wider world (Fig. 1.4). "Their motivation for learning computer science very much hung on the purpose that computing was going to be used for," suggests Jane Margolis, co-author of *Unlocking the Clubhouse: Women in Computing*, about women computer science students at Carnegie Mellon. "It wasn't just hacking for hacking's sake. There was a real social context that gave them motivation and meaning" [15]. Students transferring into computing majors from other disciplines, such as the sciences, also may require computing programs to offer catch-up courses.

While for years computer science programs were notoriously "hard"— frequently a large lecture class functioned as a wash-out course to thin the ranks [16]—it's become apparent that women were disproportionately hit by such treatment. Computer science programs are now actively looking for ways to

Figure 1.4. Computing as meaningful work in society. Burroughs recruiting in 1980 pictured Toni Sternal, a project manager based in Pasadena, California. After 10 years in field engineering, Sternal directed a team of hardware support specialists in the "center of activity for medium computer systems." (Courtesy of Charles Babbage Institute.)

improve retention and satisfaction of all students, in part because their enrollments are down overall, leading to consideration of the third and fourth "explanatory factors." Positive role models and mentoring in the classroom and at work are crucial institutional supports. The well-regarded "A Study on the Status of Women Faculty in Science at MIT" [17] found that female junior faculty were rarely included in the informal networks and mentoring relationships that assisted male junior faculty in learning the ropes, including how to hire graduate students, submit conference papers, and craft successful grants. Efforts at mentoring, especially with established professionals outside one's own institution such as MentorNet, seem particularly promising [18]. Fourth, peer support seems particularly important to students, whether women, men, or underrepresented minorities, who may have their sense of self-confidence jarred by daily challenges. So-called pair programming is one positive step, where two students together tackle programming assignments instead of working alone. Educational researchers have found that women in such pair-programming classes are substantially more likely to take additional computing classes or, if a computing major, to successfully complete the major.

Finally, all reform efforts need to confront the distinctive culture of computing. If language creates culture, then computing has created its own universe. You start a computer by *booting* it, if it unexpectedly *crashes* or *bombs* an expert might do a *code dump*, you *execute* instructions or programs, or if something goes wrong you *kill* or *abort* them, a *code warrior* dreams of creating

Figure 1.5. Men as self-appointed masters of computing. Computer data punched on paper tape scrutinized by the masculine gaze. (Compare Figures 3.1, 9.5, and 12.6.) (Courtesy of Charles Babbage Institute.)

a *killer app*—all these everyday terms in computing are loaded ones that carry distinctive values. And this is not a woman's world. "Women are obligated to adopt some degree of macho to become part of [the computing world]," suggests Karen Coyle. "To question the masculinity of computers is tantamount to questioning our image of masculinity itself: computers are power" [19]. Popular images in advertisements, movies, computer games, and computer magazines all tend to reinforce the assertive male dominance of the field (Fig. 1.5). "Is it possible that this emphasis on engineering and other masculine activities arise because computing, particularly programming, and software activities are in fact not 'manly' enough?" asks Frances Grundy. "Do these terms to some extent compensate for the absence of the screwdriver, the soldering iron and the oily rag—even maybe the roar of the engines?" [20]. And, it bears saying, garden-variety sexism persists in computing education and work. Female computer-science graduate students recently reported "incidents ranging from differential and demeaning to crude and offensive behaviors" [21].

The "girl gamers" movement in the mid-1990s formed an intentional countermovement aimed at recruiting women into computing. Gender had only recently emerged in computer gaming. The earliest computer games, such as Spacewar and Space Travel, did not themselves feature explicitly gendered content: spaceships and photon torpedoes were the screen images. While the

avatar-paddle for the Atari videogame Pong (1972) was also without explicit gender, Ms. PacMan (1980–1981) was the first to feature a gender-specific avatar. In the 1980s damsels-in-distress figured in the video games Donkey Kong and Dragon's Lair and in countless games since [22]. The controversial female avatar Lara Croft anchored the best-selling Tomb Raider video games (first launched in 1996) and the character, played by Angelina Jolie, starred in the subsequent movie. Lara is renowned for her intelligence, good looks, daring, and wit. She is also ogled on screen for her hypersexualized virtual body. Her creator, Toby Gard, once lamented, "I just wish that when she was taken out of my hands they hadn't made her boobs so big" [23].

The "girl gamers" movement was launched with the hope of fostering girls' interest in computers and computer games by encouraging the development of games that toned down the typical gratuitous violence and sexually aggressive imagery. Two edited volumes from MIT Press form something like bookends. The first volume, *From Barbie to Mortal Kombat* (1998), presented programmatic chapters, many written by idealistic young women suggesting a New Jerusalem was at hand. The movement hoped for a "virtuous cycle" where girls playing computer games would lead to women writing game software, and hence more girl-friendly game experiences, and even more girl gamers. There are some signs of success. Women's participation as gamers is certainly up— recent industry statistics indicate 38% of U.S. game players are women, playing an average of 7.4 hours per week (just 0.2 hour less than the average male gamer)—and there are changes in the gaming industry [24]. For instance, in *Tomb Raider: Legend* (2006), Lara Croft was redesigned in part to appeal to girl gamers [25]. And in recent years, the best-selling "Sims" game franchise (launched in 2000) has a solid majority of female players. Women create an estimated 50% of the characters in "Second Life," the popular online role-playing platform.

Even so, many obstacles remain in the gaming world. Women comprise just 11.5% of the game industry workforce according to the International Game Developers Association, and many games as well as many game-industry trade shows persist in using preposterous sexual stereotypes. In "The Future of Games Does Not Include Women" (2006), Nikki Douglas, the long-serving senior editor of Grrlgamer.com, blasted the game industry with a strong critique of its pervasive, blatant, and offensive male bias. She cited a 2006 game advertisement in *Computer Gaming World* where the principal image "is a woman lying in lingerie on a bed in [high heels] with a bullet-hole in her forehead. The tagline is 'Beautifully executed'." The second MIT Press volume, *Beyond Barbie and Mortal Kombat* (2008), presented a much more sober and cautious view of girl gamers [26].

HISTORY IN THE PRESENT

This book's chapters, taken together, represent a unique examination of the historical evolution of gender and computing. We firmly believe that effective interventions to improve professional practices in computing (and other technical fields) require greater historical awareness and understanding. This is especially important in the field of computing, with its perennial celebration of

progress and the belief that the past is gone and done. Yet, as William Faulkner famously observed in *Requiem for a Nun*, "The past is never dead. It's not even past." Effective reform efforts will need to grapple with the somewhat paradoxical fact that the computing profession has at once a compelling recent history as well as a longer institutional and cultural history that stretches back many decades. We need to learn lessons from both of these histories, for they are very much with us today.

This book's first three chapters, including this introductory one, are efforts at specifying the gender-gap problem in computing and introducing historical tools for conceptualizing it. In Chapter 2, Caroline Hayes presents a full set of national statistics to get a better picture of the turning points in the United States. She draws on several existing data sets, including ones from the National Science Foundation and several longitudinal surveys. The result is a long-run and multilevel portrait of women in computing, from the 1960s to the present. Her data anatomizes the upside through the mid-1980s as well as the unprecedented downside since then. Two aspects of her chapter are distinctive. While it is common to treat "computer science" education as a lump entity, Hayes shows that there are distinctive trajectories and dynamics at work at the undergraduate level (bachelor's) as contrasted with the graduate level (master's and doctoral degrees). In brief, while women's participation at the master's and doctoral levels is still low, the figures have been rising slowly across the decades. (There are worrying trends in the ranks of women computer-science faculty, especially at mid-career.) It is at the bachelor's level, with the unprecedented drop in women's participation, that something really unusual is going on. Moreover, she presents striking new data from the Bureau of Labor Statistics that suggest women's participation in the computing workforce is falling off—and possibly even faster than the dire figures for computing enrollments might predict. We believe this unexpected link is one of the undiscovered "missing pieces." If confirmed, her findings suggest that a broad cultural shift—influencing women at universities as well as in the computing work force—may be the chief challenge for reformers to address.

In Chapter 3, Thomas Haigh examines a classic instance in the automation of American industry, as data-processing computers were introduced into offices. He recounts the professionalizing efforts by the industry's managers and supervisors as they confronted data-processing's strongly feminized labor force (Fig. 1.6). The Data Processing Management Association, for years the largest professional organization in computing, improved the professional standing of its members by striving for the "masculinity of the organization man," consciously separating the emerging professional field from feminized office work. He notes that the effort to remake "business computing as men's work occurred because of, not despite of, the presence of women in the field." He concludes that sex typing and status anxiety, far more than any supposed natural talents of women or men, account for gender-segregated work in data processing. He also contextualizes his narrative through a statistical analysis of occupational data, again finding strong evidence of gender marked employment. Moving up the salary ladder—from keypunch workers (at the bottom), through computer operators, programmers, and (at the top) systems analysts—he finds remarkable consistency in that "the proportion of women drops and the average pay rises."

Figure 1.6. Computer automation of female clerical work. Women working on data-entry terminals supplemented the main OCR data-entry system at this installation (compare Fig. 1.2). (Courtesy of Charles Babbage Institute.)

While women's proportion in the job category of computer software developer has been shrinking, Haigh's reading of the statistics indicates some small measure of hope. There seems to be a rise in the aggregate number of women employed in such high-status jobs as information science manager, systems analyst, and computer software engineer.

The unsettled and unstable dynamics of gender and computing are the topics in the two middle sections of the book. Chapters 4–7 (Schlombs, Hicks, Ensmenger, Downey) deal with specific institutional contexts, while Chapters 8 and 9 (Corneliussen and Tympas et al.) deal with popular culture and mass media.

The chapters in Part II: Institutional Life distill lessons from automation or computerization in several distinct sectors—including offices, government, the emerging profession of programming, and those information-centric institutions known as libraries. In Chapter 4, Corinna Schlombs assesses the gender consequences of computerized automation in government and private-sector offices. Even though many proponents of automation believed that electronic computers carried the promise of improving working conditions, the historical record is distinctly mixed. In the early 20th century, following Herman Hollerith's pioneering use of punch cards for the 1890 Census, women became the primary workers in the punch-card industry, a novel development since women were relative newcomers to office work at the time. Schlombs aptly contrasts Germany and the United States, where punch-card work took two quite different paths. Whereas in Germany punch-card work was a male-only domain, dirty and loud, and often physically kept separate from the rest of the office, in the United States women soundly dominated such work, which was also altered through office

design and architecture. By 1930 there were more than 30,000 women punch-card machine operators. After the Second World War, the introduction of computers into offices seems to have put many of these women out of work. Computers effectively replaced the legions of punch-card workers, and instead of moving into the higher-status computing jobs, women filled the follow-on occupation of data-entry clerks. One important lesson, especially given the computing field's general enthusiasm about the transformative character of technology, is that while technology induces changes "the outcomes of the change are constrained by the pre-existing organization of work of which gender is an integral part."

In Chapter 5, Marie Hicks presents an example where computing was initially a women's sphere of work and then "very self-consciously re-engineered as a field of masculine endeavor." The shift reflects the emergence and hardening of a "gender line" in computing. Her extended case study is the British governmental sector, as it became increasingly dependent on computing with the postwar expansion of the welfare state and the need to compete in a high-technology economy. British women dominated the prewar mechanical punch-card work, much as Schlombs described for the United States, but in Britain women also dominated the early installations of government computing. "Boys generally prefer laboratory work to computing," as one 1955 government report put it, and computing became a feminized job class. Computer programmers were recruited from the largely feminized Machine Grades of employment although there was creeping preference for recruits from the male-heavy Executive Grades. In the mid-1960s, with the launch of Prime Minister Harold Wilson's avowed "technological revolution," the government advertised programming positions as "suitable for women" as well as for men. The door for women's advancement from lower to higher grades was closed in 1970, however, when the government created a new Automatic Data Processing work grade for programmers and systems analysts but explicitly excluded the (feminized) grades from either having a favorable review for an upgrade or, for the Machine Grade, from applying at all. Women's computing work in the government sector thus became "peasant work," literally a dead end. Hicks observes that these "different hiring rubrics for men and women" constituted a potent institutional and cultural form of gender discrimination against women. And, consequently, Britain's economic performance flagged. Once again, the fundamental point seems to be the notions of gender that undervalued women's contributions to the workforce and consequently overvalued men's. Connecting her history to the present debates on women's underrepresentation, Hicks concludes that simply increasing the number of well-qualified women graduates is unlikely to address the underlying problems of gender and culture.

In Chapter 6, "Making Programming Masculine," Nathan Ensmenger outlines how men and women became programmers. In the early days, he reminds us, no one really knew how to select good candidates for training as programmers. A variety of different selection mechanisms were widely discussed in the computing profession as well as in individual companies. The most famous by far was IBM's Programmer Aptitude Test, which was widely used to identify promising recruits (and only years later actually evaluated and found to be a poor predictor of programming talent) [27]. "My smashing grade

Figure 1.7. Emergence of gendered work in office computing. Men and women often worked side-by-side (here at a Honeywell computer center in the late 1960s) but typically did different jobs. Women often tended data storage units. (Courtesy of Charles Babbage Institute.)

on the PAT was like a guardian angel which would hover over my entire career at IBM," noted one programmer hired in the 1960s [28]. In the event, these selection mechanisms were put into place during the years that women first entered the programming profession in large numbers (Fig. 1.7). It's not at all clear that these selection mechanisms actually discriminated against women. All the same, his chapter underscores how such selection mechanisms, including the imperatives of professionalization and anxieties about professional status, shape the culture of computing and elevate certain norms while devaluating others.

In Chapter 7 Greg Downey examines library automation with attention to "the changing social meanings of both femininity and masculinity which we might refer to as 'gender'." His chapter parallels Marie Hicks's in that librarianship too was a firmly feminized profession well before computer automation. Beginning in the 1960s, the library profession showcased the future of electronic catalog records and networked communication systems at the World's Fairs in Seattle and New York while library leaders, primarily males at the most prestigious academic libraries, enthusiastically promoted computing in many forms, including the national efforts that spawned MARC and OCLC. As with office work, however, computerization and computers themselves had specific gendered consequences for the work of librarians (predominantly female and at many diverse sites) as well as the image of the library profession. This chapter examines the ferment raised by library feminism in the 1970s and 1980s, as women sought parity in library professionalism, as well as the subsequent discussions about computerized library catalogs through the 1990s. The library profession came surprisingly late to an understanding of the profound impact of computer automation, Downey finds, and seemed on balance not to properly

understand the links between professionalization, computerization, and gender. Overall, by spotlighting the debate on gender and library automation, his chapter suggests that "moments of new technological possibility … are moments of social reflection and change."

In Part III: Media and Culture, the chapters deal with the images of computing to be found in popular culture and mass media. These images shape practices, although not always in straightforward ways. In Chapter 8 Hilde Corneliussen uses the tools of discourse analysis to understand the construction of gender and computing. Her chapter analyzes a data set of 200 newspaper articles from Norway's largest national newspaper, *Aftenposten*, with the goal of understanding how computing was represented and perceived in the public sphere. The time period, from 1980 to 2007, spans the personal-computer and networked eras of computing. She notes several larger patterns. In a Scandinavian instance of "geek mythology" [29], newspaper reports were most likely to stress men's mastery and competence in using computers while, in contrast, reports about women and computing often focused on their supposed indifference and lack of mastery or skill. These reports simply overlooked the large majority of male computer users who were not technical adepts as well as the sizable number of women who were technically proficient users of computers. Partial fragments of a gendered pattern were inaccurately generalized to be hard evidence about men, women, and computing. A related point was the "intersection rhetoric," where evidence about home uses of computing, or educational experiences with computing, was mobilized as an explanation for work uses, or vice versa. Women who might prefer not to have computers at home were presumed, somewhat illogically, to lack educational experiences and to be in grave danger of being "left behind" in the workplace. There seems to be a big picture of the correct way, aptly termed a hegemonic discourse, of conceptualizing computers and the future [30]. Corneliussen also makes visible the "nonhegemonic groups," including groups of female computer users as well as male nonusers. She also finds that as computers have become more pervasive in society since 2000, there is great attention to the "new" users of computing, often less experienced, and who are inevitably portrayed as female. Such a double standard makes it difficult for women to establish themselves as genuine technical experts about computing in work, education, or business.

In Chapter 9, Aristotle Tympas and co-authors examine the construction of gender and computing through advertising images. They examined and analyzed 1500 advertisements in the leading Greek journal for home computing, *Computing for All*, again beginning with the PC and networking era in the 1980s through to the recent past. In a different manner, they challenge the notion that computing is an exclusively male domain. In these advertisements, there is no shortage of women; but there is a very strong pattern in how women are shown with computers and what they are shown doing with them (Fig. 1.8). Time and again women are working on the screen, hands on the keyboard, or dealing directly with the printer—fully engaged with the routine office work of computing. In sharp contrast, men are rarely shown with hands on the keyboard (more frequently with a phone or coffee cup in their hands) and while they might receive a computer printout, they don't do the actual work of printing. There is a strong normative slant that women are supposed to be doing some computing

Figure 1.8. Women in computing confront a "crowded" field. This "powerful data entry and editing system" from Inforex (1975), while promising to minimize programming effort and save thousands of dollars annually, left this woman precious little room for movement. (Courtesy of Charles Babbage Institute.)

jobs, while men are doing others (compare Fig. 1.7, 5.3, and 12.7). And it's not a surprise how these gender-marked advertisements map onto the higher- or lower-status jobs in computing. These gendered patterns continue straight into the world of computer education. Vocational computer schools aimed at teaching students to be proficient at routine data-entry jobs show women doing this work, hands on keyboards, often with generic computers: a vision of their futures, if you will. By comparison, computer schools teaching students to be programmers typically show men at the job, often with an interesting variety of computers; again a vision of the future. In an important comparative point, Tympas and co-authors note that Greek women—as well as Turkish and Malaysian women—are unusually prominent in university-level computing education, at least compared with the United States, but that despite their higher educational attainments they end up in similar office-level positions just as U.S. women lacking computing degrees. It seems that gender shapes these outcomes as powerfully as educational opportunities, which is an important cautionary tale for reform efforts.

In Part IV, our book's final chapters offer several ways to move forward on the "problem" of gender and computing. (Chapter 12 summarizes the "lessons learned" from the book's chapters and Chapter 13 suggests their consequences for reform efforts.) Janet Abbate's Chapter 10 is based on a wide-ranging set of 52 interviews done with notable women in the computer field. Drawing on this veritable "who's who" of women programmers and computer scientists, Abbate presents compelling interview abstracts documenting what

these women found attractive about the field of computing and why they got excited about it. While earlier studies, such as the Margolis–Fisher book, *Unlocking the Clubhouse: Women in Computing* [31], emphasized that men were the ones most often emotionally attracted to computing, Abbate's interviews certainly provide evidence of these notable women's deep and passionate attractions to the field. There is certainly something fresh in a woman computer scientist announcing, "I still think, of all the fields open to women, computer science is the most wonderful one." Genuine enthusiasm about computing animates these voices. Abbate's set of interviews ranges widely across industry, government, and the academic world, and includes women from the United Kingdom as well as the United States They were mostly active during the years that women were flooding into computing, from the 1950s through the 1980s. As Abbate notes, computer programmers were in high demand and, revealingly, "the profession was new enough that they had little awareness of *any* popular image, positive or negative." This combination of high demand, newness, and weak gender stereotypes—positive or negative—help to make clear why so many women chose computing as a profession during these years. Another "missing piece" to the gender gap, however, may be located in Abbate's assessment that the way these women defined success in their careers and experienced pleasure in their work did not match prevailing male and female stereotypes. The sad fact is that the computing profession, as it took form and matured across these same decades (see Chapters 3–6), did not value the accomplishments that these leading women attained.

In Chapter 11, "Programming Enterprise: Women Entrepreneurs in Software and Computer Services," Jeffrey Yost opens with the celebrity cases of HP's Carly Fiorina and eBay's Meg Whitman and other notable women business executives at Oracle and IBM. The chapter surveys the broader environment for IT employment for women, including the opportunities for women working as programmers, systems analysts, computer engineers, and computer operators during the classic mainframe era of computing. The core of his chapter profiles the successful careers of three women active in entrepreneurial companies in the computer services industry as well as the trade associations for that industry. Luanne Johnson, Grace Gentry, and Philiss Murphy each ran successful software and computer services companies, and also took up leadership roles in the Association for Data Processing Services Organizations (ADAPSO) and the National Association of Computer Consultant Businesses (NACCB). These women's notable successes certainly need celebrating. All the same, these brand-new computing fields offered alternatives to the more established career lines where gender discrimination did occur. Early on, "women weren't 'good enough' to be programmers," recalled one woman programmer. "We were hired at 20 percent less than men and only allowed to set up the test cases." Such pay disparities persisted for many years, as Yost's statistics gathered from the trade press demonstrate. Some gender-based slights dogged even these successful women—such as when a bank demanded that Peggy Smith, a long-established businesswoman, have her new husband co-sign for a business loan, despite his having no role in the business. Yet in the main, there were few gender-specific barriers to success in this field and so, as Phyliss Murphy explained her success, it was her ability to deliver results *and* her gender that "stood out."

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