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The More Things Change, the More They Stay the Same: Gender Differences in Attitudes and Experiences Related to Computing Among Students in Computer Science and Applied Information Technology Programs

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Abstract

Previous research suggests that the current trend towards applied information technology (IT) programs can potentially expand the involvement of women in computing. This paper reports on a Web-based survey of female and male students in computer science and applied IT programs in five public U.S. universities, designed to determine if there were differences in their demographic characteristics, uses of and attitudes toward computers, and reasons for selecting an IT major. The findings reveal that while some differences exist between the computer science and applied IT students, especially in their demographics, more differences are due to gender than to major, and these tend to replicate earlier findings for computer science contexts alone. At the same time, women's higher enrollments in the applied programs suggest that they see advantages to studying IT outside a traditional computer science environment, such as the possibility of applying computing knowledge to socially-meaningful work.

Introduction

A number of studies have documented the problem of the shrinking numbers of women enrolled in computer science programs at the undergraduate and graduate levels, and attempted to address the causes (Bryant & Irwin, 2001; Cohoon, 2001; Margolis & Fisher, 2002; Moorman & Johnson, 2003; Creamer, Burger, & Meszaros, 2004). Some, such as the Carnegie Mellon study, have gone further to propose and implement solutions (Lee, 2002; Margolis & Fisher, 2002; Natale, 2002; Beyer, Chavez, & Rynes, 2003). All of this research focuses predominantly on educational programs and employment in the field of computer science, rather than examining trends in information technology more broadly defined.

As Berghel and Sallach (2004) point out, however, the current trend in U.S. universities is toward merger of computer science and computing with other academic units that teach applied forms of information technology. Such units include (but are not limited to) information systems (traditionally found in business schools); instructional technology (traditionally found in schools of education); information science (traditionally combined with library science); and informatics (a new, interdisciplinary field of study at the intersection of people, information, and technology, with roots in computing applications to medicine). Berghel and Sallach call this a paradigm shift in the reorganization of academic instruction in computing and information technology on campuses across the country. Futher, the "breadth and diversity of subject areas [in the new schools and colleges] suggests that the process of computer information technology program evolution has yet to slow down or stabilize" (p.84).

This trend is potentially important to expanding the educational involvement of women in computing. Disciplines such as library and information science and education have histories of recruiting and retaining large numbers of women, and women in these disciplines are more likely to achieve professional parity or near parity with men (Quint, 1999; Wolverton, 1999). Moreover, as has been previously observed (Ahuja, Herring, Ogan, & Robinson, 2004), applied IT fields in general are grounded in the contexts of real-world problems, tend to provide a more gender-balanced environment, and thus may constitute a more woman-friendly culture, attracting female students and fostering their educational success. Thus lessons might be learned by examining the characteristics of the students, the nature of the programs, and the institutional climate in applied information technology disciplines, just as previous research has found that such factors make a difference to the successful recruitment and retention of women in computer science programs (Cohoon, 2001; Margolis & Fisher, 2002).

Among the findings that emerge repeatedly from previous research is that girls and women are less likely to choose computing as a career in the first place, for reasons that have been traced variously to lack of aptitude, interest, or experience regarding computers, on the one hand (Badagliocco, 1990; Kramer & Lehman, 1990; Young, 2000), and to cultural stereotypes and perceptions that computing is a mostly masculine activity, on the other (Kiesler, Sproull, & Eccles, 1985: Turkle, 1988). If few women opt to study IT, efforts to make IT education more women-friendly can have a limited effect, at best. The question arises, therefore, whether applied IT careers attract more women, and, more generally, what kind of students enroll in applied IT programs, as compared to computer science programs. Answering this question is an important first step in understanding the potential of new, interdisciplinary, applied IT disciplines to foster more equitable outcomes for women as regards computing technology.

The research we report on in the present study compares the demographics, attitudes, and behaviors related to computing among undergraduate and graduate students majoring in applied information technology disciplines with those majoring in computer science. The specific questions that motivate this research, which is part of a larger study of educational experiences and the institutional culture of information technology education,[1] are as follows: Are there significant differences in the backgrounds, experiences, and attitudes toward computing of students studying computer science and students studying information technology in some other applied discipline? Are there differences between women and men in these areas, both within and across program types? If so, do the differences suggest that applied IT programs offer advantages and opportunities for women?

Methodology

As part of a larger longitudinal study of five U.S. research institutions where information technology is taught, we conducted a web-based survey of all male and female undergraduate and graduate majors in five academic units: computer science (CS), informatics (I), information science/studies (IS), instructional systems technology (IST) and management information systems (MIS). The universities surveyed are: Indiana University Bloomington, University at Buffalo (formerly SUNY Buffalo), University of Illinois at Urbana/Champaign, University of Michigan at Ann Arbor and Dearborn, and University of Washington. These publicly-funded research institutions were selected based on the minimum requirement of having a computer science unit and at least two out of four of the other IT-related units. We also gave preference in the selection process

[1] National Science Foundation IT Workforce Grant #0305859, “Toward Gender Equitable Outcomes in Higher Education: Beyond Computer Science.”

to universities with programs in instructional technology and/or informatics, as these are relatively less common. The universities selected have a total of 18 IT units (programs, departments or schools), of which five are in computer science, five in library and information science/information studies, three in management information systems, three in instructional technology, and two in informatics.

The survey was conducted in March and April 2004 by the Center for Survey Research at the academic institution of the authors. We selected a web-based format for the survey on the expectation that information technology students would be comfortable with this format. Response rates have been found to be roughly equal for Web surveys and mail surveys (Truell, Barlett, & Alexander, 2002). The majority of students were contacted directly through their university e-mail accounts, invited to participate in the study, and given information about how to access the web survey. For reasons of student privacy, students in three units were contacted through an administrator in their unit via e-mail.

The survey contained 100 questions related to students' experience, behaviors, and attitudes regarding computers, their parents' occupations and attitudes toward gender roles, student demographic information, and information about mentoring, stress and burnout in their academic environment. These questions were based on previous research that posited that women's low participation in higher education computing programs can be traced to factors such as lack of experience with computers (Badagliocco, 1990; Ray, Sormunen, & Harris, 1999), the influence of parents and other role models (Shashaani, 1994), and a "masculine," obsessive, computing culture that women find alienating (Turkle, 1988). Only those parts of the data from the survey that relate to students' backgrounds and attitudes towards computing will be addressed in this chapter.

As we were not informed of the number of students in the three units where the administrator made first contact with the students, it was not possible to determine total response rate for those units. Response rates for the rest of the units ranged from 32% to 85%.[2] The total number of respondents was 1768, of whom 1516 responded to a question

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[2] Because we did not conduct a random sample survey, we make no claims for the representativeness of this sample. We believe, however, that these responses are not atypical for students studying in information technology programs in top-tier public research universities in the United States.

asking for their gender. The latter number is used to report the results for this chapter. Results were analyzed using the statistical software program SPSS 11.

Analysis

To assess the differences in gender by type of program, we split the sample, placing all computer science (CS) students in one group and all the rest of the students from applied information technology disciplines (Applied) in another. In the CS group, a total of 508 males and 115 females completed the survey, while in the Applied group, a total of 414 males and 479 females did so. The proportions of responses by gender (roughly 4 to 1 vs. 1 to 1 males to females for the CS vs. Applied responses, respectively) are thus in keeping with our expectation of finding a higher proportion of women in the applied IT units. In three of the units where library and information science is the focus of study, about twice as many women responded to the survey as did men. Library and information science is a special case and is discussed further below.

Demographics

As regards level of academic program, undergraduate students make up the majority of the students in CS in our sample (57.0% of CS vs. 23.0% of Applied students). In contrast, the sample is skewed more towards master's students in the Applied programs (12.8% of CS and 65.2% of Applied). Doctoral students comprise 30.2% of the CS students and 11.8% of the Applied students. There are several reasons why these distributions differ. Computer science is a popular undergraduate major. Moreover, students who come to graduate school in CS are primarily seeking a doctorate and may acquire a master's degree along the way, but the master's degree is not the main goal of most graduate computer science students. The goal of these students is more frequently a career in academia where the doctorate is the minimum requirement. In the Applied fields, in contrast, the professional master's degree is sought after by students desiring jobs in industry, teaching, or librarianship. While Ph.D.s are offered in most of the Applied units in our sample, some schools where library and information science is taught (two in our sample) do not offer undergraduate degrees.

Table 1

Academic Level by Gender for CS and Applied Units
(N=1456)

	Males	%*	Females	%*
Computer Science				
Undergraduates	275	57.1	64	56.1
Master's Students	63	13.1	13	11.4
Ph.D. Students	144	29.9	37	32.5
Applied				
Undergraduates	141	35.2	56	12.2
Master's Students	206	51.4	357	77.8
Ph.D. Students	54	13.5	46	10.0

*Percent within gender in Computer Science or Applied.
119 Computer science students (18.3% of total) and 193 Applied students (16.6% of total) did not identify their year in school in any of these categories.

When academic level is broken down by gender, interesting asymmetries emerge, as shown in Table 1. While the proportions of males and females at different levels are roughly the same in the CS units, the distribution of males and females in the Applied units varies. More women are enrolled in Applied master's programs than men (77.8% vs. 51.4%), although most of this difference is accounted for by the large enrollments of women in units where library and information science is taught, and especially, in courses of study related to library science. Seventy-nine percent of library science students and 82% of librarians are female, according to a 2002 report (Maata, 2003). Conversely, at the undergraduate level in the Applied units, men are almost three times as prevalent as women (35.2% vs. 12.2%). This difference shows up primarily in units where informatics or information systems is the focus. There are slightly smaller numbers of women in Applied doctoral programs at the Ph.D. level (13.5% men vs. 10.0% women), but this difference is not significant.

Table 2

Age by Gender for CS and Applied Units
(N=1496)

	Males	%*	Females	%*
Computer Science				
18-24	329	65.3	70	62.0
25-34	160	31.7	39	34.5
35-44	14	2.8	1	.9
45-54	1	.2	3	2.7
55-65	0	0.0	0	0.0
Applied				
18-24	156	38.1	95	20.2
25-34	166	40.6	220	46.8
35-44	62	15.2	82	17.4
45-54	18	4.4	61	13.0
55-65	7	1.7	12	2.6

*Percent within gender in Computer Science or Applied.
252 students did not identify their age. A few other responses could not be interpreted.

In terms of age, the CS students fit a traditional age pattern, while the Applied students tend to be older (See Table 2). Almost all of the CS students, including those in the doctoral program, are under the age of 35. In the Applied units, however, 27.5% of the total number of people responding to the question asking when they were born were age 35 and over, and 11.1% of those students were age 45 or over. The high numbers of students of non-traditional age obviously impact the results of this study, particularly in those students' attitudes and experiences related to computing. For some respondents, computers were not yet available during their formative years. Such is not the case for the CS students.

Other demographic patterns are consistent with the age and academic level data. Of those who said they live with a spouse or domestic partner, 75% are studying in Applied programs. In CS, 95 men (19%) and 24 women (21%) reported living with a spouse or domestic partner, while 155 men (37%) and 203 women (42%) in the Applied group reported doing so. In the CS group of students, only 25 men (5%) and 3 women (3%) said they had any children living in their households. In the Applied group, many more of the men (16%) and women (18%) said they had children in their homes.

We also asked whether respondents were currently employed. Since the survey was administered during the school year, answering this question in the affirmative would mean that they were employed while studying. In the CS group, 277 (55%) men and 66 (57%) women said they were employed, while 321 (78%) men and 398 (83%) women on the Applied group reported current employment. The high percentages of both men and women reporting employment in the Applied group is a further indicator of their non-traditional student status. It also impacts the time they have available to spend on their studies and to pursue extracurricular activities related to their majors.

Some previous studies have found a relationship between parents' careers and socioeconomic status and their children's attitudes towards and choice of careers (Shashaani, 1994; Tilleczek & Lewko, 2001). In our survey whether or not the father was employed in an information technology field was not significantly different for men and women in either the CS or Applied groups. However, significantly more women in the CS group (4.5% of men vs. 13.2% of women) reported having mothers who worked in an IT field (Phi=.14; p=.002). Equal proportions of men and women in the Applied group reported having a mother who worked in IT (4.6%).

We asked questions about whether respondents' fathers and mothers held traditional views about the roles men and women should adopt—for example that men should be the primary wage earners and women should be the primary child care providers in the home. Though the responses to these questions do not qualify as demographic information, we include them here as they potentially relate to student age. For both the CS and Applied groups we found gender differences as regards the fathers' (perceived) views. Men reported having fathers with more traditional views than did women (Phi=.09; p=.01 for Applied and Phi=.10; p=.03 for CS). However, when it came to reporting on their mothers' views, the difference was only significant for CS students, with a higher percentage of men in the CS group reporting that their mothers had traditional views (Phi=.11; p=.01). Stated differently, more women in computer science reported that their mothers did not hold traditional views than the men in those units did. This finding is consistent with work by Shashaani (1994) that adolescents' attitudes toward computers follow from the gendered views of their parents regarding appropriate sex roles in the field of computing, and that girls with less traditional mothers hold more positive attitudes towards computing.

Computer Experiences

While earlier studies found that males started using computers at younger ages than did females (e.g., Badagliacco, 1990), more recent studies have found no age differences (Beyer, Chavez, & Rynes, 2002; Beyer, Rynes, Chavez, Hay, & Perrault, 2003; Colley & Comber, 2003). This is to be expected, given that PC household penetration rates have been steadily increasing from the time of the PC's inception in the early 1980s, particularly among higher SES households (U.S. Department of Commerce, 2000; U.S. Census Bureau, 2001). In the present study, however, men in both CS and Applied groups reported having begun using computers earlier than women did. Moreover, when we compare men and women across units we find that men in the Applied units were significantly more likely to learn earlier and on their own while women learned later and through school or other organized instruction (Kendall's tau-c=.21; p=.000); the difference was also significant for the CS group (Kendall's tau-c=.08; p=.04). While the higher percentage of older students in the Applied group could partially explain the difference in age of exposure and opportunity, it is surprising that an experience gap persists in the younger CS group, where both males and females have had the opportunity to use computers most of their lives.

Previous research has traced a connection between computer game playing in childhood with comfort with computers and later choice of computing careers (Gorriz & Medina, 2000; Natale, 2002). In response to a question on our survey about game-playing activity when the respondents were children, CS majors reported much higher frequencies than Applied majors. Moreover, also consistent with previous research (Fromme, 2003; Oosterwegel, Littleton, & Light, 2004), the males in both groups reported more computer game playing than the females (Kendall's tau-c=.36; p=.00 for CS and Kendall's tau-c=.18; p=.000 for Applied). From ages 12-17 the main activity involving computers reported by males was games (48.2% of CS and 38.8% of the men in the Applied group). For female CS majors, the most popular activity was communicating with friends (32.7% vs. 14.4% of women in the Applied group). Overall, males and females in both groups favored different activities (Cramer's V=.28; p=.000 for the CS group and Cramer's V=.28; p=.000 for the Applied group). In contrast, the largest percentage of women in the Applied group chose the "other" category (45.2%). We asked respondents to specify what they meant by "other." Because so many of this group were born and grew up in the time before the PC was available, a majority of the respondents who cited "other" said they did not have a computer and had no exposure to a computer when they were age 12-17.

Many from the Applied group also responded 'not applicable' when asked when they learned to program a computer. In the Applied group, 15.2% of the respondents said they did not know how to program. Students in applied programs of study may work only with computer applications, and thus may not be required to learn how to program as part of their course of study. In contrast, no CS student reported a lack of programming knowledge. Of the respondents who answered with one of the fixed choices, men in both groups reported learning how to program a computer at younger ages and more on their own than in structured environments (See Table 3).

Table 3

When and Where Respondent Learned to Program a Computer by Gender for CS and Applied Units (N=1250)

	Males	**%***	**Females**	**%***
Computer Science (N=602)				
On their own as a child	108	22.1	6	5.3
On their own as a teenager	135	27.6	11	9.7
Classes in summer or camp	35	7.2	8	7.1
Classes in middle/high school	116	23.7	47	41.6
Classes in university	95	19.4	41	36.3
Applied (N=648)				
On their own as a child	29	8.5	14	4.6
On their own as a teenager	78	22.7	18	5.9
Classes in summer or camp	13	3.8	16	5.2
Classes in middle/high school	78	22.7	70	23.0
Classes in university	145	42.3	187	61.3

Cramer's V=.28; p=.000 (for differences between men and women in CS)
Cramer's V=.29; p=.000 (for differences between men and women in Applied)

*Percent within gender in Computer Science or Applied.

The differences between the place and time men and women learned to program are significant for both groups (Cramer's V=.29; p=.000 for Applied and Cramer's V=.28; p=.000 for CS).

Reasons for Choosing IT

Career choice can often be attributed to some person who served as an inspiration. We asked respondents to identify individuals—parents, teachers, employers, friends, spouses, etc.—by gender as the primary individual who encouraged them to study information technology. Of those identified, men were identified more often by males and women were more often identified by females as providing primary encouragement by both the CS and Applied groups (See Table 4). The differences were even greater for the Applied group than for the CS group (Cramer's V=.33; p=.000 for Applied and Cramer's V=.19; p=.000 for CS). Students' fathers were reported to be much stronger influences for both male and female CS students (21.0% for men and 27.2% for women) than they were for the Applied group (12.1% for men and 7.1% for women). This finding is consistent with that of a survey of members of the Systers' electronic mailing list by Turner, Bernt, and Pecora (2002), in which women who majored in computer science or information systems as undergraduates and then went on to work in IT careers indicated their parents, and particularly their fathers, as influential in their career decision. Sashaani (1994) also found that parental encouragement strongly and positively affected children's attitudes toward computing. About half of all students in the Applied group and half of the men in the CS group said that nobody had encouraged them to study information technology. However, only one-fourth of the women in CS said that nobody encouraged them.

Table 4

Gender of Person Identified as Individual Who Most Encouraged Respondent to Study Information Technology by Gender of Respondent for CS and Applied Units (N=671*)

	Male	%**	Female	%**
Computer Science				
Person identified was Male	169	75.4	41	56.2
Person identified was Female	48	21.4	26	35.6
Person identified was spouse	7	3.1	6	8.2
Applied				
Person identified was Male	117	69.2	74	36.1
Person identified was Female	39	23.1	92	44.9
Person identified was spouse	13	7.7	39	19.0

Cramer's V=.19; p=.05 (for differences between men and women in CS)
Cramer's V=.33; p=.05 (for differences between men and women in Applied)

*N is low as a majority of respondents identified either "nobody" or "other."
**Percent within gender in Computer Science or Applied.

We also asked the students directly why they had chosen an information technology field of study, to determine if the reasons varied according to gender or between students in CS and Applied fields. Questions about various aspects of the nature of IT work were placed on a four point scale ranging from not at all important to very important. Finding well-paid employment is a central concern of many people in choosing a career, and the students in this study were no exception. Of the Applied group, 82% of the respondents said that finding well-paid employment was either a somewhat or very important factor; there were no differences between men and women in the response to this item. CS students also counted salary as important, but the men placed more emphasis on this as a factor in choosing their major than did women (Kendall's tau-c=.07; p=.03). Other factors that men and women in both the Applied and CS groups found equally important were having a flexible work schedule, and the challenge inherent in the subject matter.

Having a personal interest in the subject matter was given high priority by both groups, with 78.9% of the men in the CS group rating it "very important." There were no differences between men and women in the Applied group on this factor, but women in the CS group rated this factor significantly lower than did men (Kendall's tau-c=-.11; p=.001). This suggests that some women enter CS programs without being strongly interested in the subject matter, but that such is less often the case for women entering Applied programs.

Previous research has found that men and women have different levels of interest in helping others as part of their life's work (Creamer et al., 2004). When asked to rate the importance of this factor to their decision to study IT, however, the CS group showed no gender differences. Only 12.7% of men and 15.8% of women said that helping others was a "very important" factor in their choice to major in an IT field. This may be explained by the fact that helping others is not generally thought of as a characteristic of work in computer science (Bentson, 2000). In contrast, gender differences did show up in the Applied group (Kendall's tau-c=.14; p=.000), with women expressing significantly more interest in this factor than did men. The Applied group includes a range of potential career paths, including jobs where helping others is part of the description, e.g., teaching and librarianship.

Another item on the questionnaire asked about the importance of role models. Technology adoption research has found that women are more likely than men to start using a new technology because people they like and respect are doing so (Venkatesh & Morris, 2000); we hypothesized that there might be a similar gender effect as regards choice of a technology-related career. About four out of ten men and women students in the CS group responded that they were studying information technology because people they admired and respected were studying or working in this field. Women said this factor was either "somewhat important" or "very important" a little more often than did men in CS (43.9% vs. 38.5%), but this difference was not significant. However, the difference on this factor for men and women in the Applied group was significant (Kendall's tau-c=.11; p=.003). Women in the Applied group were more likely than men to say they were drawn to the field because of people they admired and respected.

We expected that a person's perceived skill in a discipline would be an important factor in selecting a major. There were significant differences between men and women in both the CS and Applied groups on this factor in our survey responses. One question asked how important the statement "I've always been good with computers" was in making the decision to major in IT. Men were significantly more likely to say that this was somewhat or very important than were women (84.7% of men and 66.0% of women in CS; and 72.9% of men and 53.0% of women in Applied fields) (Kendall's tau-c=-.18; p=.000 for CS; Kendall's tau-c=-.28; p=.000 for Applied). This result is consistent with previous research (Herring, 1993; Young, 2000; McCoy & Heafner, 2004) which found that women's self-ratings of their computer skills tend to be lower than those of men. However, since the question did not ask them directly about their perceived computer skill, it may be that women believe their skills are just as good as those of the men but that skill level was simply not so important in attracting them to IT. This interpretation is found not to be valid in the analysis of the variables in the computer attitudes section described below.

The series of questions about reasons for choosing their major was followed by a question about respondents' relative satisfaction with their decision to major in an IT field. Overall both groups were quite satisfied with their majors. Only 55 in the CS group (9%) and 41 of the Applied group (5%) said they were somewhat dissatisfied or very dissatisfied with their decision. Further, men and women in both groups were equally satisfied with the choice they had made. Women in the CS group were a little less satisfied than men in that group, but the difference did not achieve statistical significance (p=.06). When we asked respondents how confident they were that they would complete their current degree program, differences between groups appeared (although not between gender within a group). Overall, students in the Applied group expressed higher confidence that they would complete their degrees (Kendall's tau-c=.12, p=.000). In the Applied group, about 87% of the men and 91% of the women were very confident of degree completion, while in the CS group 77% of men and 76% of women expressed that level of confidence.

Attitudes toward Computer Work

We asked a battery of questions used in previous surveys regarding individuals' skills, efficacy, comfort, and use of computers. Previous studies have found that women tend to have lower confidence and comfort levels than men with computer use (Compeau, Higgins, & Huff, 1999; Durndell & Haag, 2002; Lee, 2002). However, Oosterwegel, et al. (2004) found that boys and girls who had images of themselves as skilled with computers were less likely to express doubts about their computer efficacy. In our survey we expected not to find strong gender-related differences between respondents' personal evaluation of how good they are with computers or their levels of confidence and comfort with computers, in as much as both the men and women who responded to the survey had chosen majors that required working with computers. However, this expectation proved not to be the case.

Comfort levels with computers were much higher for men than for women. That was true of both the CS group and the Applied group (Kendall's tau-c=.22 for Applied, p=.000 ; Kendall's tau-c=.19 for CS, p=.000). In both groups only about half of the women said they were "very comfortable" using computers, compared with 86% of men in CS and 77.3% of men in the Applied group. A related question asked how comfortable the respondent felt when trying new things on the computer. Gender differences emerged again for both groups, though the difference was larger for the Applied group (Kendall's tau-c=.20, p=.000 for Applied; Kendall's tau-c=.11, p=.000 for CS). Even in the CS group, 5.2% of women said they were "not too comfortable" trying new things on the computer, while none of the men in the CS group expressed that view.

Self-confidence with computers, a concept related to comfort with computers, was also lower for women than for men in both groups. In the CS group, 13.1% of the women vs. 2.6% of the men said they were "not very confident" or "not at all confident" when working with computers. In the Applied group the confidence gap was also large, with 11.3% of women and 3.1% of men responding in those categories. The differences in both groups were significant (Kendall's tau-c=.31, p=.000 for Applied; Kendall's tau-c=.25, p=.000) for CS.

Given the gender gap in comfort and confidence, it is not surprising that when the students were asked to rate their computer skills and their grades in programming classes compared to those of their classmates, the women rated themselves lower than the men. The men in CS rated their skills at the highest levels, as "better" or "much better " than others in their major (67.1% of the group), while the women in the Applied group rated their skills the lowest (only 24.0% rated their skills as "better" or "much better"). The same level of gender difference emerged for both groups (Kendall's tau-c=.24, p=.000 for CS and Applied).

Differences between men and women also appeared in the ease with which they reported learning new programming languages. Of those respondents who have learned programming, men in both the CS and Applied groups reported learning new computer languages more easily than did women (Kendall's tau-c =.15; p=.04 for the Applied group and Kendall's tau-c=.11, p=.03 for the CS group). Similarly, more men reported getting high grades in programming classes, although the difference was significant only in the CS group (Kendall's tau-c=.10, p=.01).

Finally, the survey addressed students' interest and persistence in resolving problems they encounter when working on computers. First we asked how much appeal the challenge of solving problems with computers had for them. Men in both the CS and Applied group expressed a higher attraction to this challenge (Kendall's tau-c=.19, p=.000 for the Applied group; and Kendall's tau-c=.08, p=.01 for the CS group). The difference was smaller for the CS group, however, with 4% of the men and 2.6% of women saying the challenge was not at all appealing. Overall, men in the Applied group said they liked to spend more of their free time on the computer than women (Kendall's tau-c=.11, p=.002), but men and women in the CS group said they like to spend about the same amount of their free time with computers (in gaming or other activities). However, men were more likely in both groups to say that they were interested in understanding how computers work (Kendall's tau-c=.22, p=.000 for the Applied group; and Kendall's tau-c=.10, p=.002 for the CS group).

The persistence issue was approached through a question that asked how likely it was that the respondent would stick with a problem with a computer program that could not immediately be solved. In both groups, men expressed greater willingness to stick with the problem (Kendall's tau-c=.19, p=.000 for the Applied group; and Kendall's tau-c=.10, p=.003 for the CS group). Persistence was also measured through a question that asked how hard it is for the respondent to stop once they start work using computers. On this question no differences were found for either group. Similarly, no differences emerged for either group on the responses to a question that asked how likely a person would be to continue to think about a problem that was left unsolved in a computer class.

The variables listed above (along with a few others) relating to attitudes about computer work were factor analyzed. Following varimax rotation, a three-factor solution emerged. Three of the questions related to ease of learning computer languages, self-rating of programming skills, and self-assessment of the grades the respondent receives in programming classes loaded on the first factor, which we labeled “skill.” The second factor included the questions about comfort with computers, comfort with trying new things on the computer and self-confidence when working with computers. We called this scale “comfort.” The third factor included questions related to enjoyment and persistence; i.e., how much the respondent enjoyed talking with others about computers, how interested the respondent was in understanding how computers work, and how hard it is for the respondent to stop work once they start working on a computer. This scale also included questions related to thinking about an unsolved problem after computer class and the relative appeal the challenge of solving computer problems had to the respondent. Our label for this scale was “engagement.” Cronbach’s alpha measure of reliability was calculated to be .71 for the three-factor solution. The variables for each of the three factors were formed into additive scales and correlated with respondent gender for the CS and Applied groups.

Table 5

Relationship Between Gender and Attitudes toward Computer Work for CS and Applied Units

	Correlation	**Significance**
Computer Science		
Skill*	r=.19	p=.01
Comfort**	r=.28	p=.01
Engagement***	r=.13	p=.01
Applied		
Skill	r=.29	p=.01
Comfort	r=.34	p=.01
Engagement	r=.21	p=.01

*Composite of three variables measuring respondents’ assessment of grades in programming classes, ease of learning computer languages and rating of personal skill in programming.
**Composite of three variables measuring respondents’ assessment of comfort with computers, comfort in learning new things on computers, and self-confidence when using computers.
***Composite of five variables measuring respondents’ interest in understanding how computers work, degree of difficulty leaving work on a computer once they have started, persistence in

thinking about unsolved problems from computer class, degree of appeal for the challenge of solving computer problems, and enjoyment received from discussing computers with others.

The three new variables—skill, comfort, and engagement—significantly correlated with gender. Though the Pearson's r was higher for the Applied group than for the CS group in all cases (See Table 5), significant gender differences were found for both groups. In other words, men in both groups reported more skill, comfort and engagement in dealing with computers.

Discussion

We began this chapter by suggesting that programs in information technology education that are focused on real-world applications would be more woman-friendly than traditional programs in computer science, and would therefore attract larger numbers of women to these programs who would persist to graduation. This first part of a larger study of five institutions where computer science and other IT disciplines are taught surveyed undergraduate and graduate majors to determine if there were differences in their demographic characteristics, uses of and attitudes toward computers, and reasons for selecting an IT major. The overall findings revealed that while some differences exist between CS and Applied IT students, especially in their demographics, more differences are due to gender than to major, and these tend to replicate earlier findings for CS contexts alone. These findings are discussed below in relation to the research questions articulated at the beginning of the chapter.

Our first question asked whether there are significant differences between students studying computer science and students studying information technology in an applied discipline. Encouragingly, we found many more women in Applied majors than in CS, along with an almost equal number of men. The Applied IT respondents tended to be non-traditional students—older, more likely to have partners and children living at home, and more likely to be working at the same time that they are going to school. Most were pursuing a professional master's degree. This is in contrast to the profile of the CS majors, who were younger, mostly single, and mostly male, although half of the CS students also reported working a job. Most were enrolled in undergraduate and doctoral programs. In comparison to the Applied majors, the CS majors played a lot of computer games when they were teenagers, all knew how to program computers, had fathers who encouraged them to study IT, and rated ‘helping others’ as not very important to their choice of a major. Thus these two approaches to IT study attract different populations of students, with Applied IT programs attracting less traditional students, including women. It is also noteworthy that the Applied students felt more confident than the CS students that they would complete their degrees, perhaps because of their greater maturity, although it may also be that the CS programs are more rigorous, a possibility that was not investigated in the present study. Since some of these differences reflect age-related career moves—often in early- to mid-career, people decide to return to school to improve their chances of moving up a career ladder, e.g., by getting a professional degree—reasons for studying IT vary more widely between the CS and Applied groups than by gender within each group.

Our second question asked whether there are differences between women and men in experiences, attitudes and computer interest within and across program types. A number of gender differences were found to be significant for the sample overall. As in previous studies, the male students in both groups had used computers earlier in life, especially to play computer games; were more likely to be self-taught, including in programming; and had fathers who held traditional views about gender roles. The men also reported being more comfortable and self-confident with computers, more skilled, able to learn programming languages more easily, more interested in understanding how computers work, more attracted to computing challenges, and more willing to stick with and resolve computing problems than did the women. Their early experiences and their greater comfort and interest levels in computers apparently gave them a competitive advantage over women in the same programs; the men also reported receiving higher grades in computing courses. However, as we did not have access to official grade reports, we could not confirm whether this was actually the case.

We were somewhat surprised to find that women still do not feel as good about their abilities related to computers and computer programming as men do, regardless of whether they are CS or Applied IT majors. It may be that lack of confidence in their skills leads women to be less comfortable. Women in both CS and Applied disciplines began working and playing on computers later than their male counterparts. Women may also require more encouragement and support to enter IT programs, since half of the women in the Applied group and one-quarter of the women in the CS group said nobody had encouraged them to go into an IT field. Even though men in both groups also said nobody encouraged them, men have other ways of building up confidence in their skills. Mastering computer skills has its own way of reinforcing a perception of higher ability, and women less often had that experience at the early age that men did. The result is that women end up in college-level IT programs feeling uncertain about their skills. When other people have provided encouragement for these students, it has usually followed gender lines, with women being more encouraged by other women. This finding points to the importance of ensuring that female role models are available in all IT fields, not just in computer science.

Gender differences are also evident within and across programs. The men in both types of programs were generally similar in their responses, but differences were found between women and men in each program, and between CS and Applied women. Having a mother who worked in IT or who held less traditional gender views was more characteristic of women in CS than of men, or of women in Applied programs. Female CS majors also reported computer-mediated communication (e.g., chatting with friends) as their most important adolescent use of computers, in contrast to males in both groups who played computer games (many of the Applied women had not had access to computers when they were teens). Female CS students had also received more encouragement, and gave personal interest as a reason for choosing IT less often, than any other group. The profile of female CS students that emerges is of young, computer-active women from two-career households whose mothers are positive role models and who receive support from others to pursue a CS career—in other words, a relatively privileged group. The only significant difference between male CS majors and other groups was that male CS majors were most likely to say that earning a high salary was an important factor for them in choosing a CS career.

Women in the Applied area, in contrast, reported different early experiences and motivations from both the men and the CS women. They were least likely to have used a computer in childhood, least likely to have been influenced by their fathers, and more likely than any other group to say they had been drawn to their major because people they admired had chosen it. They also rated helping others as an important reason for choosing an IT major more often than did any other group. The societal relevance of Applied IT careers attracts women to them, as expected, suggesting that new, interdisciplinary Applied programs may indeed provide meaningful opportunities to increase the representation of women in the IT professions. No responses characterized the men in Applied programs as distinct from the other groups.

Our final question asked whether applied IT programs provide advantages to women. Women's higher enrollments in the Applied programs indicate that they evidently see some advantages to studying IT outside a traditional computer science environment, for example, the possibility of applying computing knowledge to socially-meaningful work. At the same time, these women suffer from many of the same problems of self-esteem and computer efficacy as do women in computer science. The lesser comfort, self-confidence and engagement with computing reported by women in both groups, taken together with males' greater experience, interest, and persistence in computer use, played out in their assessment of the grades they receive in programming classes when they compare themselves to their classmates.

These perceived disparities may have consequences for women's future professional success. Although retention and graduation statistics are not yet available for this sample, previous studies have found that women are more likely than men to drop out of computer science programs (Cohoon, 2001). Moreover, women are less likely to pursue IT careers after graduation, in part due to the difficulty of balancing a career with family obligations (Greenhaus & Beutell, 1985). When they do pursue careers, they are less likely than men to rise to high-ranking professional positions. Even in "women-dominant" Applied IT professions such as education and library science, most high-ranking administrators are men (Growe & Montgomery, 2000; McDermott, 1998). Finally, if women manage to rise to the top in Applied IT careers, applied IT professionals as a whole still tend to receive lower pay and less prestige, and are considered less technologically knowledgeable, than computer scientists. This is especially true of "feminized" professions such as teaching and librarianship (Lorenzen, 2002).

Underlying these and other gender-based social inequities is the naturalization of a gender hierarchy according to which males are expected to succeed in activities perceived as especially challenging or difficult, and are rewarded for doing so, while females are expected to be less ambitious and concern themselves with work that is necessary but less highly rewarded by society. Women's reported lower self-confidence and engagement with computing, generally considered to be a difficult and challenging activity, fits this pattern. Further research is needed to determine whether gender differences in actual performance are evident, or whether women simply report lesser skill, but effectively do just as well as men. In other words, it is possible that there is a bias in the survey responses towards gender-appropriate responses, which could underestimate women's actual ability and comfort in IT.[3] At the same time, it would not be surprising to discover that by internalizing society's lesser expectations for them as regards computing, women's ability to succeed in this domain is effectively compromised. In spite of numerous reported gender differences that favor more successful outcomes for men, the women in our study indicated that they were just as satisfied with their major as the men in the same programs, suggesting acceptance of an unequal status quo.

Conclusions

Applied IT fields attract more and different kinds of women than does computer science, a positive finding that predicts greater representation of women in IT professions in the future, as computing increasingly comes to be taught in units that combine technological skills with applications to real-world problems. At the same time, the finding that women report less skill, comfort and engagement with computing than do men, and that female Applied IT majors are no more confident than female CS majors, argues against the simple hope that Applied IT programs will solve the deeply-ingrained problems women face in deciding to enter the traditionally masculine world of computing.

[3] In their discussion of mathematics skills, Kramer and Lehman (1990) refer to this behavior as "learned helplessness." It is also possible that men exaggerate their ability and level of comfort with computers.

It is concerning that the gender differences found in studies over the last fifteen to twenty years persist today, even among populations of students who have grown up with computers, and who choose to major in computer science and applied IT fields. We support Clegg's (2001) call for policies to change the discourses related to women and computing, in academia and in society at large. Her charge is that the disciplinary boundaries of computer science must be challenged so that the skills required to succeed in this field are not "culturally overlaid with the aura of masculinity" (p. 320). We further agree with Clegg that the "questions concerning who has the power to shape the production and reproduction of gendered meanings in technology, and how transformations can be achieved, remain central in both theory and practice" (p. 321).

This study has addressed one part of this issue, by comparing the backgrounds, attitudes, and computing practices of male and female students majoring in computer science and applied IT fields at five public U.S. universities. Future research in our larger study will seek to determine how the academic environments in which these students receive IT training foster or fail to foster their success, and whether institutional policies and practices reinforce the gendering of IT to the same extent in applied disciplines as they have historically done in computer science.

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