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Gender and Career Choice Determinants in Information Systems Professionals: A Comparison with Computer Science

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Introduction[*]

Information technology (IT) professionals are critical assets in today's knowledge-based economy. Moreover, a highly skilled and adaptable IT workforce representing the overall population is vital to the successful strategic utilization of IT (Ang & Slaughter, 2000). Much of the scholarly literature on personnel issues in Information Systems (IS) is concerned with management of employees after they have entered the workforce, focusing on issues such as retention, advancement, performance, and career development (Ang & Slaughter, 2000; Nakayama & Sutcliffe, 2001; Niederman & Moore, 2000). However, the decision to pursue an IT career typically takes place years before an individual enters the workforce, often in conjunction with education choices. This chapter is based on the premise that more attention needs to be directed to factors that lead to career choice of IT (Ahuja, 2002), including educational choices and experiences.

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The attraction and retention of women is a major concern in information systems and information technology occupations in general (Goyal, 1996; ITAA, 2000). This concern has, if anything, become more acute in recent years, in that the numbers of women in professional-level IT jobs and in IT-related education programs have been declining (Camp, 1997). Recent statistics indicate that women account for only about 20 percent of the United States technology workforce and 25 percent of technology workers in the European workforce (Maitland, 2001). Moreover, men and women in the IT workforce typically hold different *types* of jobs, with women being under-represented in higher-paid IT positions (Council of Economic Advisers, 2000; Igbaria, Parasuraman, & Greenhaus, 1997; Meares & Sargent, 1999). For these reasons, in order to move more women through the IT pipeline and thereby better utilize the entire workforce, it is important to examine the factors determining IT-related career choice and satisfaction with this choice among women.

How men and women view themselves in relation to their work is influenced by cultural and social factors. Bem (1981) proposed *Gender Schema Theory* that argues this process to be mediated by cognition as children encode and organize incoming information according to the definition of "male" and "female" behavior current and active in that society at that time. Gefen and Straub (1997) have argued that gender-related social expectations have roots in national culture. On Hofstede's (1980) scale of masculinity-versus-femininity, certain countries consistently show a masculine tendency. For example, the USA and Switzerland show somewhat masculine tendencies (62 and 70 on a scale of 1 to 100, where 1 is the lowest and 100 is highest), and Japan shows strong masculine tendencies (a score of 95 on the same scale). Masculine cultures tend to

establish gender differences in attitudes regarding computers in grade school (Collis, 1985), and these attitudes widen with age (Smith, 1986). Attitudes towards computers, in turn, have been correlated with achievement in computer-related classes (Fetler, 1985; Steering Committee on Human Resources in Computer Science and Technology, 1993).

When it comes time for career choice, people are attracted to jobs and work environments that are compatible with their attitudes and preferences (e.g., Cable & Judge, 1996; Judge & Bretz, 1992). Previous research has reported gender differences in attitudes and values among IT workers (Igbaria, Parasuraman, & Greenhaus, 1997; Panteli, Stack, Atkinson, & Ramsay, 1999). This literature suggests that men and women workers want and value different things in their preferred careers (Bentsen, 2000). However, relatively little research has examined the reactions of members of underrepresented groups to different types of jobs (Rynes & Barber, 1990), or to different branches of IT. This question is especially relevant for IT professionals-in-training, who must choose to major in a particular field of expertise as part of their educational trajectory. Alongside the canonical technology field of computer science, recent years have seen the rise of a number of IT fields with a more applied focus, including Information Systems (business applications), Information Science (library applications), Instructional Technology (educational applications), and Informatics (science applications). Elsewhere, we have posited that these fields may be more attractive to women than computer science because of their applied foci, and because of their association with professional cultures in which women are better represented (Ahuja, Herring, Ogan, & Robinson, 2004).

The perception of gender differences in IT careers appears to be a global issue and

affects the competitiveness of countries internationally. Researchers in Australia have found that IT work is perceived by high school and college students as difficult, boring and solitary in nature, requiring little interaction with fellow workers or customers (Greenhill, von Hellens, Nielsen, & Pringle, 1997; Nielsen, von Hellens, Pringle, and Greenhill, 1999). As a result, the number of female IT graduates is low, and there is corresponding under-representation of women in the Australian IT industry (von Hellens, Nielsen, & Beekhuyzen, 2004). Tan and Igbaria (1994) found that in Singapore, women receive lower salaries than men in many IT jobs, particularly among software professionals. They suggest that this, coupled with the rapid growth of technology and the shortage of IT professionals, has had an adverse impact on the country's competitiveness. Canada is also reporting a severe human resources shortage of people with software skills (Van Brussel 1998). In Canada, women are under-represented in the IT industry at 30% of software workers, compared to 56% in white-collar jobs in other industries.

In this chapter, we report on preliminary findings from a web-based survey of students majoring in computer science and applied IT disciplines at five major US institutions. Our study compares the responses of students in each type of program, looking for differences in demographics, behaviors, and student attitudes regarding their field of study and their own career potential. Specifically, we are interested in discovering what differences, if any, exist in the backgrounds, experiences, and attitudes toward computing of students studying computer science and students studying information technology in applied disciplines. More generally, we are interested in the implications these comparisons have for applied IT programs, including those in the

Information Systems area, in terms of removing barriers and creating career opportunities for women.

Gender and the IT Workforce

The shortage of women in IT has been the subject of numerous recent studies with an emphasis on pipeline issues (e.g., Camp, 1997; Woszczynski, Beise, Myers, & Moody, 2003). Ahuja (2002) proposed that social and structural factors are responsible for this shortage, causing the pipeline of women candidates for IT jobs to shrink progressively. As a result, women choose IT majors much less frequently than their male counterparts, and even fewer complete their programs of study (Camp, 1997). At the same time, women dominate many information-related careers (e.g., library science, communications, journalism), and more than fifty percent of Internet users in North America are female (Friedman, 2000; Greenspan, 2003).

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

Although women still represent far less than half of MIS students, MIS programs specifically, and applied programs in general, have had relatively greater success in

attracting women undergraduates compared to computer science (Freeman & Aspray, 1999). Freeman and Aspray (1999) and others (e.g., Margolis, Fisher, & Miller, 2000) suggest that this may be due to the focus in these applied programs on the social aspects and use of IT, which is more consistent with many women's attitudes and preferences, rather than just the technology itself.

For several reasons, applied fields such as information science, information systems, and instructional systems technology have an advantage over computer science when it comes to attracting future female professionals. In a recent *InformationWeek* article, Chabrow (2004) attributes declining computer science enrollments to the failure of most universities to do a good job of providing computer science majors with an understanding of how information systems have an impact on an organization. In contrast, applied IT programs are grounded in the contexts of real-world problems: business, education, information management, etc. Moreover, they are not as male-dominated as computer science: information science and instructional systems technology are both traditionally associated with female-dominant professions (librarianship and education, respectively), and business, although traditionally male-dominated, has been changing rapidly in this regard. Applied IT fields may thus constitute a more woman-friendly culture, attracting female students and fostering their educational success. If this is the case, lessons can 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).

For example, as regards personal characteristics, women frequently report lower computer aptitude (Fetler, 1985) and higher levels of computer anxiety (Igbaria & Chakrabarti, 1990; Morrow et al., 1986) compared to men, including in real world settings (Bozionelos, 1996). A significant body of research in psychology (e.g., Hunt and Bohlin, 1993) has shown an inverse relationship between computer anxiety and computer self-efficacy, a known determinant of perceived ease of information systems use (Venkatesh and Davis, 1996). Research also suggests that higher levels of computer anxiety among women can lead to lower self-efficacy, thus increasing their computer avoidance (Igbaria and Parasuraman, 1989; Venkatesh and Morris, 2000). Anxiety in general has also been found to be negatively related to performance and persistence in the profession (Brod, 1982; Friend, 1982; Humphreys and Revelle, 1984). It remains to be addressed whether levels of computer anxiety and computer self-efficacy differ for women who choose applied IT as compared to computer science careers.

In the above paragraphs, we have summarized evidence of perceptions by women of their own lack of aptitude, interest, or experience regarding computers, as well as cultural stereotypes and perceptions that computing is a mostly masculine activity. Unless these factors receive research and practical attention, few women will continue to opt to study IT, and efforts to make IT education more women-friendly can only have a limited effect. 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. Specifically, 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? We attempt to answer these questions as a preliminary first step in understanding the potential of new, interdisciplinary, applied IT disciplines to foster more equitable outcomes for women in relation to information technology.

Methodology

This chapter reports on part of a larger longitudinal investigation of gender and educational experiences at five U.S. research institutions where information technology is taught. The methodology employed in the present study is 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 of 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 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,

four in library and information science/information studies, three in management information systems, four in instructional technology, and two in informatics.

A web-based format was chosen because we believed information technology students would be more 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 via e-mail through an administrator in their unit.

The survey consisted of 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 are 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%. The total number of respondents was 1768, of whom 1516 responded to a question

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.

Results and Discussion

In this study, we sought to examine how men and women respond differently to factors determining IT-related career choice. We also examined factors determining their satisfaction with this choice. We conducted our analysis by splitting the sample into computer science (CS) and applied information technology (Applied) students. 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 in keeping with our expectation of finding a higher proportion of women in the applied IT units. Encouragingly, we found many more women in Applied majors than in CS, along with an almost equal number of men (Table 1). 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. Below we discuss the main findings of this study.

Factors determining career choice

We examined several factors that can lead to men and women choosing IT careers. These are discussed in detail in the following paragraphs.

Parents' occupation and attitudes. Research has shown 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%).

Further, we found gender differences as regards the fathers' (perceived) views for both the CS and Applied groups. 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). In sum, 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.

Early Computer Experiences. Men in both CS and Applied groups reported having begun using computers earlier than did women. 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 (Table 2).

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 our study, 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 age12-17.

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). 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).

[Insert Table 3 about here]

Social Expectations and Encouragement. In order to determine if there were external sources of encouragement, 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. In general, 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. Shashaani (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.

[Insert Table 4 about here]

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.

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%, not significant). Women in the Applied group were significantly more likely than men to say they were drawn to the field because of people they admired and respected (Kendall's tau-c=.11; p=.003).

Self-efficacy. We found significant differences between men and women in both the CS and Applied groups on ***self-efficacy*** (perceived skill in a discipline). 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; McCoy and Heafner, 2004; Young, 2000) 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.

Outcomes: Satisfaction with IT as a career choice

Overall, our respondents 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 to major in that particular field. 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 genders 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.

Self-efficacy also emerged as a factor in determining satisfaction with IT as a career choice. 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. Overall, 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.

These results extend previous research suggesting that girls and women are less likely to enjoy, use, and fully adopt computers and computer tools at all stages of education (Colley, Gale & Harris, 1994; Gefen, 2000). Women tend to participate less and are less comfortable with computers than are men (Moldafsky & Kwon, 1994). The role of social expectations in gender differences in computer abilities has been shown in Collis's (1985) work. Collis found that girls expressed general confidence in female abilities with regard to computers but did not display the same confidence in their own abilities as individuals, displaying a "we can, but I can't" syndrome.

Anxiety in general is negatively related to performance and persistence in the profession (Brod, 1982; Friend, 1982; Humphreys & Revelle, 1984). In our study, when 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).

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).

Summary and Conclusions

This chapter was motivated by the observation that in order to best utilize the entire available workforce it is essential to understand individual and group differences in the attitudes of potential employees (Konrad, Ritchie, Lieb, & Corrigall, 2000). Gender differences in attitudes and values among IT workers have previously been reported (Bentsen, 2000; Igbaria et al., 1997; Panteli, et al., 1999); the present study extends the literature in this area. Specifically, we have reported on computer-related attitudes and behaviors among students majoring in computer science and applied information technology disciplines at undergraduate and graduate levels, thereby contributing to the limited literature on variation in preferences for IT job type (cf. (Rynes & Barber, 1990).

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.

First, we found many more women in Applied majors than in CS, along with an almost equal number of men. Second, 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.

Second, we addressed the question of 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.

Women still do not report the levels of self-efficacy related to computers and computer programming that men do, regardless of whether they are CS or Applied IT majors. Women in both CS and Applied disciplines began working and playing on computers later than their male counterparts. These results corroborate and extend previous research findings that in general, women report lower computer aptitude (Fetler, 1985) and higher levels of computer anxiety (Igbaria and Chakrabarti, 1990; Morrow et al., 1986) compared to men.

It follows that women may 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 were 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. 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.[1] 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.

In conclusion, we have shown that Applied IT fields attract more and different kinds of women than do 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

[1] 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.

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.

Harvard University president Lawrence H. Summers recently suggested that one factor in women's lagging progress in science and mathematics might be innate differences between the sexes, reopening the nature vs. nurture debate. There is support for the nature view in the literature. Pinker (2002), on whose work Summers partially based his suggestion, quotes research by Linda Gottfredson, an expert on vocational preferences, that concludes that in general women tend to be more interested in dealing with people whereas men are more interested in dealing with things. Vocational tests show that boys lean towards "realistic," "theoretical" and "investigative" pursuits, while girls appear to be more inclined towards "artistic" and "social" pursuits (Pinker, 2002, p. 353). These claims are supported by research on gender differences in job attribute preferences (see Konrad, Ritchie, Lieb, & Corrigall, 2000 for a meta-analysis). In general, women are more likely to value extrinsic job attributes (e.g., opportunities to make friends and help others) and intrinsic factors (e.g., variety and task enjoyment) associated with interpersonal relationships. Men, on the other hand, are more likely to value salary, opportunities for advancement and leadership, and autonomy. Similarly, Igbaria, Parasuraman, and Greenhaus (1997) found that a higher percentage of men identified themselves as primarily Technically-oriented while a higher percentage of women rated themselves as primarily Lifestyle Integration-oriented (that is, they valued

integrating family and self-development as well as career concerns). These preferences have clear implications for choice of an IT career.

At the same time, research into purportedly innate characteristics underlying IT success, such as males' superior ability in mathematics, presents contradictory findings. Boys have outscored girls on the math half of the SAT exam in the US by about 30 to 35 points for the past three decades (Angier and Chang, 2005). Moreover, in an international standardized test administered in 2003 to 250,000 15-year-olds in 41 countries, boys did moderately better on the math portion in just over half the nations. However, Japanese girls were on par with Japanese boys on every math section save that of "uncertainty," which measures probabilistic skills, and Japanese girls scored higher over all than did the boys of many other nations, including the United States. And in Iceland, girls out-performed Icelandic boys by a significant margin on all parts of the test, as they habitually do on their national math exams. "Interestingly," Angier and Chang (2005) note, "in Iceland and everywhere else, girls participating in the survey expressed far more negative attitudes toward math." These findings suggest that while we can not conclusively rule out the influence of nature in women's choice of careers in IT, nurture (including culture) appears to play a role as well.

From a practical standpoint, in any event, embracing the nature argument is unlikely to attract more women to IT careers. Fortunately, the low participation of women in information technology has drawn academic researchers' and policymakers' attention in several countries outside the US in recent years. In the United Kingdom alone, about 70 different organizations, projects or initiatives have addressed problems common to Science, Engineering and Technology related to infrastructure, time and

funding resources, and lack of effectiveness in increasing numbers of women in IT (Greenfield, 2002). In Australia, noting the low participation of women in IT fields and the declining numbers of women studying computer science, several researchers have begun to address the problem in affiliation with Australian Women in Computing (Parker, 2004; Nielson et al., 2001). The WinIT project, launched in 1995, originally investigated the attitudes of high school and university students towards IT education and careers; in 1999, the research was extended to cover women working in the IT industry and IT academia (von Hellens et al., 2004).

Some international industry groups are also joining the effort to increase the numbers of women working in their midst. Women in Technology International (http://www.witi.com/center/aboutwiti/) is open to professional women and students about to embark on careers in technology, with the goal of empowering "women worldwide to achieve unimagined possibilities and transformations through technology, leadership and economic prosperity." With a membership of more than two million women, the organization has networks in the United States, Great Britain, Hong Kong, Australia and Mexico. Another such organization is the Australian Information Industry Association (AIAA) with 300 member companies that serve the informational and networking needs of IT professionals in Australia.

Clearly, the under-representation of women in IT is a complex problem that is unlikely to be solved by short-term interventions or unidimensional analyses. Areas such as mentoring, stress, and work-life balance issues represent important avenues for future research. Moreover, one of our findings suggests that having a mother working in IT promotes entry of her daughters into IT-related fields; this should be researched further,

inasmuch as it suggests a possible long-range strategy for increasing the number of women in IT. Another finding with strategy implications is that computer game playing in childhood correlates with choice of an IT education program, providing further impetus for encouraging girls to play with computers. The finding of a link between computer comfort levels and actual university outcomes (including career choice and advancement) is also worthy of further investigation.

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Table 1

Academic Level by Gender for CS and Applied Units

(N=1456)

	Male	**%***	**Female**	**%***
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.

Table 2

Age by Gender for CS and Applied Units

(N=1496)

	Male	**%***	**Female**	**%***
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.

Table 3

When and Where Respondent Learned to Program a Computer by Gender for CS and Applied Units

(N=1250)

	Male	%*	Female	%*
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.

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.