Toward Gender Equitable Outcomes in IT Higher Education: Beyond Computer Science

(National Science Foundation 01-33, Information Technology Workforce (ITWF) Proposal)

PROJECT SUMMARY

As the need for information technology (IT) professionals continues to grow, so too does the need to engage women and girls in courses of study that will qualify them for IT-related careers. The growing number of professions that do not require training in computer science, but rather in cognate IT disciplines, offer the potential to correct the pattern of gender inequity traditionally found in computer science. This project proposes to investigate tertiary education programs in information science, information systems, instructional systems technology and informatics, with computer science as a baseline comparison, in major IT degree-granting institutions across the U.S. in order to determine which are most successful at recruiting and retaining female students, and what factors favor success over time. Findings will be used to inform programmatic recommendations aimed at moving more women into the IT pipeline through a diverse range of educational programs.

RESEARCH QUESTION AND HYPOTHESES

As the need for information technology (IT) professionals continues to grow, so too does the need to engage women and girls in courses of study that will qualify them for IT-related careers. Despite much concern over the past 20 years about low numbers of female students in computer science departments (e.g., Klawe & Leveson 1995), and some recent successful efforts to increase their numbers (Margolis & Fisher 2002), women remain a significantly underutilized resource in the IT workforce (National Council for Research on Women 2001; National Science Foundation 2000). For example, as recently as 10 years ago, only 5% of upper management in IT industry (Science 1992) and 6.5% of IT faculty positions (Frenkel 1990) were held by women. By 2000, women still comprised only 13% of computer science faculties in the United States (Taulbee 2001).

However, while a gender imbalance in computer science is still strongly evident, the prospects for women may be brighter in the growing number of IT-related professions that do not require training in computer science, but rather in cognate disciplines such as information science, management information systems, instructional systems technology, and the nascent field of informatics. Together, these fields train more IT professionals than does computer science, and their importance is likely to grow in the future. University-level programs in cognate IT disciplines are potentially more attractive to women than degree programs in computer science, for a number of reasons discussed below. As yet, however, few studies have focused on the experiences of female students in IT programs outside the domain of computer science. Nor has any systematic comparison been attempted of such programs to determine which are most successful at recruiting and retaining female students, or what factors favor success.

According to previous research, among the most important factors that discourage girls and women from studying computer science is culture: computing is historically and conventionally associated with masculinity, an association that attracts boys to computers who then become role models for other boys, creating environments in which girls feel marginalized (Hacker 1990; Turkle 1984). Margolis & Fisher (2002) argue that “women are further alienated by a stifling "geek culture" that celebrates obsessive computing at the expense of broad interests”. The abstractness of much computer science instruction exacerbates the gender bias, in that girls are more likely to be interested in real-world problem solving in contexts involving human users than in machines and programming languages per se (Clarke 1992; Ray, Sormunen, & Harris 1999). A related deterrent for women is that most introductory computer science courses focus on programming skills rather than concepts of computer science. Girls and women like IT, the findings suggest, but want to do something with it to improve the world; they are not satisfied with mastering computing skills for their own sake.

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. First, they are grounded in the contexts of real-world problems: business, education, information management, etc. Second, 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. We therefore hypothesize that more women will choose to pursue training, and have more successful educational experiences, in applied IT fields than in computer science. However, it is difficult to determine from published data whether that has been true up to this date. The Classification of Instructional Program codes in the *Digest of Educational Statistics* lump computer and information science statistics together. Those data also include information systems in the same category.

As IT expands into cognate domains, it also carries with it elements of masculine computing culture. Moreover, the cultures of business, education, and library science do not attract female students to the same degree, as noted above. Thus our second hypothesis is that some obstacles to gender equality will persist in cognate IT fields, but that they will vary in importance according to the disciplinary context. Specifically, we expect that fields such as information science and instructional systems technology will attract and retain more women than fields such as information systems. Informatics, as a new field lacking in

traditional associations with either male or female practitioners, has the potential to attract both in equal numbers; alternatively, it could carry over the masculine connotations of computing technology.

Last, even within a single field, practices vary from institution to institution. Some institutions have been more successful than others in achieving gender equity, as the recent Carnegie Mellon study shows for the field of computer science (Margolis & Fisher 2002). Factors such as the availability of female role models, mentoring, networking, curriculum, advising, and financial and administrative support have all been identified as making a positive difference in female students' experiences in computer science programs (Spertus 1991). We hypothesize that this will be the case in applied IT programs as well. Specifically, we expect that more female-oriented institutional cultures, as determined by the availability of resources such as those mentioned above, will produce more successful outcomes, where success is defined both in terms of the quantity of women who enter and finish IT-related educational programs, and the quality of their educational experiences.

In order to assess these hypotheses, we propose to conduct a systematic, large-scale investigation of the role of academic culture in relation to women's IT educational experiences over time, where culture is considered at both disciplinary and institutional levels. In order to achieve this goal, multiple disciplines and institutions will be investigated.

BACKGROUND: WOMEN IN COMPUTER SCIENCE PROGRAMS

According to the National Science Foundation (NSF 2000), women account for an increasing percentage of the bachelor's degrees in all major science and engineering fields except for mathematics and computer science. In contrast, both the number and relative percentages of women earning bachelor's degrees in computer science have decreased in the last decade. In 1984, women earned 37 percent of the bachelor's degrees in computer science, while in 2000 women had dropped to 20 percent (Bryant and Irwin, 2001). Computer science master's degrees awarded to women dropped from 29 percent in 1984 to 26 percent in 2000 (Bryant and Irwin, 2001). Only in doctoral degrees did the percentage increase between 1984 and 2000 (from 12 to 15 percent), although this percentage has also decreased in recent years since reaching a high of 18.66% in 1995. Figure 1 shows the percentage of computer science degrees awarded to women between the years 1984-85 and 1999-2000, compared with degrees awarded to women in all science and engineering fields.

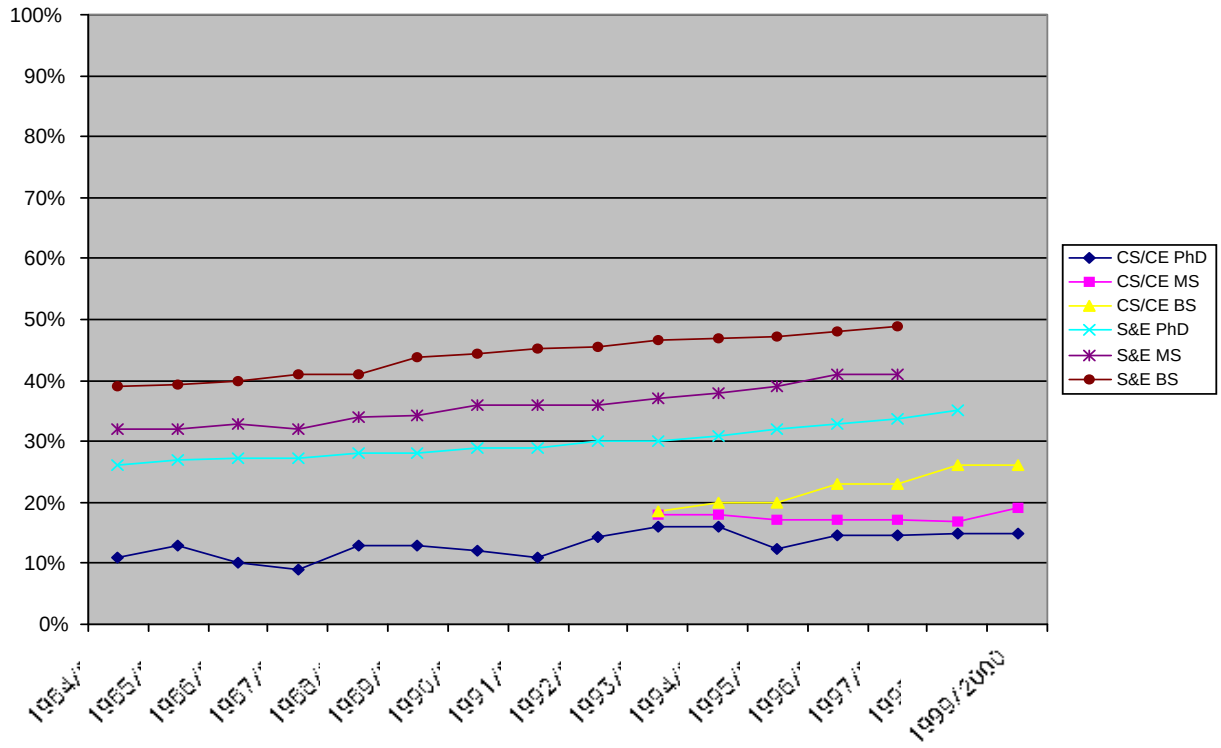

Figure 1. Percentage of Science & Engineering and Computer Science/Computer Engineering Degrees Granted to Women (Sources: NSF S&E Degrees, NSF S&E Doctorate Awards, and CRA Taulbee Survey)

Many influences have been cited as contributing to the educational gender gap in computer science, including aspects of institutional culture such as role models (Pearl et al. 1990), mentoring and advising (Whiteley et al. 1991), informal networking

(Smith-Lovin and McPherson 1993), sense of belonging and identity (Ely 1995), work-family conflict (Netemeyer et al. 1996), and teaching styles (Cohoon 2001). However, gender equity in other IT disciplines has not yet been a major focus of research. To address this need, our study will compare the effects of institutional culture in computer science and in non-computer science IT departments on the recruitment, retention and educational experiences of women students.

LITERATURE REVIEW

Lack of Role Models

At the stage where women make critical decisions about their careers, role models can be instrumental in steering them in one direction or the other. By their very presence, role models provide evidence that a successful career in the field is a possible and unremarkable occurrence (Pearl et al. 1990). With so few women in upper management in IT industry (Science 1992) and IT faculty positions (Bryant and Irwin 2001), such guidance and support for female students is severely limited. Camp (1997) has characterized the educational pipeline in computer science (CS) as the "incredible shrinking pipeline", due to the observation that not only does the pipeline shrink from high school to graduate school, but bachelor's degrees awarded in CS to women decreased almost every year over the last decade (see previous section). Indeed, Pfleeger and Mertz (1995, p.63) have recognized that "despite a host of efforts to attract and keep women and minorities in computing, they continue to be underrepresented across the several computer science disciplines", and suggest that a major problem in attracting and keeping women in computing is the lack of role models at all levels, particularly at senior levels. Educational and career encouragement has been found to be more important for women than for men (Tharenou, Latimar, and Conroy 1994). Given an environment into which girls and women may not be integrated, encouragement for advancement from role models has been found to be essential to increase women's awareness of the education and training needed for IT skills.

Further, career choices in college are often made in consultation with faculty members. If female students lack female role models with whom they can discuss career choices in relation to life-style implications, they may not feel they have complete information to evaluate their options with respect to IT careers. Under such circumstances, female students may, by default, self-select for careers in which other women are visibly present, thus further intensifying the gender-based stereotyping of professions (Cohoon 2001).

Mentoring and Advising

Researchers and practitioners alike have expressed concern that the IT field is not developing and advancing enough women to the higher ranks. One reason for this may reside in a lack of opportunities for women to find a mentor. Mentoring has been found to be critical in the advancement of professional careers (Dreher and Ash 1990, Kram 1983). If we are to ensure that employers select their employees from a complete and broad pool of human resources, they must ensure that female IT professionals have ample mentoring opportunities.

Mentoring is "an intense developmental relationship of relatively long duration in which the protégé receives a range of career and psychological help exclusively from one senior [individual] (Clawson 1980, Kram 1985, Levinson et al. 1978)" (Whiteley et al. 1991, p.133). A mentor in an organizational setting is "an experienced, productive manager who relates well to a less-experienced employee and facilitates his or her personal development for the benefit of the individual as well as that of the organization" (Noe 1988, p.65). In a university setting, a mentor is typically a teacher, and the protégé a student or junior faculty member (Spertus 1991). The mentoring relationship may be formal or informal.

Research has shown that although women can benefit as much from mentoring as men, there is a lack of female mentors in IT professions (Klawe and Leveson 1995) and in organizations in general (Noe 1988; Parker and Kram 1993; Ragins 1989; Warihay 1980). This is true in academic professions and colleges as well. In her study of Virginia computer science programs, Cohoon (2001) found that presence of female faculty was an influential factor in female student's disproportionate attrition from computer science majors. Moreover, the number of mentoring relationships (mentorships) available to women does not appear to be keeping pace with the increasing number of women needing mentors (Berry 1983; Shockley and Stanley 1980). A proactive facilitation of mentorships may be beneficial for the development and advancement of women in IT careers.

Research suggests that women face more gender-related interpersonal and institutional barriers in obtaining a mentor than do men (Ragins and Cotton 1991; Kram 1985; Ragins 1989). One explanation for a lack of mentors for women in traditionally male-dominated professions such as computer science can be found in the theory of interpersonal attraction. The theory of interpersonal attraction posits that individuals are most comfortable interacting with those who are similar to them (Dreher and Ash 1990; Heider 1958). This theory has been empirically confirmed in the context of mentoring relationships (Larwood and Blackmore 1978; Noe 1988). Kram (1985) also concluded that men and women find it more comfortable to mentor protégés of the same gender. In academic settings, moreover, some "faculty men may see women as being different from themselves, less intellectually able, less committed and dedicated, or simply inappropriate for academic careers" (Simeone 1987, p. 103). A lack of women at higher ranks, therefore, may have a negative influence on the ability of women to find mentors. In other studies, dissimilarity has been linked with turnover and drop-out rate (Kirchmeyer 1997).

Another reason for a lack of mentors may be that women have less access to informal settings necessary for initiating and building mentor relationships (Hunt & Michael 1983). Further, a traditional expectation for women is to take a passive role in initiating relationships (Hill, Bahniuk & Dobos 1989).

Mentoring appears to be related to a number of outcomes. In the workplace, these include promotion (Dreher and Ash 1990; Whitely et al. 1991), incomes (Dreher and Ash 1990), career mobility (Scandura 1992), career satisfaction (Fagenson 1989), and pay and benefit satisfaction (Dreher and Ash 1990). Riley and Wrench (1985) have reported that women who had one or more mentors experienced greater job success and job satisfaction than women who did not have a mentor. In a university environment, mentors can initiate the protégé into the expectations of academic life, provide encouragement and comments on his or her work, provide career assistance, and lend credibility to the protégé's work through their own reputation (Simeone 1987).

Some researchers have argued that the benefits of mentoring may be amplified for women. Consider the following statement made by Ragins and Scandura (1994): "Women may expect and receive greater benefits from the mentoring relationship than men not only because the relationship meets their developmental needs, but also because mentoring role expectations are more aligned with gender role expectations for women. Specifically, the essence of mentoring involves helping protégés and nurturing their development. These behaviors are certainly aligned more with traditional female than male gender-role expectations" (p. 960). In addition, mentoring may be even more important for women to the extent that it helps women overcome advancement barriers (Kanter 1977).

In light of the potential benefits of mentoring for women, it is important to consider and examine ways to counter the trends discussed above. One way to do this is to better understand the factors that make a mentoring relationship effective in different cultural and institutional contexts. While several studies have successfully demonstrated the effects of mentoring on women's advancement in various areas (Kram 1983; Burke 1984), to our knowledge, no studies have been conducted to assess its effects in IT-related educational programs.

Informal Networking

Informal networking has long been recognized as important to career advancement (Smith-Lovin and McPherson 1993). Informal networks can serve several purposes, ranging from obtaining information regarding opportunities to socialization in the institutional culture. Informal networks may be in a reciprocal relationship with mentoring. on the one hand, they allow a protégé to be exposed to potential mentors; on the other hand, a mentor is a link for the protégé to gain entry into the social networks within an organization or profession. However, Ragins and Cotton (1991) have shown that corporate informal networks are primarily made up of men. The lack of access to informal networks may play a role in a woman choosing IT as a career (organizations often rely on informal networks for recruiting). This factor becomes increasingly important for advancement within the organization and within the field. Informal networks are effective tools for male advancement that had been established before women started climbing the professional ladders. Some of this network, often referred to as the "old boy's club", is based on masculine activities which reflect traditional social and cultural roles, such as sports talk, golf tournaments, and other shared experiences as a means for building camaraderie. Unfortunately, the failure of women to achieve upper-level positions or gain access to those in such positions tends to perpetuate the established informal network structures. As studies suggest, women are often left out of these informal networks of "power sharing and dissemination" across industry and academia (Ragins and Cotton 1991; Kram 1983).

Gallos (1989) has observed that while career development for men typically translates into increased autonomy and separation from others, career development for women is tied more to attachments and relationships. Gallos further suggested that while relationships are important for men in later career stages, when they face immortality and generativity issues, relationships are important for women throughout their careers. In a study of 189 male and 78 female executives, Van Velsor and Hughes (1990) found that women reported a greater reliance on work relationships as sources of development and learning. Taylor et al. (2000) found that women, more than men, turn to same-sex friends and colleagues as a means to combat stress. Thus informal networking may potentially play an especially beneficial role in the academic and professional success of women.

Online discussion groups can facilitate networking among women. In the field of computer science, the Systers mailing list provides women with a "forum for discussion of both the problems and joys of women in our field and a medium for networking and mentoring" (Frenkel 1990, p. 36). Spertus (1991) notes that "the list is particularly important to women in computer science because they are so dispersed and might not otherwise be able to interact with many other female computer scientists and engineers." In addition, some schools have formal and informal get-togethers for women faculty and students in computer science and engineering (Spertus 1991). The availability of networking opportunities for female students in other IT fields, however, has not yet been the subject of comparative investigation.

Sense of Belonging and Identity

Back in the late 1970s, Kanter (1977) wrote about tokenism. Since then, many researchers have addressed the effects of women's under-representation in groups on their experiences at work (see Yoder 1991 for a review). Research shows that

under-representation of women can lead to isolation from professional and social networks, and increases work-related stress for women.

In addition to examining gender on the basis of biological sex, researchers find gender may be conceived as a psychological state because individuals may display traits predominantly associated with the opposite sex (Oakley 1972). Social identity can, therefore, be a social construction (Ely 1995). In work and educational environments where women are underrepresented, social stereotyping of women can be a part of the socially constructed reality. This can lead to group- and self-attributions that can be damaging to performance. It is perhaps due to this phenomenon that overrepresentation of white men in high status positions may contribute to devaluation of women and other minorities.

Finding female role models and mentors can be helpful to a woman's self-image. The existence of women who have succeeded demonstrates that women can fit in, and that success is possible. For students, "the [faculty mentor] helps to form with the protégé the sense of him or herself as a member of the profession, encouraging and fostering a self-image as a legitimate member of the community of scholars" (Simeone 1987, p. 101). Spertus also recommends attending classes with other women and participating in women's professional groups as ways for female students in computer science to increase their confidence and self-image as computer scientists. It is as yet unknown to what extent women in other IT-related fields see themselves as central or peripheral to their fields.

Work-family conflict

Career choice decisions are typically made during university education and the initial stages of one's career. At that time, many women make critical choices about the field in which they would like to pursue a career. The potential for work-family conflict may play an important role in this decision.

Many women's university experiences coincide with the stage in a woman's life when she is marrying and starting a family. These women may be faced with trying to manage a career, a home, and child-care. Additionally, women who have full personal lives may be viewed as lacking a strong commitment to their work or not being as serious about their careers as their male colleagues (Barinaga 1992). This can be especially true in the "hacker culture" prevalent in the world of information technology in universities. Hackers are perceived as keeping exceptionally long hours, late nights and manifest "highly focused, almost obsessive behavior" (Frenkel 1990; see also Turkle 1988). For many women, this work ethic conflicts with their family responsibilities. Meanwhile, hackers, who are predominantly male, are seen as being "bright and creative", while women remain on the periphery of this dominant culture. Missing out on valuable interaction with faculty and colleagues can translate into missed opportunities for learning and participation in projects (Rasmussen and Hapnes 1991). Rasmussen and Hapnes suggest that this type of culture is important in producing and reproducing male domination in higher education in computer-related fields and that it influences the integration of women and their position within the field of computing.

Work-family conflict can also be a source of stress in the workplace, especially in the modern age of the "electronic briefcase". In many IT-related jobs, workers are expected to work late, be on-call to solve technical problems, and travel. Work-family conflict has been defined as "a form of inter-role conflict that occurs when the demands of work and family are mutually incompatible in some respects for career oriented men" (Higgins and Duxbury 1992). Models of work-family conflict suggest that conflict arises when demands of participation in one domain of life are incompatible with demands of participation in another domain. This conflict can have an important effect on the quality of both work and family life (Greenhaus 1988; Greenhaus and Beutell 1985; Netemeyer et al. 1996). To the extent that women consider these factors when making a career choice, they may be discouraged from choosing IT-related professions.

Research on work-family conflict has been examined in organizational studies in the context of several different fields (for example: police officers, health care workers, engineers, workers in the construction industry, etc.). To date, however, no research has been specifically conducted with IT workers. There is a need for such an examination in the context of IT workers because IT careers tend to demand long hours, travel, and constant updating of skills. These factors are likely to lead to work-family conflict for both men and women. However, it can be expected that because women, more than men, have traditionally focused on family and children, women will experience more work-family conflict than men in the IT industry. It remains to be determined to what extent other IT fields besides computer science require that their practitioners take time away from their personal lives in order to succeed professionally.

METHODS

Evaluating Institutional Cultures

Our study hypothesizes that female-oriented academic cultures will produce more successful outcomes, where *culture* is defined as traditions, attitudes and practices, and *success* is defined both in terms of the quantity of women who enter and finish IT-related educational programs, and the quality of their educational experiences. One aspect of our study will examine different academic cultures, (1) to characterize the cultures as more or less "woman-friendly" (Jones 1990;Cohoon 2001) and (2) to assess their effects on students' educational experiences. For the purposes of this study, the notion of academic culture is operationalized at three levels:

• the culture of the professional discipline at the national level, including the policies and practices of each discipline's primary national associations
• the culture of the university, including campus-wide policies and programs
• the culture of the department or school, including resources and curricula

Our premise is that an institutional setting that is female-oriented will be more welcoming and conducive to women's success at all levels than other kinds of institutional settings. At the same time, it is possible for interventions at one level to overcome obstacles at another (e.g., the successful interventions of the computer science department at Carnegie Mellon University to increase female enrollment in a discipline with a traditionally poor record of female recruitment and retention; Margolis and Fisher 2002). To assess the degree of accessibility and "woman-friendliness" of each academic culture at the national, university and departmental levels, we will collect and evaluate data in the following areas.

Demographic

Proposition 1: In keeping with previous research on the negative effects of underrepresentation, we anticipate that settings in which more women are present – especially in visible, high status roles – will be more women-friendly than those in which few women are present. This will be measured by collecting demographic data on:

- Number and distribution of women faculty, graduate students and undergraduates in the discipline, university and departments/schools.
- Number and positions of women in the university/campus and departmental administration, and in campus computing units
- Ethnic distribution of women in the discipline, university and departments/schools[1]
- Number of women in the leadership of the professional association, and on editorial boards of major journals

Educational Programs and Opportunities

Proposition 2: In keeping with research that finds that women are put off by the abstractness and social isolation associated with computer science instruction and study, we anticipate that settings that provide opportunities for real-world applications and collaborative learning will be more women-friendly than those that do not. Thus we will collect data on:

- Content of the curriculum in IT (e.g., abstract concepts vs. applications)
- Opportunities for engaging in small-group research or internships
- Opportunities for women to work in groups with other women
- Programs that encourage the application of IT to human problems and aesthetics
- Cross-disciplinary programs and/or opportunities for interdisciplinary work and applications

Support Programs for Women

Proposition 3: We anticipate that women-friendly institutions will be more likely to offer programs that are cognizant of the ways in which women students have been marginalized and dissuaded from continuing in IT and in science more generally. Such programs might include:

- Mentoring programs specifically for women
- Training for faculty on issues of under-representation of women and minorities in IT
- Networking opportunities for women at post-secondary, graduate and professional levels
- Internship opportunities for women in IT-related degree programs
- Career support and services for women entering IT related professions
- Departmental ties to gender studies/women's studies programs that provide theoretical insight into the challenges faced by women in IT
- Lecture funds/programs that bring women in IT to the campus

Recruitment and Retention Initiatives

Proposition 4: In recognition of the currently lower numbers of women in IT professions and the need to provide additional incentives to encourage more women to train for such professions, we further anticipate that institutions that provide recruitment and retention initiatives will be more women-friendly than those that do not. Thus we will also collect data on:

[1] Though we are also interested in the issues related to minority women students, because of their small numbers, we will not study them in depth. We will, however, examine more closely women who come to study in the United States from other countries, as they are likely to constitute the largest group of women in some of the programs we examine.

- Outreach to high schools and secondary–level students (through summer programs, special weekends, workshops, etc.)
- Level of administrative support for recruitment and retention of female students into IT
- Programs to recruit and retain women faculty in IT
- Fellowship availability and distribution of funding to IT graduate students and undergraduates
- Funding opportunities and distribution to IT women faculty, professionals, graduate students and undergraduates (including travel grants, research funding, and summer opportunity funding)

The aspects of institutional culture under investigation are summarized in the following table.

Table 1. Measures of "women-friendliness" at three levels of institutional culture

	Demographics	Educational Programs	Support Programs	Recruitment and Retention
Profession	Number of women in the profession; in leadership roles of national organizations; on editorial boards of major journals	Training programs (e.g., summer institutes) and workshops oriented towards women in IT	Women's caucuses in national organizations; networking opportunities at conferences	Student fellowships; research grant programs for women in IT
University	Number of women (faculty and students) on campus; number and positions of women in university administration	University-wide IT initiatives; cross-disciplinary programs and/or opportunities for interdisciplinary work and applications	University-wide mentoring programs for women; training for faculty on under-representation of women and minorities in IT; presence of active Gender Studies/Women's Studies program on campus	Outreach to high school students; administrative support and programs for hiring women faculty in IT; funding opportunities (travel grants, summer salary, etc.)
Department	Number of women (administrators, faculty, students) in department	Applications-oriented curriculum; internship opportunities; opportunities for group work	Mentoring; career support for women entering IT professions; lecture funds/programs to bring IT women to campus	Fellowship availability; record of admitting and graduating women students/hiring and retaining women faculty

Although some information of this type has been collected previously at the professional level, even the most current published data will need to be updated at the time of the study. In addition, it will be necessary to collect comparative data from each discipline, university and department using a consistent set of criteria and methods. That is what we propose to do in this study.

IT Disciplines and Study Institutions

Data for this project will be collected from five IT disciplines and seven research universities in the continental United States. The IT disciplines are: computer science (CS), informatics (I), information science/studies (IS), instructional systems technology (IST), and management information systems (MIS). These disciplines were selected because they represent the major IT paradigms in higher education at the present time. A number of U.S. universities offer degree programs in two or more of these disciplines, enabling comparison across departments within a single university. The disciplines also represent a range of degrees of *prima facie* "women-friendliness", based on the numbers of females students currently enrolled in disciplinary programs at our home institution, Indiana University Bloomington. At IUB, computer science and informatics have more men than women students, followed by management information systems, whereas instructional systems technology has a roughly equal gender distribution of students, and information science (which is housed with library science at IU) has more women than men (Campus Sex & Race Profile, Student Enrollment by Major, Sex, Level and Race, 2002). To the extent that these gender

demographics are characteristic of each discipline, they predict greater women-friendliness, and consequently, better outcomes for female students, in IS and IST than in MIS, Informatics and CS. The selection of disciplines thus suggests a hypothesis regarding the effects of disciplinary culture that can be empirically tested.

The target study institutions are: Indiana University Bloomington (IUB), State University of New York at Buffalo (SUNY Buffalo), University of California at Berkeley (UC Berkeley), University of Illinois at Urbana/Champaign, University of Michigan Ann Arbor (U Mich), University of Pittsburgh, and University of Washington (UW). The institutions were selected based on the minimum requirement of having a computer science unit and at least two other IT-related units. In addition, we restricted the sample to high-ranking public or semi-public (i.e., U Pitt) universities such that the overall quality of the institutions would be similar and would not initially be in question. Finally, we gave preference in the selection process to institutions with programs in instructional technology and/or informatics, as these are relatively less common, albeit important IT paradigms in terms of their potential to create gender equity.[2]These criteria led to the selection of seven large research institutions geographically dispersed across the continental United States. Large research institutions are important to study because of their role in educating future IT workers (at the undergraduate level) and faculty for smaller institutions (at the graduate level). Both undergraduate and graduate programs are included in the study. Table 2 shows the IT-related units and degrees granted at each institution.[3]

Table 2.. IT-related units and degrees granted at each study institution

Unit Institution	Computer Science	Informatics	Information Science/Studies	Instructional Systems Technology	Information Systems (Business)	Other
IU Bloomington	BS/BA/MS/PhD	BS/MS	MIS/MLS/PhD	MS/PhD	BS/MS/MBA/PhD	
SUNY Buffalo	BA/BS/MS	BA/MA/PhD MLS	(Department in Informatics)		BS/MS/MBA	Math Dept: Computing & Applied Math concentration
Syracuse University	BS/MS PhD-computer engineering		BS/MS/MLS/PhD	MS/PhD		
Univ. of Illinois	BS/MS/PhD		MS/PhD	IT graduate specialization	BA/MBA/PhD	Medical Information Science Dept.
Univ. of Michigan	BS/MS/PhD		MS/PhD			Concentration/ specializations in ED
Univ. of Pittsburgh	BS/MS/PhD		BS/MS/PhD		IS concentration	BS/MS in Health Info Mngmt/Systems
Univ. of Washington	BS/MS/PhD		BS in Informatics MS/MLIS/PhD		BA/MS/PhD	Division of Biomedical & Health Informatics (in Med School)

We expect that the results found for these universities will generalize to other U.S. universities with multiple IT-related programs. We also expect that some results will generalize to smaller universities and colleges, e.g., because students trained at the larger

[2] This potential derives from the fact that instructional technology is taught in schools of education, which traditionally attract more women than men students, and informatics is an emergent discipline whose associations with gender have not yet fully formed.

[3] There is some overlap between the contents of information science/studies and informatics schools that is not consistently reflected in the schools' names. For example, Informatics at SUNY Buffalo and the School of Information at the University of Washington cover similar content, but have different discipline names. This reflects the historical reality of schools of information/informatics arising in most places out of schools of library and information science. An exception is Indiana University, which maintains both a (traditional) school of library and information science and a (new) school of informatics.

institutions will become instructors at smaller ones. Empirical validation of the latter hypothesis is beyond the scope of the present study, however.

Data Collection and Analysis

Data will be collected about the experiences of students in each program and institution in a three-phase process. The first two phases will be conducted once; the third phase will be repeated three times. In preparation for this process, a sample of subjects will be identified. The schools in the study will be contacted and asked for the list of majors in all the targeted units in the university. A randomsample will be drawn from each department—across year in school, graduate and undergraduate populations, nationality, race and gender. Because of small sample sizes, however, we will not be able to examine women of color in depth for this study. With regard to gender, the sample will include both males and females, but will over sample for women since some programs may include very few women. If the unit does not admit majors until the sophomore or junior year, we will also select from the students who have declared one of the targeted departments as their intended major. Also included in our sample will be all of the full-time faculty, administrators and academic advisers for each department.

For the first phase of the data collection process, we will send out letters describing the study to all the students, administrators, faculty, and academic advisers in the initial sample. The letters will explain that we plan to survey them, and obtain their informed consent. In the letters, we will advise all potential respondents that this study relates to the future of the fields that directly involve information technology, how those fields will be defined, and the preparation students are making for entering those fields. We will also explain our goal of determining the characteristics of the best academic environments for the preparation of students for 21st century technology careers. The letters will be sent out once near the beginning of the project, in September 2003.

For the second phase, the subjects will be surveyed. A proportionate stratified probabilitysample, taking into account the relative sizes of each department or school, totaling about 1000 consenting students selected for their demographic characteristics, will be surveyed in a web-based format set up on a secure server.[4] In addition, a census of consenting faculty and administrators will be interviewed by telephone by staff at the Center for Survey Research on the Indiana University campus.[5] The student survey will take a broad-brush approach to the areas of satisfaction and concern in the information technology units on each of the campuses. The survey will attempt to assess gender-based concerns in each unit without identifying those concerns in a direct manner. Towards that end, several open-ended questions asking the individuals to identify and describe areas of personal concern will be included. More direct questions may be asked of faculty and advisers than of students, as it is assumed that the people involved in administering and teaching the curriculum will be aware of the relatively small numbers of women in their programs. Separate survey instruments will be developed for each of the populations in the study—administrators, advisers, faculty, and undergraduate and graduate students. The interviews are expected to last from 30 to 45 minutes. The surveys will take place once, in October/November of 2003.

In phase three, based on the preliminary analysis of the data from the surveys, respondents from each population in each unit on each campus will be selected for further in-depth study. Individuals who are selected for this part of the study must agree to be interviewed face-to-face once a year over a period of three years, beginning in February/March of 2004 and ending in spring of 2006. Graduate students from Indiana University who are trained in interviewing techniques will collect the data. In each university, 15 undergraduates, eight master's students, and eight doctoral students from each unit will be randomly selected for interviews. The aim of this longitudinal qualitative study is to flesh out the issues raised by the survey, pursuing in greater depth issues of mentoring, feelings of belonging and identity, gender differences and similarities, use of female role models, attitudes and behaviors regarding male and female students, academic success, participation in campus technology organizations, participation in internships, nature of the use of computers and the Internet, use of networking in the unit, and team work structure.

The face-to-face interviews will involve on-site visits to the target campuses. In these interviews and other data gathering on campus we will be collecting additional information on role models; mentoring and advising; informal networking; sense of belonging and identity; and work-family conflict. Qualitative information will be gathered by observing official events, conferences, workshops, and other special programs conducted for students in the institution. Observation of classes will also take place to assess the social dynamics for men and women in that environment. Additional interviews may be conducted with other campus administrators and students outside the IT programs about their perceptions of the gender issues for IT students on campus. In addition, data will be collected from publicly-available departmental/school documents, newsletters, listservs and websites. These data about the units' environment will be used to supplement the formal interview data.

---

[4] This method is designed to elicit the maximum number of responses from students, who may be more likely to participate in web-based surveys than in phone interviews.

[5] Telephone interviews work best for in-depth interviews with adults, and are more economical of their time. A 2000-2001 national study of 524 journalism faculty conducted by the Center for Survey Research at Indiana University yielded a 77% response rate, so we feel confident in the choice of type of interview and in the work of the Center.

As independent measures of success, we will examine grades and standardized test (SAT, GRE, and GMAT) scores for gender comparisons in aggregate terms, along with admission records, and graduation and retention rates within the units all broken down by gender. If the unit goes through a process of accreditation, reports prepared for the accreditation team and the formal review report for the unit will be included in the analysis.

With the exception of the observational data on the environment, the collected data will be analyzed quantitatively and statistically, controlling for such variables as gender, role (student/faculty/administrator), student level (undergraduate/master's/doctoral), U.S. vs. non-U.S. citizen, institution, discipline, time and cultural practices hypothesized to relate to "women-friendliness". Correlational analyses and hierarchical regression and other tests that allow us to examine the relationships between groups will be used. The findings will be evaluated in light of the hypotheses and triangulated with the qualitative environmental observations. The ultimate goal of the project is to articulate recommendations based on the empirical findings to encourage the creation of circumstances that favor successful outcomes for women in IT-related disciplines. To that end, we will make a case for applying the results from the research conducted at these five schools to other IT programs around the country.

A time line for carrying out the data collection and analysis is shown below.

Time line for data collection and analysis

Year 1	Fall 2003	Identify initial subject sample in August Send out letters in September (Phase 1) Conduct surveys in October and November (Phase 2)
	Spring 2004	Preliminary analysis of survey data in January First face-to-face interviews and on-site observations in February or March (Phase 3)
	Summer 2004	Finish analyzing survey data
Year 2	Fall 2004	Analyze first face-to-face interviews Collect institutional data
	Spring 2005	Second face-to-face interviews and on-site observations in February or March (Phase 3)
	Summer 2005	Analyze second face-to-face interviews
Year 3	Fall 2005	Finish analyzing second face-to-face interviews Finish collecting institutional data
	Spring 2006	Third face-to-face interviews and on-site observations in February (Phase 3) Analyze third face-to-face interviews
	Summer 2006	Conduct quantitative and qualitative analyses of results

Dissemination of Results

The conclusions to this research will be of special importance to the universities that are the targets of the study. Therefore, we plan to invite representatives from those schools to a conference to be held in Bloomington, Indiana at the end of the project. We will prepare a report containing the findings to be shared with the participants in the research as well as with professional associations. We will also invite a selection of faculty and administrators from teaching colleges where information technology courses are taught in a variety of departments. We will post our findings to a web site created for that purpose, and present the findings at a panel of the CRA Conference at Snowbird. Last but not least, we will prepare articles for publication in the education-oriented journals as well as the theoretical journals of the disciplines involved.

CONCLUSION

Statement of Contribution to Education

The results of this project will contribute to education in IT fields with special benefits for women, although we believe that IT programs more generally, including both women and men, can benefit from the results.

- The project will lead to the identification of successful (and unsuccessful) strategies, with the goal of informing IT programs what to do (and to avoid) to attract and retain female students.
- Implementing such strategies effectively should lead over time to more women entering IT educational programs, resulting in greater diversity (of students, perspectives, ideas) in such programs and a corresponding increase in the number of women in the "pipeline" for IT-related

employment.

- Comparative statistics produced by the project can be used as a baseline in future research on IT education and gender, much as this project draws on findings from previous research on female students in computer science.
- To the extent that we are able to show that other IT disciplines succeed where computer science has thus far failed, the results could encourage new ways of thinking that break down the traditional monopoly of computer science on IT education, and show women more options than they currently think they have, thereby encouraging more women and girls to consider IT-related programs of study.

Ultimately, the challenge is cultural – IT needs to be widely seen as a domain that women enjoy and in which they can excel. Evidence of this needs to be public and pervasive; children need to grow up knowing it from an early age. To the extent that new IT paradigms such as are taught in schools of information, informatics, education and business help to create those cultural associations, they can contribute to replacing the present exclusionary masculine culture of computing with a more inclusive and diverse one. The growing economic and social importance of IT in the United States makes this broader outcome not only strongly desirable, but necessary if we are to meet the demands of the IT workforce and benefit as a society from the contributions of the entire population.

References

Adams, G.A., King, L.A., & King, D.W. (1996). Relationships of job and family involvement, family social support, and work-family conflict with job and life satisfaction. *Journal of Applied Psychology* 81(4), 411-420.

Barinaga, M. (1992). Profile of a field: Neuroscience (The pipeline is leaking). *Science* 255(13), 1366-1367.

Berry, P. (1983). Mentors for women managers: Fast-track to corporate success. *Supervisor Management* 28(8), 36-40.

Bryant, R. and Irwin, M. (2001). Current and future Ph.D. output will not satisfy demand for faculty. *Computing Research News*. March 2001, 5-11.

Burke, R.J. (1984). Mentors in organizations. *Group and Organizational Studies* 9, 353-372.

Camp, T. (1997). The incredible shrinking pipeline. *Communications of the ACM* 40(10), 103-110.

Clarke, S. (1992). Strategies for involving girls in computer science. In C. Martin & E. Murchie-Beyma (Eds.), *Search for Gender Free Paradigms for Computer Science Education* (pp.71-86). Eugene, OR: International Society for Technology in Education.

Clawson, J. (1980). Mentoring in managerial careers. *Work, Family and the Career: New Frontiers in Theory and Research.* New York: Praeger Publishers.

Cohoon, J.M. (2001) Toward improving female retention in the computer science major. *Communicationsof the ACM*. 44(5), 109-114.

Dreher, G.H. & Ash, A. (1990). A comparative study of mentoring among men and women in managerial, professional, and technical positions. *Journal of Applied Psychology* 75(5), 539-546.

Duxbury, L., & Mills, S. (1989). The electronic briefcase and work-family conflict: An analysis by gender. In J.I. DeGross, J.C. Henderson, & B.R. Konsynski (Eds.), *Proceedings of International Conference on Information Systems* (pp. 165-172). Baltimore, Maryland: ACM Publications,.

Ely (1995). The power in demography: Women's social construction of gender identity at work. *AMJ* 38(3), 589-634.

Fagenson (1989). The mentor advantage: Perceived career/job experiences of protégés vs. non-protégés. *Journal of Organizational Behavior* 10, 309-320.

Frenkel, K.A. (1990). Women and computing. *Communications of the ACM* 33(11), 33-46.

Frone, M.R., Russell, M., & Cooper, M.L (1992). Antecedents and outcomes of work-family conflict: Testing a model of the work-family interface. *Journal of Applied Psychology* 77(1), 65-78.

Gallese, L.R. (1993). Do women make poor mentors? *Across the Board* 30(3), 23-26.

Gallos J.V. (1989). Exploring women's development: Implications for career theory, practice, and research. In M.B. Arthur, D.T. Hall, & B.S. Lawrence (Eds.), *Handbook of Career Theory* (pp. 110-132). Cambridge. MA: Cambridge University Press.

Greenhaus, J.H. (1988). The intersection of work and family roles: Individual, interpersonal, and organizational issues. *Journal of Social Behavior and Personality* 3, 23-44.

Greenhaus, J.H., & Beutell, N.J. (1985). Sources of conflict between work and family roles. *Academy of Management Review* 10(1), 76-88.

Gutek, B.A., Searle, S., & Klepa, L. (1991). Rational versus gender role explanations for work-family conflict. *Journal of Applied Psychology* 76(4), 560-568.

Hacker, S. (1990). The culture of engineering. In S. Hacker, D. Smith, & S. Turner (Eds.), *Doing it the Hard Way: Investigating Gender and Technology* (pp. 111-112). London: Unwin Hyman.

Heider, F. *The Psychology of Interpersonal Relations*. Wiley, New York .

Higgins, C.A., & Duxbury, L.E. (1992). Work-family conflict: A comparison of dual-career and traditional-career men. *Journal of Organizational Behavior* 13(4), 389-411.

Hill, S.E.K., Bahniuk, M.H., & Dobbs, J. (1989). The impact of mentoring and collegial support on faculty success: An analysis of support behavior, information adequacy, and communication apprehension. *Communication Education* 38, 15-33.

Hunt, D.M., & Michael, C. (1983). Mentorship: A career development training tool. *Academy of Management Review* 8(3), 475-485.

Jones, K. S. (1990). Citizenship in a woman-friendly polity. *Signs* 15(4).

Kanter, R.M. (1977). *Men and Women of the Corporation*. Basis Books, New York.

Kirchmeyer, C. (1997). Relational demography and career success: A longitudinal atudy of mid-career managers. *Proceedings of the Academy of Management Meeting*.

Klawe, M. & Leveson, N. (1995). Women in computing: Where are we now? *Communications of the ACM* 38(1), 29-35.

Kram, K.E. (1983). Phases of mentor relationships. *Academy of Management Journal* 26, 608-625.

Kram, K.E. (1985). *Mentoring at work*. Glenview, IL: Scott, Foresman & Co.

Larwood, L.B., J. (1978). Sex discrimination in manager selection: Testing predictions of the vertical dyad linkage model. *Sex Roles* 4, 359-367.

Levinson, D.J., Darrow, C.N., Klein, E.B., Levinson, M.A. & McKee, B. (1978). *Seasons of a Man's Life*. New York: Knopf.

Margolis, J. & Fisher, A. (2002). *Unlocking the Clubhouse: Women in Computing*. Cambridge, MA: MIT Press.

National Council for Research on Women (2001). *Balancing the Equation: Where Are Women & Girls In Science, Engineering & Technology?* New York: NCRW.

National Science Foundation (2000). *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2000*. http://www.nsf.gov/sbe/sis/nsf00327/pdfstart.htm

Netemeyer, R.G., Boles, J.S., & McMurrian, R. (1996). Development and validation of work-family conflict and family-work conflict scales. *Journal of Applied Psychology* 81(4), 400-410.

Noe, R.A.. (1988). Women and mentoring: A review and research agenda. *Academy of Management Review* 13(1), 65-78.

Oakley, A. (1972). *Sex, Gender and Society*. London: Sage.

Parker, V.A.& Kram., K.E. (1993). Women mentoring men: Creating conditions for connection. *Business Horizons* 36(2), 42-51.

Pearl et al. (1990). Becoming a computer scientist. *Communications of the ACM* 33(11): 48-57.

Pfleeger, S. L. & Mertz, N. (1995). Executive mentoring: What makes it work? *Communications of the ACM* 38(1), 63-73.

Powell, G.N. & Mainiero., L.A. (1992). Cross-currents in the river of time: Conceptualizing the complexities of women's careers. *Journal of Management* 18, 215-237.

Ragins, B.R. (1989). Barriers to mentoring: The female manager's dilemma. *Human Relations* 42(1), 1-22.

Ragins, B.R., & Cotton, J.L. (1991). Easier said than done: Gender differences in perceived barriers to gaining a mentor. *Academy of Management Journal* 34(4), 939-951.

Ragins, B.R. & Scandura., T.A. (1994). Gender differences in expected outcomes of mentoring relationships. *Academy of Management Journal* 37(4), 957-971.

Rasmussen, B., & Hapnes, T. (1991). Excluding women from the technologies of the future: A case study of the culture of computer science. *Futures* 23(10), 1107-1119.

Ray, C. M., C. Sormunen, & T. M. Harris (1999). Men's and women's attitudes toward computer technology: A comparison. *Office Systems Research Journal* 17(1), Spring. http://www.nyu.edu/education/alt/beprogram/osrajournal/ray.PDF

Riley, S., & Wrench, D. (1985). Mentoring among women lawyers. *Journal of Applied Social Psychology* 15(2), 374-386.

Scandura, A. (1992). Mentorship and career mobility: An empirical investigation. *Journal of Organizational Behavior* 13(2), 169-174.

Science. (1992). Women in science. 255(1050), 1365-1376.

Shockley, P. & Stanley., C.M. (1980). Women in management training programs: What they think about key issues. *Public Personnel Management* 9, 214-224.

Shuttleworth, T. (1992). Women and computer technology. Have the promises of equal opportunities been fulfilled? *Women in Management Review* 7(7), 24-30.

Simeone, A. (1987). *Academic Women: Working Towards Equality*. Massachusetts: Bergin & Garvey Publishers, Inc.

Smith-Lovin, L. & McPherson, J. M.. (1993) You are who you know: A network approach to gender. In *Theory on Gender/Feminism on Theory* (England, P. Ed). New York: Aldine De Gruyter.

Spertus, E. (1991). "Why are there so few female computer scientists?" ftp://ftp.ai.mit.edu/people/ellens/

Taylor, S. E., Klein, L. C., Lewis, B. P., Gruenewald, T. L., Gurung, R. A. R., & Updegraff, J. A. (2000). "Biobehavioral responses to stress in females: Tend-and-befriend, not fight-or-flight." *Psychological Review* 107(3).

Tharenou, P. Latimar, S., & Conroy, D. (1994). How do you make it to the top? An examination of influences on women's and men's managerial advancement. *Academy of Management Journal* 37(4), 899-931.

Turkle, S. (1984). *The Second Self*. New York: Simon and Schuster.

Turkle, S. (1988). Computational reticence: Why women fear the intimate machine. In *Technology and Women's Voices* (Kramarae, C. Ed.), Routledge & Kegan Paul, Inc., New York.

Van Velsor, R. & Hughes, M. W. (1990). *Gender differences in the development of managers: How managers learn from experience*. Report no. 145. Greensboro, North Carolina: Center for Creative Leadership,.

Warihay, D.D. (1980). The climb to the top: Is the network the route for women? *Personnel Administrator* 25(4), 55-60.

Whitely, W., Dougherty, T.W. & Dreher, G.F (1991). Relationship of career mentoring and socioeconomic origin to managers' and professionals' early career progress. *Academy of Management Journal* 34(2), 331-351.