Gender Differences in Computer Science Students

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Abstract

We examined gender differences and differences in Computer Science (CS) majors vs. non-majors in ability in quantitative areas, educational goals and interests, experience with computers, stereotypes and knowledge about CS, confidence, personality, support and encouragement, stress and financial issues, gender discrimination, and attitudes toward the academic environment in CS. What is unique to this investigation is its multivariate nature. While others have studied these variables in isolation, our study looks at them collectively to identify important interactions among variables. This will eventually allow us to identify a profile of women who pursue careers in CS. The findings are reported in detail below. Particularly noteworthy is that men had more confidence in using computers than did women even when statistically controlling quantitative ability. In fact, female CS majors had less computer confidence than did male non-majors!

Categories & Subject Descriptors

K. 3 [**Computers & Education**]: Computer & Information Science Education – Computer Science Education.

General Terms

Measurement, Experimentation, Theory.

Keywords: Gender, Confidence, Stereotyping

1 Introduction

This nation faces a serious shortage of computer scientists. From 1986 to 1996, the number of men majoring in CS dropped by 33%, whereas the number of women dropped by 55% (calculated from data in [23]). The U.S. Department of Labor projects that between 2000 and 2010 an additional 1.6 million workers with degrees in information technology are needed [13]. This shortage of computer scientists provides impetus for increasing the representation of women in CS.

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Two reasons for the small number of women in CS are negative stereotypes regarding the field and low confidence. We [1, 3, 5, 6, 7, 8, 9, 10] have repeatedly found that females have inaccurately low confidence in masculine domains, including mathematics, chemistry, and CS.

CS is stereotyped as even more male-dominated than the traditional male bastions of chemistry and mathematics [4]. Both men and women *incorrectly* believe that men in CS have higher GPAs than women [4]. Furthermore, women who succeed in CS are often viewed as "exceptional", leaving intact the stereotype that women do not belong in CS [14].

The stereotypes about CS majors are unflattering. They are perceived to be intelligent but deficient in interpersonal skills [4, 9, 10]. This has been termed the "computer nerd syndrome" or "geek mythology" [18, 21]. These perceptions of CS majors conflict more with the gender roles of females than of males, because women have a stronger interpersonal orientation than men [12, 20].

The major goal of the present research is to discover the reasons for the dearth of women majoring in CS. Our study is unique in that it uses a multivariate approach. Other researchers have focused on studying individual variables predicting interest in and/or retention in CS. We focus on identifying the important interactions among variables. This will eventually allow us to identify a profile of women and men who pursue careers in CS.

2 Method

We distributed questionnaires to 56 students (24 females, 32 males) enrolled in a CS course during the spring and fall 2001 semesters. We visited two types of courses: 1. Basic-level courses such as "Computer Productivity Tools" that do not count towards the CS major and 2. courses that are required for the CS major such as "Introduction to CS". Very few students in basic-level courses end up majoring in CS, whereas required courses are mostly taken by CS majors or eventual CS majors. Henceforth we refer to students in these two course types as "non-majors" and "majors". We want to point out that the "majors" group also includes students who have not officially declared the CS major yet.

Participants were paid $8 to fill out questionnaires assessing demographic information; ability in quantitative areas; educational goals and interests; experience with computers; stereotypes and knowledge about CS; confidence; personality; support and encouragement; stress and financial issues; gender discrimination; and attitudes towards CS courses and instructors.

3 Results

We performed 2 x 2 analyses of variance (ANOVAs) using gender as one variable and courses typically taken by CS majors vs. non-majors (referred to as majors vs. non-majors) as a second variable. Table 1 gives selected means and standard deviations from these analyses, and we discuss each in the subsections below.

	CS Majors				Non-majors			
	Females		Males		Females		Males	
Selected variables	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Math ACT scores	26.3	3.7	25.3	4.8	23.4	4.3	23.4	3.2
Hours/week spent on school wor	21.0	12.3	25.6	12.3	14.0	8.5	13.9	8.9
Educational aspirations	.6	1.1	1.3	1.1	1.1	1.1	2.0	1.0
Select career to interact with pec	3.1	.9	2.9	.1	3.7	.7	4.5	.8
Select career to get extrinsic rew	3.0	.9	3.7	.8	3.8	.7	4.5	.6
Hours/week spent on computer	33.0	22.2	32.7	21.7	18.4	12.5	20.2	13.4
Estimated salaries of computer scientists	45800	7208	44080	7696	40833	7334	49714	15724
Estimated GPAs of CS majors	3.2	.3	3.0	.3	3.4	.2	3.4	.3
CS is good career due to flexible work schedule	3.4	1.4	4.0	1.5	3.8	1.2	4.8	1.2
"Computer scientists are loners"	4.1	1.7	4.2	1.2	3.5	1.3	3.1	2.0
Conscientiousness	4.6	1.0	4.0	.6	4.8	.7	5.1	1.0
Open to new experiences	3.9	1.3	4.2	1.0	4.7	.8	4.9	.8
Masculinity	4.9	.6	5.2	.6	4.8	.7	5.8	.7
Interpersonal attachment	3.8	.5	3.1	1.0	3.5	.3	3.3	.9
Reassurance of competence	3.4	.5	3.1	.6	3.1	.5	3.6	.9
Certain of financial support	2.6	1.8	2.5	1.6	4.0	1.3	4.3	1.0
Perception of gender discriminat	2.4	1.2	1.9	.9	2.2	.9	3.2	1.4
Perception of academic environn	4.4	1.1	3.8	1.3	5.1	1.0	4.0	1.6
CS classes are overwhelming	2.8	.8	3.3	.7	2.7	.4	2.5	.5

Table 1. Means and standard deviations for selected variables.

3.1 Demographic Variables

This sample consisted of 82% Caucasian, 9% Hispanic, 7% Asian, and 2% African American students. Eight of our respondents had not declared their major, 14 were business majors, 6 majored in other subjects, and 28 were CS majors. Male and female students and CS majors and non-majors were remarkably similar in demographic variables including age, number of siblings, year in college, number of children, prevalence of disabilities, socioeconomic status, and parental level of education. Non-majors were less likely to be married than were CS majors, χ^2 (3, N =56) = 8.40, $p < .04$, and had attended fewer semesters of study than CS majors, $F(1, 52) = 4.51$, $p < .04$.

3.2 Ability in Quantitative Areas

There were no gender or major vs. non-major differences for self-reported college GPA, $F(1, 51) = 1.37$, $p < .25$, $F(1, 51) = 2.40$, $p < .13$. In other words, women, men, CS majors, and non-majors did not differ to a statistically significant degree in self-reported college GPA. CS majors scored significantly higher than did non-majors on the science portion of the ACT, $F(1, 29) = 4.59$, $p < .05$, and had marginally better composite ACT scores, $F(1, 29) = 4.03$, $p < .06$. There were no significant gender differences for ACT mathematics, science, or composite scores, $Fs(1, 29) < 1$. The lower N of our sample for analyses involving ACT scores is due to the fact that some of our participants had not taken the ACT.

3.3 Educational Goals and Interests

CS majors, non-majors, men, and women were equally likely to plan to take more math and science courses, $Fs(1, 53) < 1.29$, $ps < .26$. Interestingly, there was no gender difference in interest in majoring in CS, $F(1, 53) = 1.32$, $p < .26$. But, not surprisingly, students taking courses counting towards the CS major listed CS as their intended or actual major significantly more frequently than did students taking non-major courses offered by the CS department, $F(1, 53) = 40.75$, $p < .0001$. Majors and non-majors and females and males alike thought that CS was a worthwhile major $F(1, 53) < 1$, $F(1, 53) = 1.79$, $p < .19$.

There was no gender difference in the number of hours spent on school work per week, but CS majors spent significantly more time on their school work than did non-majors, $F(1, 53) = 8.00$, $p < .007$.

Men had significantly higher educational aspirations than did women, $F(1, 53) = 5.58$, $p < .03$. In terms of selecting a career, non-majors rated interactions with people as more important than did CS majors, $F(1, 52) = 14.93$, $p < .0001$. Non-majors valued extrinsic rewards in their career selection more than did CS majors, $F(1, 53) = 12.36$, $p < .001$. Similarly, men valued extrinsic rewards more than did women, $F(1, 53) = 9.63$, $p < .003$. Thus, female CS majors value extrinsic rewards in their career selection the least and male non-majors value extrinsic rewards the most.

3.4 Experience with Computers

There were no gender or major vs. non-major differences in age at first computer use, $Fs(1, 52) < 1$. Majors spent significantly more time than non-majors using a computer, $F(1, 53) = 5.83$, $p < .02$. This was attributable to the difference in the number of hours spent on school-related computer projects, $F(1, 50) = 7.49$, $p < .009$, rather than to a difference in the number of hours using the computer for non-academic activities, $F(1, 53) < 1$.

Twenty-nine of the 56 participants knew someone with a CS degree prior to taking a class offered by the CS department. This did not differ significantly by gender, χ^2 (1, N = 56) = .04, $p < .84$, or major vs. non-major, χ^2 (1, N = 56) = .60, $p < .44$. Significantly more CS majors (97.2%) than non-majors (40%) had experience in computer programming, $F(1, 53) = 29.75$, $p < .0001$, and marginally more males (90.6%) than females (58.3%) had programming experience, $F(1, 53) = 2.85$, $p < .10$. Significantly more men (72%) than women (38%) had installed RAM in a computer, $F(1, 53) = 5.44$, $p < .03$.

3.5 Stereotypes and Knowledge about CS

There were no gender or major vs. non-major differences in knowledge of what CS is, $F(1, 53) = 1.23$, $p < .27$, $F(1, 53) = 2.50$, $p < .12$. Both males and females rated the career opportunities of individuals with CS degrees as excellent, $F(1, 44) < 1$, but CS majors rated the career opportunities marginally higher than did non-majors, $F(1, 44) = 3.42$, $p < .08$. Males

believed that computer scientists are loners and that they are interested in numbers to a greater extent than women did, $F(1, 53) = 5.41$, $p < .03$.

For participants' estimates of compensation in CS there was a borderline significant interaction between gender and major vs. non-major, $F(1, 50) = 3.87$, $p < .06$. Whereas male and female CS majors gave similar estimates, female non-majors' salary estimates were lower than male non-majors'. This lack of awareness of the high financial compensation in CS on the part of female non-majors is of concern.

There were no gender or major vs. non-major differences for the estimated number of hours typical computer scientists work, $F(1, 52) = 2.10$, $p < .16$, $F(1, 52) < 1$. There were also no gender or major vs. non-major differences for the estimated percentage of women computer scientists, $F(1, 52) < 1$, $F(1, 52) = 3.01$, $p < .09$. However, non-majors thought that the average GPA of CS majors was higher than the CS majors thought, $F(1, 52) = 14.88$, $p < .0001$.

We asked questions regarding CS as a career for parents of young children. A factor analysis yielded a three-factor solution: flexible work schedule, extrinsic rewards, and stress. Non-majors agreed more strongly than majors that Computer Science was a good career choice for parents of young children because of its flexible work schedule, $F(1, 49) = 6.18$, $p < .02$. There were no gender or major vs. non-major differences for perceptions of CS being a good career for parents of young children because of extrinsic rewards, $F(1, 50) = 1.91$, $p < .18$, $F(1, 50) = 1.73$, $p < .20$, or because of low levels of stress, $F(1, 50) < 1$, $F(1, 50) = 2.35$, $p < .39$.

Women, men, CS majors and non-majors did not differ in their beliefs about the compatibility of family life and a career in CS for women, $F(1, 53) = 1.37$, $p < .25$, $F(1, 53) < 1$. They believed that CS was a career where family life and career would be compatible for women.

3.6 Confidence

To determine whether there was a gender difference in confidence when controlling for quantitative ability, we regressed confidence in computer skills on gender, mathematics ACT score, and their interaction.

The regression revealed that participants with higher math ACT scores had higher confidence in their computing ability than participants with lower ACT scores, $F(1, 27) = 5.43$, $p < .03$. An important finding was the significant gender effect. Women had less confidence than did men, even with ACT scores controlled, $F(1, 27) = 11.93$, $p < .002$. There was no significant difference between majors and non-majors in level of confidence, $F(1, 27) = 1.02$, $p = .32$. As Figure 1 illustrates, female CS majors actually had less computer confidence than male non-majors, even when taking their ACT scores into account. At every level of quantitative ability and regardless of whether they are taking courses designed for majors or non-majors, females have less confidence in their computer aptitude than males!

3.7 Personality

We asked questions which yielded a personality profile of each participant. Female non-majors were less conscientious than male non-majors, whereas female CS majors were more conscientious than male CS majors, $F(1, 53) = 5.19$, $p < .05$. Non-majors were more open to new experiences than were CS majors, $F(1, 52) = 7.71$, $p < .008$.

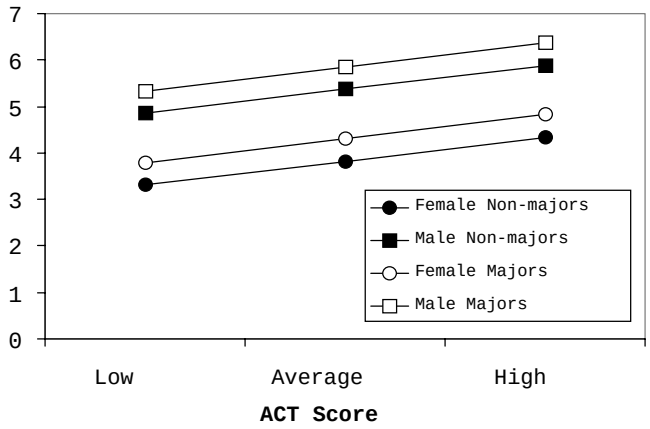

Figure 1: Gender Differences in Confidence by Math ACT Score.

Men's gender roles were significantly more "masculine" (e.g., aggressive, domineering) than were women's, $F(1, 53) = 8.29$, $p < .006$. However, men's and women's gender roles did not differ in femininity (e.g., nurturing, kind), $F(1, 53) = 1.62$, $p < .21$. There were no significant gender or major vs. non-major differences in self-esteem, $F(1, 53) = 2.60$, $p < .12$, $F(1, 53) < 1$, neuroticism, $F(1, 52) < 1$, $F(1, 52) = 1.65$, $p < .58$, or importance placed on having a family, $Fs(1, 53) < 1$.

3.8 Support and Encouragement

There were no significant gender or major vs. non-major differences in support and encouragement from others. Female participants reported more interpersonal attachment and connectedness with others than did males, $F(1, 53) = 5.19$, $p < .03$. Male non-majors were more reassured of their competence by others than were male CS majors, $F(1, 52) = 4.40$, $p < .05$. However, female non-majors reported less reassurance of their competence from others than did female CS majors.

3.9 Stress and Financial Issues

There were no significant gender or major vs. non-major differences in stress, $Fs(1, 53) < 1$. The majority (85.7%) of our respondents were employed at the time of the survey. There were no significant gender or major vs. non-major differences for the number of hours worked, $Fs(1, 53) < 1$. Non-majors were significantly more certain of having adequate financial support to complete their college education than were CS majors, $F(1, 53) = 12.65$, $p < .001$. The three major sources of educational funding for all our participants (in order of importance) were parents, student loans, and self (through employment or savings).

3.10 Gender Discrimination

Male non-majors thought there was more discrimination against women in the CS department than male CS majors did, whereas female non- majors and majors did not differ in their perceptions

of gender discrimination, $F(1, 51) = 5.94$, $p < .02$. Overall, students believed that there was little gender discrimination in the CS department.

3.11 Attitudes towards CS Courses and Instructors

CS majors found the academic environment in CS less positive than non-majors did, $F(1, 52) = 4.73$, $p < .04$. Non-majors, majors, women, and men had equally lukewarm perceptions of the faculty, the social atmosphere in the CS department, and programmatic issues, $Fs(1, 52) < 1$. The CS lab was perceived somewhat positively by those participants who had used it (mostly CS majors). CS majors thought that their CS classes were more difficult and overwhelming than did non-majors, $F(1, 51) = 8.25$, $p < .01$.

4 Discussion

This research examined a large number of variables that could potentially adversely affect the number of women in CS. We found no gender differences in quantitative ability, interest in CS, stereotypes and knowledge of CS, or attitudes towards CS courses and instructors. In addition, participants viewed CS as a field where family life and career are compatible goals for women and they did not believe that there was gender discrimination in the CS department.

Thus, the present research suggests that these variables are not the causes of the dearth of women in CS, saving us from expending effort to change these variables. Instead we should focus our energies on changing the variables that were found to negatively impact women in CS. We turn to these next.

The stereotypes of CS majors as "nerds" (cf. [16]), their perceived obsession with machines and lack of interest in people, and associations of technology with masculinity conflict more with the gender roles of women than with those of men [12, 20]. Coupled with the inaccurate perception of women's lower ability in CS [4], and female non-majors' lack of awareness of excellent income opportunities in CS, these stereotypes probably conspire to deter women from majoring in CS. In addition, women in CS may suffer from stereotype threat, which "occurs when targets of stereotypes alleging intellectual inferiority are reminded of the possibility of confirming these stereotypes" [15].

Furthermore, CS majors had more negative perceptions of the academic environment in the CS department than did non-majors. Although there was no gender difference in perceptions of the academic environment, women may be more affected than men by their negative perceptions of the academic environment and support [22], which may lead to increased attrition among female majors.

Female non-majors felt less reassured of their competence than female majors. Women who have supportive friends and family are more likely to major in CS [11]. Thus, we speculate that reassurance of one's competence by others may increase the probability that a woman musters the courage to enter into a male-dominated major such as CS.

We found that women's computer confidence was much lower than men's, even when we statistically controlled quantitative ability. In fact, female CS majors had less confidence in their computer skills than did male non-majors! In a previous study of first-year college students who had not taken any CS courses yet, we also found that women have lower computer confidence, when controlling for math ACT scores [10]. This suggests that low computer confidence affects women regardless of level of computer experience or quantitative ability. Low computer confidence among women is a major barrier to women's advancement in CS.

One cause of women's low confidence is their less playful and relaxed attitude towards computers [21]. This is exemplified in this study by men's greater likelihood to have installed internal components such as RAM. Confidence is also affected by the amount of previous experience with computers [24]. Indeed, women had somewhat less programming experience than men. This may be explained by the fact that their interest in programming develops at a later age than men's [19]. This lack of programming experience is likely to adversely affect women's confidence.

What is the consequence of low confidence? Positive self-perceptions of ability are intimately tied to aspirations, educational choices, preference for challenging tasks, intrinsic motivation, and persistence. Thus they have desirable effects on performance (for a review see [2]). This suggests that females' low computer confidence has deleterious behavioral consequences. It may decrease the likelihood that women will choose to major in CS and increase the likelihood that female CS majors will drop out of CS. This means that women miss the opportunity to enter into a highly paid field with excellent career potential. Therefore it is of utmost importance to CS educators to help increase female CS students' computer confidence. Encouragement and steering female students to internships, teaching or lab assistantships, and other opportunities that can bolster their confidence in their skills may accomplish this.

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