Why are There so Few Female Computer Scientists?

Abstract

Women pursue education and careers in computer science far less frequently than men do. In 1990, only 13% of PhDs in computer science went to women, and only 7.8% of computer science professors were female. Additionally, the percentage of female computer science students appears to be increasing at only a slow rate or even decreasing. Apart from ethical concerns at women's lack of participation in computer science, the demographics of the country are such that the United States will not have enough engineers and scientists unless underrepresented groups increase their participation. This report examines the influences against a woman's pursuing a career in a technical field, particularly computer science. Such factors include the different ways in which boys and girls are raised, the stereotypes of female engineers, subtle biases that females face, problems resulting from working in predominantly male environments, and sexual biases in language. Finally, I discuss effective and ineffective ways to encourage women. A theme of the report is that women's underrepresentation is not primarily due to direct discrimination but to subconscious behavior that tends to perpetuate the status quo.

This report is expected to become an MIT Artificial Intelligence Laboratory Technical Report.

Introduction

Only a small percentage of computer scientists and computer professionals are female. In the most recent years for which statistics are available, women received a third of the bachelor's degrees in computer science, 27% of master's degrees, and 13% of PhDs. Not only do women make up just 7.8% of computer science and computer engineering faculties, only 2.7% of tenured professors are female [Frenkel 1990, page 38] [Gries et al 1991]. Even worse, these numbers seem to be improving only very slowly or even dropping [Leveson 1989, page 3]. Many girls are still steered away from math and science or choose not to pursue careers in these fields. Additionally, many women who go into computer science are conscious of being treated differently from men or feel that they face additional barriers. This report describes some of these barriers.

As someone who has loved math and computers ever since I was a little girl, I have always found it strange that so few females share these interests. At the computer camp I attended, the boy-girl ratio was six to one. It was similar at high school math club and the math summer program I attended. At MIT, only about 20% of the computer science undergraduates are female, while other departments, such as biology, are at least 50% female. I researched this report to explore why females so consistently stay away from computer science, why people of both sexes seem to expect less from women, and why a woman is considered unfeminine if she is an engineer. Because math and computer programming came easily to me and to many other women who have had the opportunities, women clearly are not inherently unable to do well in them. Instead, girls and women are choosing, consciously or subconsciously, not to go into or stay in computer science. While one cannot rule out the possibility of some innate neurological or psychological differences that would make women less (or more) likely to excel in computer science, I found that the cultural biases against women's pursuing such careers are so large that, even if inherent differences exist, they would not explain the entire gap. In this paper, I describe the biases that women face in pursuing careers in computer science and how they deal with them.

Organization

My report examines the following topics, each occupying a chapter:

1. Societal pressure against women's being successful, particularly in engineering.

2. Ways in which the male-dominated environments discourage women.

3. Inequalities in language, their causes and effects.

4. Negative consequences of some attempts to help women.

5. Conclusions and recommendations.

At the end of the report are appendices which contain additional information, such as the methods I used for data collection and implications of recent research on sex-based intellectual differences. Finally, there is an annotated bibliography.

The report does not directly address the problems of racial minority group members, such as blacks and hispanics, who are also underrepresented in computer science. Readers should not interpret my lack of material on this subject as implying that no bias exists against these groups. On the contrary, I have been told by a black female computer scientist that the color barrier is greater than the sex barrier. In many parts of this report, such as Section 1.2.1 on subconscious bias, the experience of people of color is analogous to that of women.

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Contents

Chapter 1

Societal Factors

> *Women beware. You are on the brink of destruction: You have hitherto been engaged in crushing your waists; now you are attempting to cultivate your mind: You have been merely dancing all night in the foul air of the ball-room; now you are beginning to spend your mornings in study. You have been incessantly stimulating your emotions with concerts and operas, with French plays, and French novels; now you are exerting your understanding to learn Greek, and solve propositions in Euclid. Beware!! Science pronounces that the woman who studies is lost* — R. R. Coleman, M.D., 1889.[1]

In this chapter, I will describe various ways in which women are steered away from professional success, particularly in traditionally male fields such as engineering.[2] Girls and women are subject to societal pressure to stay away from such subjects or to accept themselves as "unfeminine". Academically successful women are generally seen as being less attractive and less happy than less highly-achieving women.[3] Additionally, there are still people who believe, consciously or subconsciously, that women are incapable of being top scientists and who take women less seriously in general.

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[1] Coleman, R. "Woman's Relations to the Higher Education and Professions, as Viewed from Physiological and Other Standpoints." *Transactions*, Medical Association of Alabama (1889), page 238. Quoted in [Ehrenreich et al 1978, page 128].

[2] Readers outside of the field may be confused by my use of the term "engineer" to include computer scientists. I do this because the field of computer science does not fit neatly into either engineering or science. Despite the "science" in the name, university computer science departments are often attached to electrical engineering departments or are part of the school of engineering. Additionally, computer programmers and designers tend to think of themselves more as engineers than as scientists, although some individuals and organizations consider computer science as a branch of the mathematical sciences.

[3] Of course, the stereotype also exists of male engineers being less attractive than other males. See, for example, [Wolpert et al 1988, page 2], [Turkle 1984, Chapter 6], and [Holland 1990, pages 164–165].

1.1 Stereotyping

1.1.1 Background

Currently, most people in positions of power and respect are male. Men are rhetorically asked in [Sandler 1986, page 3]:

> Imagine that your lawyer, your doctor, your priest, rabbi, or minister, your Senator and Representative, your mayor, the president of your institution, most of its trustees, almost all of the deans and most of your colleagues were all women. How would you feel?

Not only are these positions held by men, but the media propagate stereotypes of women. A recent study found that "women are often still depicted on television as half-clad and half-witted, and needing to be rescued by quick-thinking, fully clothed men" [Adelson 1990]. Whether or not people realize it, many of their expectations of men and women are based on what they have observed and by what messages their culture presents. As one Usenet[4] reader wrote:

> This group [comp.society] has been discussing various stereotypes for a long time now. The problem is that we haven't acknowledged the importance of stereotypes to human cognition. We could easily call stereotypes heuristics. A heuristic is a device that allows a processor to use some sort of knowledge to reduce a search. In very rough terms, stereotypes allow the wetware in our heads to do less search when looking for evaluations of people and behaviors to events.
>
> The human brain is the best known implementation of these heuristics. In fact the human brain is so reliant upon heuristics, that when presented information that contradicts such a heuristic we feel confusion and discomfort.
>
> So where is all this going? For better or worse, humans will continue to make stereotypes based on input from their environment. Since the average person rarely meets programmers, and the only programmers that people see are male geek actors on the TV, we will still have the geek image. I have to admit, most programmers I know are not ex-jocks. Most programmers I know are male, have interests in math and the insides of computers and will allow their personal appearance to slip during those wonderful, coffee-filled, marathon programming sessions. See, I have the disease too. (disease = stereotype)[5]

I believe that the author of the message is unusual not in having biases but in being aware of them. It has been empirically shown, as will be described in the

[4] Usenet, a large electronic bulletin board system, is described in the appendix on methods.
[5] Katz, Douglas J. Comp.society, May 14, 1990.

following sections, that many people expect less of females without realizing it. These stereotypes are not as harmless as the author implies however, as they sometimes impair people from seeing past the stereotypes. Additionally, people tend to live up or down to the expectations that are communicated to them.

1.1.2 Bias in Children's Toys and Computer Games

The social biases that influence females begin in childhood, where boys and girls are often treated differently on the basis of sexual stereotypes. From the earliest ages, girls are given different types of toys than boys. For example, one study of children from one to six years of age found:

> Boys had more vehicles, toy animals, military toys, educational-art materials, sports equipment, and spatial-temporal objects. On the other hand, girls had more dolls, doll houses, and domestic objects [Rheingold et al 1975].

The difference in toys cannot be explained purely by the children's preferences — the expectations of parents and other gift givers play a major role. Numerous studies, cited in [Pomerleau et al 1990, page 360] have found:

> When interacting with an infant who was introduced as a girl, adults used feminine toys (for instance, a doll) and talked more to 'her'. When the infant was presented as a boy, they used masculine toys (e.g., a hammer) and encouraged more motor activity.

These stereotypes are perpetuated by toy companies, which market toys in a stereotyped manner. A 1969 *Life* ad contained:

> Because girls dream about being a ballerina, Mattel makes Dancerina ... a pink confection in a silken blouse and ruffled tutu ... Barbie, a young fashion model, and her friends do the 'in' things girls should do — talk about new places to visit, new clothes to wear and new friends to meet.... Because boys were born to build and learn, Mattel makes Tog'l [a set of blocks for creative play].... Because boys are curious about things big and small, Mattel makes SuperEyes, a telescope that boys can have in one ingenious set of optically engineered lenses and scopes [Komisar 1972, page 305].

While such an ad would not appear today, it indicates the environment in which today's young scientists were raised.

As recently as 1985, a study found:

> [T]he content of toy catalogues and the pictures of children on the packages of toys are still strongly stereotyped. In catalogues and in stores, special sections are reserved for sex-stereotyped toys. Girls' sections contain dolls and accessories, doll houses, arts and crafts

> kits, toy beauty sets, and housekeeping and cooking toys. Building sets, sports-related toys, transportation toys, workbenches and tools are featured in the boys sections ([Schwartz et al 1985] in [Pomerleau et al 1990, page 365]).

In addition to marketing toys in a stereotyped manner, such factors influence the design of toys. It was reported that:

> Jaron Lanier, head of VPL, gave a talk at UIST in 1989 about his experience productizing the data glove for Nintendo games....[H]e said that [the] toy manufacturer was very strictly divided from the very highest levels into the girl's toy division and the boy's toy division. He strongly resisted the glove from becoming either a girls' toy or a boys' toy, but he lost. He said that they immediately categorized it as a boys' toy and put all kinds of black Darth-Vader-ish, sports-car-like paraphernalia all over it to make it appeal to boys. He also said, had it been categorized as a girl's toy, it probably would have been pink and frilly.

Not only are there differences in varieties of "old-fashioned" toys given to children, but these biases are carrying over into the realm of computerized toys and games. These games are both based on traditionally male interests, such as war and sports, and are marketed toward boys. [Kiesler et al 1985, pages 456–457] reports:

> On one rack [in a computer store], covers in comic-book style depicted such games as Olympic Decathlon (4 male athletes on cover), Cannonball Blitz (3 men in battle), Swashbuckler (9 male pirates), Thief (1 male detective), Alien Typhoon (1 male space explorer) and Money Munchers (1 man in a suit). In all, 28 men and 4 women were illustrated on the covers. The women were on the covers of Monopoly (2 men and 2 women playing the game), Palace in Thunderland (1 very fat queen), and Wizard and the Princess (1 wizard standing, 1 princess in supplicating position on floor).

Girls' lesser usage of computer games could be a factor in their being less positively disposed toward computers and in their lack of interest in computer courses [Lockheed 1985, page 118], particularly as students who have played computer games are more likely to do well in their first college computing course [Kiesler et al 1985, page 457].

It should be noted that nobody with whom I have spoken proposes that a conspiracy exists among manufacturers and advertisers to keep females in their place. Rather, companies aim their products at the largest segment of the population that is predisposed to use them. Additionally, females are more willing to buy products advertised for males than vice versa [Courtney et al 1983].

1.1.3 Stereotypes of Boys and Girls

Anecdotal evidence suggests that when an infant is dressed in blue, passers-by say how smart he looks; if the same baby is dressed in pink, people say how pretty she is. Boys' clothing is often decorated with cars and trains; girls' clothing rarely is. More rigorously, numerous studies of sex stereotyping of infants are reviewed in [Stern et al 1989], including:

> Parents in one study, for example, were asked to rate and describe their newborns shortly after birth when the primary source of information about the baby was his or her gender (Rubin et al., 1974). Although the infants did not differ on any objective measures, girls were rated as littler, softer, finer featured, and more inattentive than boys. Other studies have revealed that parents treat male and female infants differently.... Fagot (1978) observed that parents of toddlers reacted differently to boys' and girls' behaviors. Parents responded more positively to girls than boys when the toddlers played with dolls, and more critically to girls than boys when the toddlers engaged in large motor activity [Stern et al 1989, page 502].

Expecting different behavior from boys and girls can be a self-fulfilling prophecy: If one sort of behavior is expected and encouraged, the child will be more likely to continue it.

Children also have been shown to have formed sexual stereotypes as early as at two years old [Weinraub et al 1983, page 33]. For example,

> Preschool children also have a good grasp of adult-validated sex-stereotyped beliefs about children's behavior. When asked in an interview-like situation which of two paper dolls — 'Michael' or 'Lisa' — would like to do certain activities in nursery school, end up in certain future roles, and have certain character traits, children $2\frac{1}{2}$ to $3\frac{1}{2}$ years old showed an impressive depth of knowledge (Kuhn, Nash, & Brucken, 1978). Children believe that girls like to play with dolls, help mother, cook dinner, clean house, talk a lot, never hit, and say 'I need some help'; they also believe that boys like to play with cars, help father, build things, and say 'I can hit you' [Weinraub et al 1983, page 34].

The careers that children imagine for males and females are influenced by sex stereotypes. By the age of three years, most children "know that girls will grow up to clean the house, be a nurse, or be a teacher, and boys will grow up to 'be boss'" [Weinraub et al 1983, page 38]. These stereotypes affect the careers that children picture for themselves:

> Even preschool children express future aspirations along sex-stereotyped lines. Both preschool and elementary school girls choose a

> parenting role significantly more often than boys (Looft, 1971; Vondracek & Kirchner, 1974). In addition, the range of occupational choice is more restricted for girls, with nurse and teacher being the most popular answers (Vondracek and Kirchner, 1974; Beuf, 1974). Boys' choices include more action oriented occupations (police officer, sports superstar) and more prestigious careers (doctor, public servant, pilot).
>
> Taking the question one step further, Beuf (1974) asked children 3 to 6 years of age what they would do if they were of the other sex. Approximately 70 percent of the children replied with a job considered appropriate for the imagined sex. More interestingly, boys frequently imagined themselves as nurses and girls imagined themselves as doctors when asked, 'What if you were a girl (boy)?' Several girls confided that they really would prefer to be doctors rather than nurses when they grew up, but couldn't because they were girls [Weinraub et al 1983, page 44].

Thus, from an early age, girls and boys learn to think of most careers as being appropriate for either men or women but not both. This will influence not just their career choice but how they view males and females aspiring to "inappropriate" roles.

Unfortunately, these stereotypes are so pervasive that it is difficult for unprejudiced parents to prevent their children from accepting the stereotypes:

- A female computer scientist told me:

  > We ... have a rather non-traditional household, and I'm surprised at how traditional my two daughters seem to be turning out.
  >
  > Both my husband and I work full-time, but when we are home, [John] does almost all the cooking (I make a meal maybe once every three weeks), he cleans up after himself while cooking so I don't do much of the cleaning in the kitchen, I do the laundry (sometimes), and we let everything else go until a friend comes to clean our house and dig us out from under the laundry I never can seem to get to....
  >
  > [Once,] I asked my 5-year-old who did most of the work around the house, me or her daddy. She said "you". Now, this kid is totally guileless — she has not learned yet how to say one thing to one person and another to another, so I'm sure she wasn't just telling me this because I was the one who asked the question. So I said, "What kind of work do I do around the house? In the living room, in the kitchen?" She said, "You clean the kitchen." *I couldn't believe it!* I might have believed her if she said I occasionally picked up in the living room — but

cleaned the kitchen? Her dad's domain? Where did *that* come from????

- Another parent reported:

  > When our daughter was very young — about 3 years old — we audiotaped an interview about what she would be when she grew up. After mentioning a number of possibilities my wife said, 'What about a doctor?' Jessica replied, 'Yeah, I could be a doctor.' Our son who was 5 at the time interrupted saying, 'I think you mean a nurse.' 'Yeah, a nurse,' Jessica said. My wife said, 'She could be a doctor if she wanted,' and our son replied, 'I don't think so...I've never seen any, at least not in Iowa.'

Stereotypes also exist specific to the computer world. One paper reports:

> We have even found that some young children believe computer games and computers are for boys. In one nursery school, Pratto (1982) asked girls and boys aged 3 to 5 to name the toys they played with. Both girls and boys reported that boys played with Atari; it was never mentioned as a game for girls. We returned to that school and asked 42 children whether they thought computers were for girls, and then we asked whether computers were for boys. Most children answered this question. Although the majority thought computers were for both genders, the boys were not as sure of this as were the girls (71% of the girls and 57% of the boys). Of the minority, more children thought computers were for boys only (14% of the boys and 11% of the girls) than thought computers were for girls only (7% of the boys and 4% of the girls) [Kiesler et al 1985, page 456].

The point of this section can be illustrated by the following incident:

> A group of parents arranged a tour of a hospital for a group of twenty children: ten boys and ten girls. At the end of the tour, hospital officials presented each child with a cap: doctors' caps for the boys, nurses' caps for the girls. The parents, outraged at this sexism, went to see the hospital administration. They were promised that in the future, this would be corrected. The next year, a similar tour was arranged, and at the end, the parents came by to pick up their children. What did they find, but the exact same thing — all the boys had on doctors' hats, all the girls had on nurses' hats! Steaming, they stormed up to the director's office and demanded an explanation. The director gently told them, 'But it *was* totally different this year: We offered them all *whichever hat they wanted*'" [Hofstadter 1986, page 156].

1.1.4 The Effects of Stereotypes on Teachers and Advisors

Additionally, stereotypes influence people who advise students, such as their parents, guidance counselors, and teachers. For example, [Stewart et al 1989] showed that, when given artificial case studies, high school teachers were more likely to advise male students than otherwise-identical female students to take courses that would prepare them for post-secondary institutions. Another study showed that high school girls "said that they had chosen business and commercial courses in order to prepare themselves for clerical jobs because they believed these were the jobs open to women" [Stewart et al 1989, page 261]. In response to a survey of female scientists,

> [M]any women felt they had been given inadequate advice on careers and choices of subject — careers advisers seemed to be fixated on nursing and teaching, and some were completely floored by requests for information about nuclear physicists or process engineers [Ferry et al 1982, pages 27–28].

Interviews with high school guidance counselors yielded similarly prejudiced advice to girls:

> A counselor in her early 30's: 'Well, if they bring me their registration card with (an AP [advanced placement] science course) listed I'll check to see if that's really what they meant... but I would never encourage it. I mean, it's usually their last year and there are so many fun things going on. I think they'll be busy enough and they can get into the serious work in college.'
>
> A counselor in her 20's: 'I just hate to see a girl get in over her head. I always try to place students at a level where I know they'll be successful. I mean, wouldn't it be frightful to spoil a beautiful record by doing poorly in a course your senior year.'
>
> A male director of guidance, mid-forties: 'Sure, I'm for the AP Program in general, but not for encouraging girls in science necessarily. Have you looked at the Bureau of Labor Statistics? It's a contracting market. There are men with Ph.D.'s in physics all over the place who can't get jobs. Why should we encourage girls? Why, if they're successful, they'd be taking jobs away from men who need them. No, it wouldn't be fair to the girls' [Casserly 1979, page 12].

Unfortunately, as the interviewer goes on to report, "these comments were chosen not because they were unique but because they represented all too commonly the attitudes of the counselors in many schools".

Additionally, even when girls are in science classes, teachers sometimes treat them differently, as shown by the following remarks from an interview of junior high school girls: