Women, Mathematics, and Computing[1]

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INTRODUCTION

In 1963, Betty Friedan wrote these gloomy words:

The problem lay buried, unspoken, for many years in the minds of American women. ... Each suburban wife struggled with it alone. As she made the beds, shopped for groceries, matched slipcover material, ate peanut butter sandwiches with her children, chauffeured Cub Scouts and Brownies, lay beside her husband at night – she was afraid to ask even of herself the silent question—"Is this all?"

The passage, of course, is from the *The Feminine Mystique* (Friedan, 1983, p. 15). Though it took another decade for the discontent that Friedan described to solidify into a political movement, even in 1963 women were doing more than making peanut butter sandwiches. They also earned 41% of bachelor's degrees. By 1995, the number of degrees conferred had nearly tripled. The fraction going to women more than kept pace, at almost 55%. Put another way, women's share of bachelor's degrees increased by 25% since Betty Friedan first noticed the isolation of housewives. Consider two more sets of numbers: In 1965, 478 women graduated from medical school. These 478 women accounted for only 6.5% of the new physicians. Law was even less hospitable. Only 404 women, or just 3% of the total, received law degrees in 1965. By 1996, however, almost 39% of medical degrees and 43% of law degrees were going to women (Anderson, 1997).

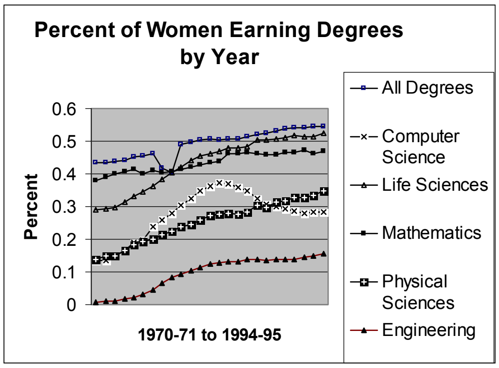
If so many women are studying medicine and law, why are so few studying computer science? That's a good question, and one that has been getting a lot of attention. A search of an important index of computing literature, the *ACM Digital Portal* (ACM, 2005a), using the key words "women" and "computer," produced 2,223 hits. Of the first 200, most are about the underrepresentation of women in information technology. Judging by the volume of research, what we can do to increase the numbers of women studying computer science remains an open question.

While most investigators fall on one side or the other of the essentialist/social constructivist divide (Trauth, Quesenberry & Morgan, 2005), this article sidesteps the issue altogether in favor of offering a testable hypothesis: Girls and young women would be drawn to degree programs in computer science in greater numbers if the field were structured with the precision of mathematics. How we arrived at this hypothesis requires a look at the number of women earning degrees in computer science historically and in relation to other apparently similar fields.

BACKGROUND

In 1997, *The Communications of the ACM* published an article titled "The Incredible Shrinking Pipeline" (Camp, 1997). The article points out that the fraction of computer science degrees going to women decreased from 1986 to 1994. This bucks the trend of women entering male-dominated professions in increasing numbers. The graph below shows the percent of women earning degrees in various scientific disciplines between 1970-'71 and 1994-'95 (National Center for Educational Statistics, 1997).

Figure 1.



If you did not look at the data over time, you would be justified in concluding that the 13% or so engineering degrees going to women represents a terrible social injustice. Yet the most striking feature of the degrees conferred in engineering and the physical and life sciences is how closely their curves match that of all degrees conferred to women. Stated another way, the fraction of degrees in engineering and the sciences going to women have increased enormously in a single generation. It has, in fact, out-paced the fraction of all degrees going to women. The curves for engineering and the life sciences both have that nice S shape that economists use to describe product acceptance. When a new kind of product comes to market, acceptance is initially slow. When the price comes down and the technology improves, it accelerates. Acceptance finally flattens out as the market becomes saturated. This appears to be exactly what has happened in engineering. Following the growth of the women's movement in the early 1970s, women slowly began to account for a larger share of degrees conferred. By the early 1980s, the fraction grew more rapidly, and then, by the 1990s, the rate of growth began to slow. A parallel situation has occurred in the life sciences, but at a much higher fraction. Women now earn more than 50% of undergraduate degrees in biology.

Computer science is the anomaly. Rapid growth in the mid-1980s was followed by a sharp decline. The fraction of women graduating in computer science flattens out in the 1990s. What is going on here? A study of German women noticed that the sharp increase in the number of degrees in computer science going to women followed the commercial introduction of the microcomputer in the early 1980s (Oechtering, 1993). This is a crucial observation. In a very few years, computers went from something most people were only vaguely aware of to a consumer product. What the graph does not tell you is that great numbers of men also followed the allure of computing in the early and mid-1980s—numbers that declined by the end of the decade.

Despite many earnest attempts to explain why women do not find computer science as appealing as young men (e.g., Bucciarelli,1997; Wright, 1994), it is important to point out that computer science is not like the other areas we have been considering. Unlike physics, chemistry, mathematics and electrical engineering, there is not an agreed-upon body of knowledge that defines the field. An important textbook in artificial intelligence, for instance, has grown three-fold in 10 years. A common programming language used to teach introductory computing barely existed a decade ago. Noam Chomsky has suggested that the maturity of a scientific discipline is inversely proportional to the amount of material that forms its core. By this measure, computer science is far less mature than other scientific and engineering disciplines.

Many studies have shown that girls are consistently less confident about their abilities in mathematics and science than are boys, even when their test scores show them to be more able (e.g., Mittelberg & Lev-Ari, 1999). Other studies attribute the shortage of women to lack of confidence along with the perception that computing is a male domain (Moorman & Johnson, 2003). Unfortunately, computer science, at least as presently constituted, requires a good bit of confidence. The kinds of problems presented to computer science majors tend to be open-ended. Unlike mathematics, the answers are not in the back of the book—even for introductory courses. There is often not a single best way to come up with a solution and, indeed, the solutions themselves, even for trivial problems, have a stunning complexity to them. The tools that students use to solve these problems tend to be vastly more complex than the problems themselves. The reason for this is that the tools were designed for industrial-scale software development. The move over the last decade to object-oriented languages has only exacerbated an existing problem (Hsia, Simpson, Smith, & Cartwright, 2005). A typical lab assignment to write a program in the C++ or Java language will require that the student have a working knowledge of an operating system, graphical user interface, text editor, debugger and the programming language itself.

One surrogate for complexity is the size of textbooks. Kernighan and Ritchie's classic, *The C Programming Language* (1978) is 228 pages long. The first program in the book, the famous "Hello world," appears on page 6. Deitel, Deitel, Lipari, and Yaeger's (2004) *Visual C++ .NET: How to Program,* on the other hand, weighs in at a hefty four pounds and runs to 1,319 pages. Students have to wade through 52 pages before they reach the book's

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