Research Foundations for Improving the Representation of Women in the Information Technology Workforce

Virtual Workshop Report

Held September 27, 1999 - November 5, 1999

Submitted by

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Table of Contents

Executive Summary

The information technology (IT) industry is growing at a rapid pace. Information technology is a vital part of today's global economy. Indicators suggest that it will continue to increase in importance during the next decade. It already impacts almost all aspects of the workplace and most aspects of our everyday life. While multiple definitions exist, one definition that reflects the general perception of IT is that it is the study, design, development, implementation, support or management of computer-based information systems, particularly software applications and computer hardware [ITAA99].

Major workforce issues have arisen as a result of the rapid rise of IT. Numerous studies support the finding that there is a significant gap between the supply and demand of IT workers. The studies project that the gap will widen during the next decade. A shortage of IT workers over an extended period time will have a negative impact on the economy. Among the costs of an IT worker shortage are slowing of innovation and product development; decline of global competitiveness of American companies; positions filled with unqualified people, thereby increasing the potential for project failure; reduction in the range of products available; and employer instability as a result of frequent movement by IT workers from one opportunity to another [CRA]. These factors indicate that it is crucial that we increase the IT workforce.

Major increases in the IT labor force can occur in many ways because people enter the IT workforce from numerous careers paths; however, one indicator associated with the shortage of workers is the number of students graduating from IT-related disciplines. An example from the field of computer science is that from the early 1990's to the present, the bachelor degree production and the master degree production have been stable, but the doctoral degree production is in decline. These numbers are discouraging in light of the indicators of higher demand for IT workers in the next decade.

With the overall production of IT graduates stable or declining, we need to investigate the demographics related to the graduates. Again, using computer science as a representative discipline, the percentage of women has declined since 1986. For bachelors degrees, the number peaked in 1986 when women represented approximately 36% of the total number of graduates. In 1996, approximately 27% of the bachelors and masters degrees were earned by women while only 15% of Ph.D. degrees were earned by women. When we consider that women represent approximately 51% of the total population, these percentages cause concern. It is crucial that we understand why the percentage of women in IT is so low and why the numbers have in fact been declining since 1986.

To address the need to increase the representation of women in the IT workforce, a virtual workshop was held to define a research agenda that addresses the under-representation of women. The Research Foundations for Improving the Representation of Women in the Information Technology Workforce Virtual Workshop was held from

September 27, 1999 to November 5, 1999. All aspects of the workshop were conducted through the Web. The objectives of the workshop were to:

1. Identify characteristics that contribute to the under-representation problem in science and technology fields in general and information technology in particular.

2. Define research issues associated with the under-representation of women.

3. Identify specific research directions that should be pursued as a part of a national research agenda.

The recommendations from the workshop are detailed in this report. The results of the workshop emphasize that the problem of under-representation of women in the IT workforce is a multi-dimensional problem that should be aggressively pursued from numerous research perspectives.

Research Recommendation Summary:

Recommendation 1
Conduct an in-depth, long-term study of the impact of computer games on the career choices of girls. The study should include analysis of playing patterns, game content, and creative aspects of the games.

Recommendation 2
Determine the role of social expectations, cultural factors, and ethnic values in the educational and career choices of girls.

Recommendation 3
Support research efforts to understand the influence on career choices of environmental factors such as family, peers, teachers, media, and counselors.

Recommendation 4
Conduct a study to determine the impact of the Internet on career choices of women.

Recommendation 5
Investigate the impact of computer science courses in the high school curriculum on the student's perception of IT careers.

Recommendation 6
Support research to determine the essential elements of teacher training programs that can change teacher perceptions and teacher behavior about women in IT.

Recommendation 7

Support research to identify learning styles, teaching styles, and tools that will encourage female interest in computer-related fields.

Recommendation 8
Support research to track the relationship between female student interests at the high school level and their eventual career choices.

Recommendation 9
Support research that measures the social relevance of curriculum content, determines its impact on recruitment and retention of women, and identifies teaching methodologies that will promote the inclusion of the social context with the technical content.

Recommendation 10
Support research to help identify strategies that will make IT-related academic programs more appealing.

Recommendation 11
Support research to identify methods to attract students to IT disciplines from non-IT disciplines. Investigate the process by which students who are studying a non-IT discipline become interested in an IT discipline.

Recommendation 12
Investigate the impact of two-year colleges in the recruitment and retention of women in IT, including articulation policies.

Recommendation 13
Develop techniques to objectively assess the effectiveness of seemingly successful programs that recruit and/or retain women in IT related majors and IT related careers.

Recommendation 14
Study the comparative effect of intervention programs on the recruitment and retention in IT of women in contrast to men.

Recommendation 15
Document with longitudinal studies the effectiveness of higher education programs and curricular changes aimed at increasing the retention of women in IT-related disciplines.

Recommendation 16
Investigate the role of university policies on the retention of women faculty members.

Recommendation 17

Conduct a thorough study to provide both qualitative and quantitative information about the status of women faculty members in IT-related disciplines.

Recommendation 18
Conduct longitudinal studies that compare career paths of men and women.

Recommendation 19
Support research in academia and industry to correlate recruitment and retention of women with workplace climate and company policies.

Recommendation 20
Encourage comparison studies to determine which factors affecting retention of women are specific to IT and to identify methods to help ameliorate the impact of the factors.

Recommendation 21
Support research to examine the effect of the temporary and the part-time IT workforce on the recruitment and retention of women.

Recommendation 22
Support research that analyzes the affect of the status of IT as a profession on the recruitment and retention of women. The research should include identification of stereotypes associated with the field and techniques to mitigate those stereotypes that are not valid.

Recommendation 23
Study the impact of male-dominance in IT fields on the perceived access to IT.

Recommendation 24
Conduct studies that identify characteristics that are needed for a successful IT career. Include research that characterizes women who are successful in the IT field. Compare characteristics of women who are successful in IT fields with those who are successful in other technical fields.

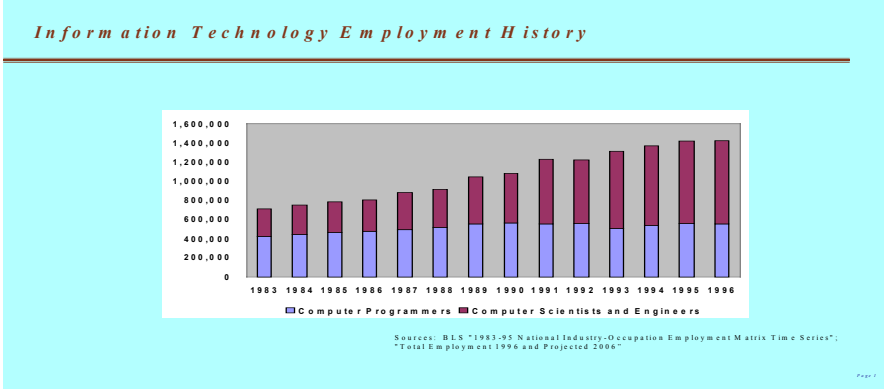
I. Background

The information technology (IT) industry represents a driving force in today's economy. It impacts virtually every aspect of the workplace and most aspects of our everyday lives. The rapid and significant advances in IT, combined with the ever-increasing demands for IT, have led to the situation where a typical IT worker is in the enviable position of being in great demand. The demand often means appealing salaries and significant benefits packages for the IT worker. The Office of Technology Policy of the Department of Commerce identifies a significant workforce shortage [OTP]. The Bureau of Labor Statistics projections suggest that more that one million new IT workers will be needed between 1994 and 2005 to fill jobs as computer scientists, computer engineers, systems analysts, and computer programmers (see Figure 1). For the same period, an annual average of 95,000 new workers will be needed. Of these workers, the demand for systems analysts is projected to increase at the highest rate, at an anticipated rate of 92% [BLS].

Multiple definitions of information technology exist. Several groups have working definitions. For example, the Information Technology Association of America (ITAA) defines information technology as the "study, design, development, implementation, support or management of computer-based information systems, particularly software applications and computer hardware" [ITAA]. The fuzzy boundaries surrounding the definition of information technology make it difficult to find a true measure of the supply and demand. One of the reasons that it is difficult to measure the IT workforce supply is that many people enter the IT workforce through nontraditional means. Workers who did not receive technical degrees are entering the IT workforce. They receive training from a multitude of sources to acquire the necessary skills to move into an IT job. To further investigate the shortage in the context of traditional and nontraditional means, the Computing Research Association conducted an IT workforce study in which they found that the preponderance of evidence suggests an IT worker shortage [CRA]. In addition, the Board of Science, Technology and Economic Policy, along with the Board of Testing and Assessment, Computer Science and Telecommunications Board, and the Office of Scientific and Engineering Personnel is conducting an IT workforce study. This study will be a comprehensive study to include a description of the IT workforce, outline of education and skills needed, profile of demographic characteristics of current IT workers, and examination of the capacities of the US educational system to meet the needs. In this study, information technology is defined as "computing and telecommunications, including hardware, software, and the integration of the two, with an emphasis on computer-based technologies and industries". An IT worker is defined as someone "engaged in creating, developing, and managing information technology, distinct from those who simply use information technologies on the job" [CSTB].

There is compelling evidence that a real shortage does exist and that the problem will worsen as we enter the new millenium. Part of the evidence comes from examining the number of people entering the workforce through the traditional educational pipeline. Figures 2 – 4 show the trends in the field of computer science since the mid 1970's [NSB]. Figure 2 indicates that at the bachelor's level, the number peaked at approximately 42,000 in 1986; however, since the early 1990's the number has remained relatively constant at about 25,000. From Figure 3, we see that the masters degree production has generally increased since the 1970's; but, since the early 1990's, the number has remained relatively constant at between 9,000 and 10,000. Figure 4 indicates that Ph.D. production has grown since the earl 1980's; however, since the mid 1990's, there has been a leveling off in the production of Ph.D. graduates.

Figure 1



Overall, the bachelor degree production and the master degree production are stable; but the doctoral degree production is in decline. These numbers are discouraging in light of the indicators of higher demand for IT workers in the next decade.

Figure 2

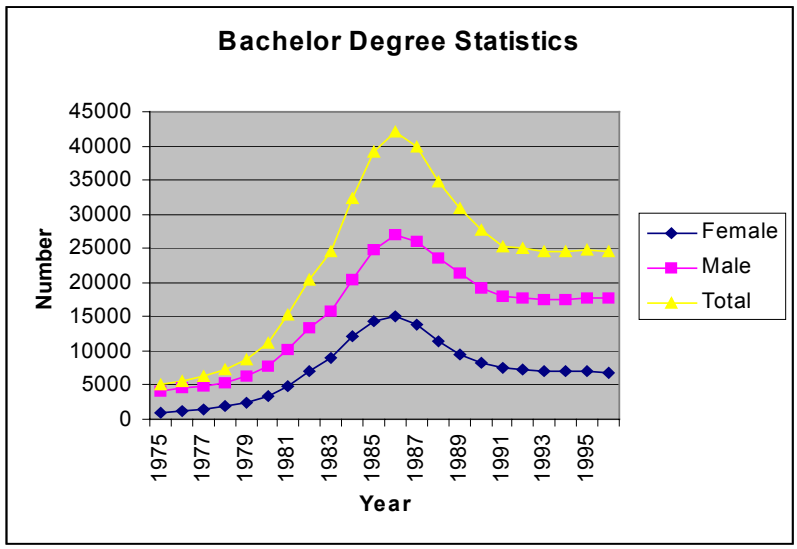


Figure 3

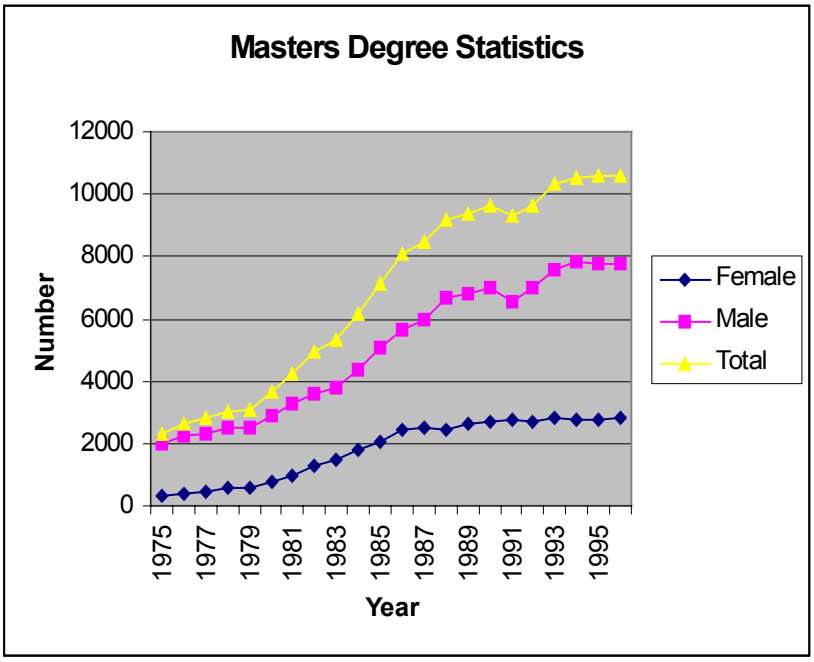


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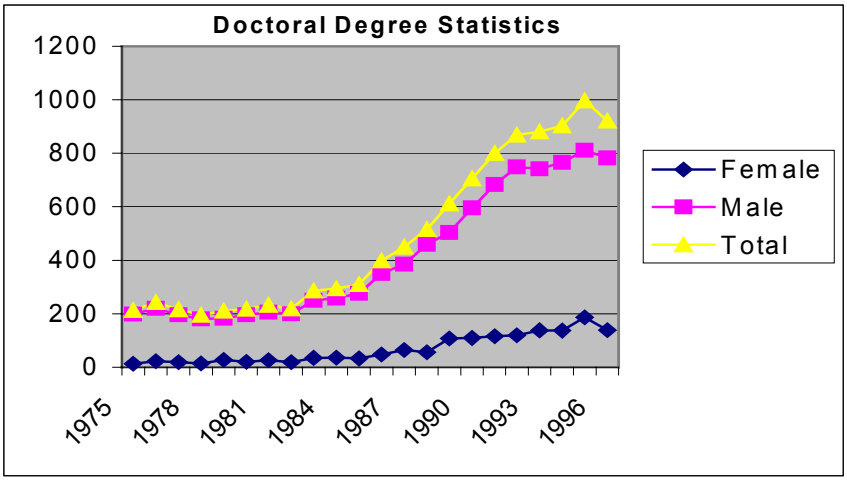
Figure 4



A significant question that arises is how will we meet the IT workforce needs? While a solution to the workforce issue necessarily has many facets, one of the obvious components to a solution is to increase the number of graduates from information technology related programs. How do we increase the number of people graduating from

information technology disciplines? When we look at the gender demographics of graduates, it becomes apparent that women are underrepresented. If we can increase the number of women graduating from information technology disciplines, we will obviously increase the pool of IT workers. Figures 2, 3, and 4 indicate that the number of women in computer science has declined since 1986. For bachelors degrees, the number peaked in 1986 when women represented approximately 36% of the total number of graduates. In 1996, approximately 27% of the bachelors and masters degrees were earned by women while only 15% of Ph.D. degrees were earned by women. When we consider that women represent 51% of the total population, these percentages cause concern. This phenomenon is referred to as "The Incredible Shrinking Pipeline" in [Camp97]. It is crucial that we learn more about why the percentage of women in IT is so low and why the numbers have been declining since 1986.

The under-representation of women in the IT workplace demands further investigation. The low representation of women in computing has been studied in many environments for over a decade. In 1990, Frenkel states "…. One wonders how many ideas that could have been contributed by female talent will never surface to enrich academic computer science. More broadly, what are the repercussions to our increasingly computer-oriented society if women – about half the population and professional workforce—are not as prepared in this discipline as are men?" [Fren90] The low representation has been correlated with computer interest, motivation, mathematical ability, lack of confidence, and socialization factors. Others have found that factors such as environment and pedagogy have a significant impact [Seym97]. In [Fish97], preliminary results of a study of experiences of undergraduate women studying computer science at Carnegie Mellon University identify cultural conceptions of computer science, pedagogy issues, and institutional culture issues as topics that impact women. In a study of why women leave computer science programs at SUNY Geneseo, self-confidence and male dominance were identified as barriers. This study found that the lack of experience of women entering the program was significant, thereby suggesting that systemic societal problems are a major influence [Scra98]. Societal pressure against women being successful, male-dominated environments, inequalities in language, and negative consequences of some attempts to help women are explored in [Sper91]. The research results on women and computing lack consensus [Houl96]. A clearer understanding of the fundamental research issues will provide a sound basis on which to pursue future research in the area. Once these research issues are identified, resources can be committed to help mitigate negative situations and to help reinforce positive situations that affect a woman's decision to enter the field and then to stay or leave the field at some point in her career.

Thus, the motivation for this virtual workshop resulted from this need to increase the number of IT workers and from the data that indicate that women are underrepresented in the IT workforce. In addition, the relative percentage of women who are preparing to enter the IT workforce is diminishing. There is a pressing need for a better understanding of the research issues that affect the participation of women in the IT workforce.

II. Workshop Organization

In order to achieve the goals of the workshop, we established a set of topics to provide a comprehensive covering of the issues relevant to women and the IT workforce. The objective was to minimize the overlap among topics; however, some overlap was inevitable. Each of the topics was the basis for an individual discussion track in the workshop. The six topics are described in Table I.

Each track was moderated by a moderator(s). The moderators were selected based on their expertise and interests. We were successful in recruiting an excellent group of moderators. The moderators brought a diverse set of knowledge, skills, and backgrounds to the workshop. Each moderator was given considerable flexibility to structure the discussion as they choose; however, each moderator was asked to open the discussion with a position paper. The workshop structure is depicted in Figure 5. A list of the moderators and their affiliations is shown in Table 2. Excerpts from the opening position papers are given in Appendix I.

We enlisted the help of social scientists to elicit the viewpoint and the expertise that the social science community has on the issue of under-representation of women. We were fortunate to have three esteemed members of the social science community contribute to the workshop. A list of the social scientists with their affiliation is included in Table 3.

We established a plan to widely disseminate information about the workshop and to invite people to participate in the workshop. We used two primary methods to identify the participants. First, all personnel involved with the execution of the workshop were charged to identify potential participants and invite them to join the workshop. Each of the moderators was charged with the task to identify people who were specifically relevant to his/her given topic and to encourage them to participate. Second, we issued a formal invitation to participate in the workshop to numerous mailing lists. The invitation is given in Appendix II. Representative samples of these lists are shown in Table 4.

During the six-week duration of the workshop, we sent additional postings to remind participants to contribute to the workshop. In addition to these lists, the coordinator spoke about the workshop at the NSF Gender Equity Annual Meeting. She invited the attendees to participate and to ask their colleagues to participate in the workshop.

The workshop was held entirely over the World Wide Web to make it accessible to a large number of people with diverse interests. There were 234 participants who registered. In order to facilitate participation in an effective manner, we posted a set of workshop policies and guidelines. These policies and guidelines are given in Appendix III. More information about the participants and the level of participation is given in Appendix IV.

Table I

Cluster Topics

1. Environmental Factors: Childhood to Pre-College
   This track covered topics such as cultural issues, socialization of young girls, peer pressure, media portrayals, computer games, family, church and role models, curriculum issues.

2. Environmental Factors: Higher Education
   This track covered the culture of the classroom and research settings. It explored the uniqueness of the culture and its impact on recruiting and retaining women.

3. Environmental Factors: Workplace
   This track included environmental factors affecting women's interest in entering the IT workplace, characteristics of IT and the comparison of IT disciplines with other scientific disciplines.

4. Academic Paths
   This track investigated the impact of such issues as pedagogies, non-CS major paths to the IT workforce, opportunities, and finances.

5. Career Paths
   This track studied the impact of career-specific opportunities, training, and mentoring.

6. Professional Organizations
   This track explored the impact of the professional societies on topics such as education, mentoring, role models, and training.

Figure 5

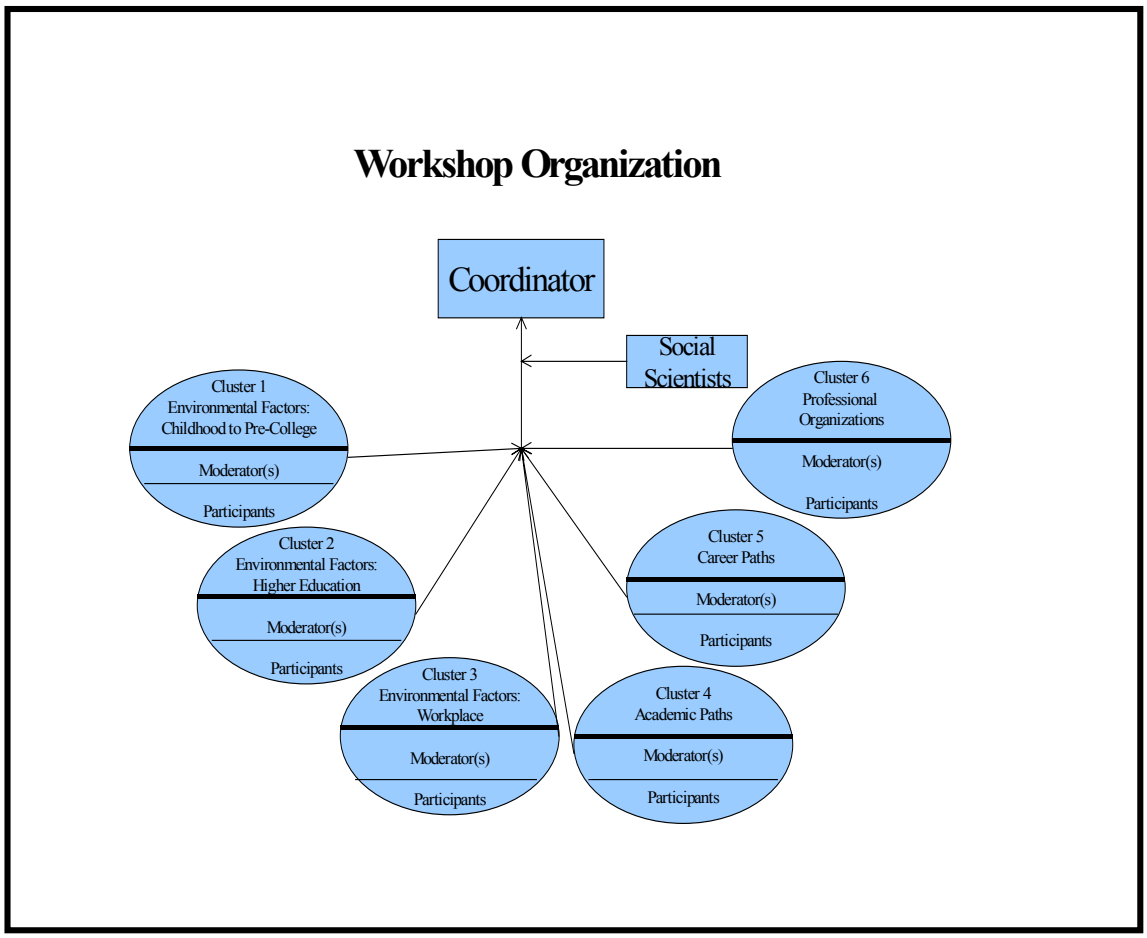

Workshop Organization
Coordinator
Social Scientists
Cluster 1
Environmental Factors:
Childhood to Pre-College
Moderator(s)
Participants
Cluster 2
Environmental Factors:
Higher Education
Moderator(s)
Participants
Cluster 3
Environmental Factors:
Workplace
Moderator(s)
Participants
Cluster 4
Academic Paths
Moderator(s)
Participants
Cluster 5
Career Paths
Moderator(s)
Participants
Cluster 6
Professional
Organizations
Moderator(s)
Participants

Table 2

Moderators

- **Environmental Factors: Childhood to Pre-College**
  - **Dr. Paul Ohme**
    - **Director, Center for Education Integrating Science, Mathematics and Computing**
    - **Georgia Institute of Technology**
  - **Dr. Peggy Jelks**
    - **Associate Professor**
    - **University of Louisiana at Monroe**
- **Environmental Factors: Higher Education**
  - **Dr. Jan Cuny**
    - **Associate Professor**
    - **University of Oregon**
- **Environmental Factors: Workplace**
  - **Dr. Shelia Humphreys**
    - **Academic Staff Member**
    - **University of California, Berkeley**
  - **Dr. Denise Gurer**
    - **Technologist**
    - **3Com Corporation**
- **Academic Paths**
  - **Dr. Anne Spalter**
    - **Professor**
    - **Brown University**
- **Career Paths**
  - **Dr. Antonio Lopez**
    - **Professor**
    - **University of New Orleans**
  - **Ms Tammy Lopez**
    - **Systems Analyst**
    - **J. D. Edwards**
- **Role of Professional Organizations**
  - **Dr. Leah Jamieson**
    - **Professor**
    - **Purdue University**

Table 3

Social Scientists

- **Dr. Paula Rayman**
  - **Director of Public Policy**
  - **Radcliffe Public Policy Center**

- **Dr. Barbara Lazarus**
  - **Associate Provost for Academic Affairs**
  - **Carnegie Mellon University**

- **Dr. Jane Margolis**
  - **Research Educationist**
  - **Graduate School of Education and Information Studies**
  - **University of California at Los Angeles**

Table 4

Representative Lists

systers

CRA

nsf website

systers-academia

ACM-W

NPACI

NSF Gender listserve

sigcse.members@acm.org

III. Participant Perspectives

We present summaries of the workshop discussion for each cluster in Sections III.1 - III.6. The summaries include recommended research questions.

III.1 Environmental Factors: Childhood to Pre-College

The primary discussion threads for this cluster were socialization of young girls; peer pressure and role models; media portrayals of women; computer games; and school and curriculum issues.

Socialization of Young Girls
The discussion on the socialization of young girls focused on parental influence and gender-defined toys.

Parental Influence:
Parental influence is evident in the roles very young children play. Many parents have been influenced by "Bill Nye the Science Guy," "Mr. Wizard," or some other male role model. Therefore, messages are transmitted to girls about their place in the world of technology, and the pressure starts at an early age with "Barbie" rather than "byte." Assumptions are made that girls "are not as interested" in science and/or math. It becomes, for some, a "self-fulfilling prophecy" due to expectations from the home, peers, and school, not to mention the messages sent by the media. A television newsmagazine reported that that teachers referred to and "coached" boys more in math and science than they did girls. Classroom environments where these differences occur can reduce the odds that young females become either mathematically or technologically literate.

Gender-Defined Toys

A toy is typically marketed either to boys or girls. Toy stereotyping may, indeed, have a direct impact on career preferences when we consider that the majority of video games are considered "gendered" toys, marketed primarily toward boys. Most video games on the market contain male characters, and only include women as over-sexed stereotypes or as a "damsel-in-distress" to be rescued by the male protagonist. These games attract more male than female players. Thus, at a young age boys play with video and computer games, which makes them more likely to develop an interest in technology and to make them feel comfortable around computers. Most girls are not exposed to as many games primarily because few quality games are on the market in either a gender-neutral or female-specific manner. The gendering of children's toys can have an important impact on future academic and career interests.

There are concerns that the computer has now become part of the "boy's corner" in school. In a kindergarten-first grade classroom, one participant noticed that groups of boys clustered around the computers and girls clustered around the art table. There is a great identity/gender segregation that happens around this age, and historically Legos,

blocks, and doll corners became the sites of this divide, and now the computer has become part of the "boy side" of the room.

Peer Pressure and Role Models

We explored the role of peer pressure, role models, family, and media in the formation of girls' perceptions of the information technology field. We considered computing environments, mindsets, and family/peer support.

Computing Environment:

In an academic environment, students are more apt to encounter competition and put-down, rather than encouragement and support. Often girls are not taught to deal with such an environment. As long as students have to be competitive to get access to resources, there may be discrimination against girls and women. The information technology work environment rapidly changes; hence, the people who excel are people who can readily respond to change. In addition, the successful people in IT jobs generally are busy building new systems rather than teaching new people. Documentation, whether on the job or in the computer lab at school, is notoriously absent, outmoded, incomplete, or incoherent. The lack of timely training resources can cause women to leave a job if they do not believe they can be productive.

Explorer Mentality:

Some observe that boys tend to be ingrained with an explorer-type mentality. An "exploratory" mindset seems to be common in young people who choose to pursue a field of study they know little about. Moreover, since IT is a relatively new field, it is unlikely that most students applying to college in the 1990's have parents who are computer scientists or electrical engineers. Some degree of explorer mentality is often needed to help students choose an "unfamiliar" field such as IT.

Encouragement of Girls:

Peer and role model pressures are often cited as reasons that girls don't pursue majors and careers in IT. Between the 5th and 10th grades, peers of both sexes (but boys more than girls), teachers, and guidance counselors begin to steer girls toward other fields and away from the field of computing. Moreover the explorer (mostly for boys) vs. colonizer mentality (for both) may be ingrained earlier by parents who grew up with the same mindset. Other stereotypes ingrained by the immediate family may include the perception of the male as "Mr. Fixit" or "Inspector Gadget."

Science, mathematics, and technology are still viewed as a "man's world." The messages are subtler than in past days, but just as effective. Most people are guilty of communicating what they were taught. Parents and teachers need to be more conscious of

serving as role models. Girls need to see their mothers and other women in their lives using computers. Teachers must overtly counter some of the gender inequity issues.

Peer pressure from both boys and other girls cannot be underestimated. It is difficult to be "smart in science and mathematics" as a young woman from about sixth grade forward. Students use terms like "geeky" to describe girls who are studious in these areas. It is only with strong support from role models, mentors, and family members that many young women are able to pursue their goals because of this pressure. Unless they have been taught that it is acceptable, perhaps even preferable, to be different and unless this teaching has been internalized, girls too often give up. Students need "to see themselves" in a field for them to achieve success.

Women role models clearly need to encourage young girls and to refrain from making technophobic comments. Another part of the problem comes from the fact that many schools do not teach computing classes that could inspire girls to investigate IT. Guidance counselors and teachers are not encouraging women as much as men to major in computer science. These mentors, who are probably the best source of career information, are not encouraging female students into IT fields.

Young women are rarely exposed to using tools, taking things apart, and putting them back together on their own while young men are actively encouraged to do such activities since early childhood. When encouraged to "take chances" and shown some basic steps, women do very well. However, it is not common for young women to receive this kind of encouragement whereas young men are expected to experiment. There is a stereotype that women should receive more and men less help when assigned a task of putting things together or taking them apart. It may be so deeply ingrained in our culture that it is difficult to change the norm. There is a perception that when girls are using a computer, they want to be told what to do next, whereas boys want to explore to find what they need. This characteristic could translate to the business environment in which women new to computer use may be afraid that if they commit an error they will break the machine. Perhaps a fear of taking risks and making mistakes is a reason many women do not feel comfortable in the IT field.

We should support science, mathematics, computer clubs and after-school programs taught by staff trained in gender equity. Activities should be interesting, fun, encourage risk-taking, and build self-confidence.

It is likely that media portrayals of females play a role in the perception of women about technology careers. It is generally accepted that the media (television, magazines, films, etc.) portrays women in a stereotypical manner and that some progress is being made in this area. The Girls Inc. website (http://www.girlsinc.org) has a feature that allows girls to provide input and rate movies based on their portrayal of females.

Computer Games

We considered the impact of computer games on the perceptions of women. Industry analysts say that less than five percent of video game players are female, but recently computer game manufacturers are targeting girls as a potentially huge market. This marketing strategy is due in part to the profit earned by Mattel's Barbie Fashion Designer, which first appeared on the shelves in October of 1996. When more game manufacturers feel they are missing out on millions, they will rush to tap into the market. They will strive to give the consumer what they want. Until we change attitudes, much of what is produced and purchased for girls will not help motivate young girls towards a technology mindset.

Some researchers question whether computer game content also affects a girl's perceptions of computer use or whether simply using a computer (even if that means designing clothes for Barbie) is sufficient. The impact of software developed by women for girls and the impact of portrayals of females in computer games should be explored.

It is possible that the percentage of females playing video games is higher than industry analysts think. It would be informative to have an accurate measurement of the percentage of females who play video games. It would also be informative to track the percentage of girls in different age groups playing video games. These data might correlate with the decline in girls' interests in IT careers as they get older.

School and Curriculum Issues

We explored the role of school and curriculum issues on career issues. Research has shown that girls have a tendency to defer to boys who want to be the computer expert in technology-based collaborative learning situations. We considered the impact of stereotypes in curricular materials and the need to inform teachers and administrators about the biases. We also considered the impact of girls-only classes and the need to increase technology participation by girls in the classroom and in computer clubs.

Girls-Only Classes:

We do not know whether "girls only" classes are an effective means to encourage girls to pursue IT related fields. Some feel that boys and girls have to learn to collaborate on an equal footing, while others have cited examples of "girls only" classes improving the participation of female students in technology fields. Some girls indicate that they are more comfortable, ask more questions, and feel more confident in a female-only environment. The impact of girls-only classes on IT career decisions remains an open issue.

Mathematics Education:

There is evidence that females lag behind males in mathematics ability and achievement. Most authors agree that males outperform females in mathematics, although women earn higher grades [Kimb89]. This male mathematical advantage exists particularly among college-bound SAT takers where there was a 35 to 46 point gender gap in mean math scores each year from 1967 through 1997 [CBO97]. However, mathematics proficiency appears to be a necessary but not sufficient factor for selection and persistence in a mathematics-related discipline. Despite their disadvantage in test scores, many women have the mathematical skill to compete successfully with men. Note that in recent years, women comprised about half of all bachelors degrees in mathematics. An important part of the problem is that women with outstanding mathematics ability and achievement major in something else. The fact that IT loses these extremely able women suggests that factors other than mathematics background are deterring women from this discipline. The NSF report "Science & Engineering Indicators - 1996" shows that mathematics proficiency test scores do not decline for girls compared to boys until sometime between ages 13 and 17, whereas the age for decline of science proficiency test scores is between ages 9 and 13. One question that we should pursue is whether the disenchantment with mathematics follows an initial disenchantment with science.

Number of CS Bachelor's Degrees:

The number of women receiving bachelors degrees in computer science has dropped dramatically since the mid-1980s; however, the number of women receiving bachelors degrees in other "masculine" disciplines such as math, physics, and engineering has increased during the same time period [Camp97]. Undergraduate women leave the computer science major at a higher rate than men [Seym97]. However, this phenomenon varies from one institution to another. Other science fields, biology for example, appear to be more "socially acceptable" to female students than IT fields. Women generally college. The salient question is “why?”

Lack of Knowledge about IT Careers:

Women often do not know what a career in computer science or computer engineering entails. Computer science and computer engineering departments need to devote some effort to reaching high school women graduates and exposing them to IT fields. A study at Georgia Tech examined freshman applications for admission. The study considered the academic discipline, gender, race, and academic qualifications of the students. A large number of poorly qualified African American and Hispanic girls apply to the Electrical and Computer Engineering Department, and the College of Computing (and not other fields); but, they are not admitted. There is speculation that they have had success working on computers in class, and have heard that computers are where the jobs are; however, they are not properly informed about the requirements for success in a degree such as computer engineering. Caucasian girls do not seem to have that misconception--they simply do not apply. The study results showed that the few who do (2.4% of the total applicants to the Electrical and Computer Engineering Department) are very highly

qualified (average math SAT of over 700) and do very well. However it is clear that for the typical middle class girl, computer engineering and computer science do not even appear on their career radar screen. The question is "why not"? Many of these students excel in math and science.

We should develop mentoring programs for girls that match them with female information technology professionals. The program could include some experiences so that the student can observe professionals in a real working environment. We should also understand how to develop parent and teacher education programs on how to work with girls in mathematics and science, how to model appropriate behaviors and attitudes toward women in science, and how to reduce gender inequities.

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Research Questions

A summary of the recommended research questions from this workshop track follows:

- Why or how has the sexual stereotyping of computer science influenced the declining proportion of women undergraduates in CS relative to other "masculine" disciplines?

- Why do female students switch out of computer science majors at a higher rate than male students?

- For students in an average elementary and middle school, does a mindset develop that, despite the fact that women are just as comfortable with computers, boys should get the IT jobs? If so, is this because IT is considered the hottest field and there might be some latent cultural bias toward encouraging males to enter the most pioneering, popular, lucrative fields?

- Have toy developers regressed in the last 10-15 years in the realm of toy stereotyping?

- Why do women with high math SAT scores tend to major in the humanities or the life sciences? Do they feel that computer science does not offer enough humanism or scope for service to the community?

- Do women, men, or both foster the stereotype of women in IT?

- Do girls (and boys) who say they are interested in IT careers around 10^{th} grade actually end up in an IT career? If not, what careers do the people who eventually hold IT jobs say they are interested in around the 10^{th} grade?

- What are the essential elements of effective teacher training programs that can change teacher perceptions and teacher behavior about women in IT? Would the change in perceptions and behavior influence student choices?

- What are ways to encourage girls' participation in computer games? Should we create better games, tie games to the curriculum, give girls opportunities to explore the games, use girls as peer tutors for the use of the games and the computers, and hold after school sessions where they can work with others to learn the games?

- Is a fear of taking risks and making mistakes a reason many women do not feel comfortable in the IT field?

- Does computer game content affect a girl's perceptions of computer use?

- Is it sufficient for girls to use computers for traditional girls' activities such as designing clothes for Barbie? Do these types of activities increase girls' interest in IT?

- Do families in which there are only female children foster more of the "exploratory" nature in girls than families where there are male children as well?

- How does the percentage of girls in different age groups that play computer games correlate to a decline in girls' interests in IT careers as they get older?

III.2 Environmental Factors: Higher Education

We summarize the results of the discussion from this cluster by presenting higher education issues relating to 1) the climate for students and 2) the climate for faculty.

Higher Education: The Climate for Students

While there is little evidence that faculty or students deliberately discourage female students, a number of research efforts have shown that aspects of the climate do impact retention rates. Factors inhibiting female retention include a lack of same-sex role models, isolation, peers, a relative lack of previous computer experience, and the lack of social relevance in curricula. The studies that produced this data, however, are only preliminary. Workshop participants were unanimous in their calls for more research. In particular, existing results are often limited to short-duration studies at single institutions. Exceptions include a longitudinal study of Carnegie Mellon University (CMU) students [Fish97], a multi-institutional pilot survey conducted by [EPA], and a comparison of retention data from 23 institutions in Virginia [Coho99]. Even these studies, which focus on Ph.D. granting institutions, ignore significant numbers of women. Further, the research results that do exist are often incomparable because of differences in target groups. Some target computer science, some computer engineering, and others target information sciences. We need to understand why women students leave IT-related disciplines. Without the solid information that such research can provide, well-intentioned efforts to increase the retention and success of women may be for naught.

We must, however, do more than merely identify environmental factors that discourage female participation; we must also know how to remedy the situation. A number of universities and colleges have attempted to improve classroom experiences of women.

Most of these efforts have been local, limited to a single department or campus. Apparently little research has been done on the effectiveness of these interventions. The research that does exist indicates that the issues are complex. The CMU study, for example, found that curricular changes adopted to address specific problems were not always effective, and the Virginia study found that departmental efforts of peer mentoring and tutoring aimed at retaining women made little difference. Again, workshop participants cited the need for more research. We need to understand what types of higher education programs and curricular changes would have a positive effect on increasing the retention of women. We should identify "best practices" and deployment strategies that could be disseminated on a national level.

Finally, a number of participants felt that it would be useful to examine other disciplines that have been successful in increasing the representation of women. These other disciplines include medicine, law, and chemistry. We need to identify barriers that are specific to IT and learn how to devise solutions that will mitigate the barriers.

While the need for further research about the student climate in higher education is apparent, workshop participants also felt that it is appropriate at this time to issue a "Call to Action" for departments based on the existing, preliminary evidence. The call should suggest eight actions, which, while improving the environment for all students, would have a greater effect on the experiences of women.

1. Departments should adapt to widely varying levels of experience among incoming students.

2. Curricula should be designed to demonstrate the relevance of the technology to real-world, social issues.

3. Students should be provided with sound career information early.

4. Departments should control teaching quality.

5. Students should be mentored.

6. Departments should look at (disaggregated) statistics and should work with students to help understand and help the students prioritize their needs.

7. Departments should increase recruitment efforts in order to balance the initial gender composition of students.

7. External groups such as funding agencies, professional societies, and accrediting agencies should provide support and pressure that encourage faculty to mentor and to make appropriate pedagogical changes.

Higher Education: The Climate for Faculty

This thread focused on environmental issues for female faculty in IT-related disciplines. There is very little research in this area. Data are scarce at the student level, but retention rates are used to document the fact that a problem exists. At the faculty level, the information is even scarcer. We know the percentages of women at each of the faculty ranks for Computer Science and Engineering Departments at Ph.D. granting institutions, but we know little else. Reliable data on faculty retention and promotion rates by gender are not available; neither is relevant "exit information" that might account for the perceived higher attrition rates among female faculty. Are there personal, departmental, or cultural barriers to the retention of women in IT-related faculty positions? Do gender-related biases in evaluating teaching or research affect promotion rates? Are there differences between departments housed in liberal arts colleges and those housed in engineering colleges? Are women given fewer opportunities for visibility or leadership? An MIT study, while not limited to IT, gives some indication of inequities [MIT], but we need to know more if calls for improvement are to be taken seriously. We need to have quantitative and qualitative data about the status of women in academia in IT-related fields. Such data will help with the development of recommendations for improving the situation and for identifying methods to persuade faculty and funding agencies to provide the resources that will increase female representation in computer science and related disciplines.

Research Questions:

1. What are the factors that promote or inhibit the retention of women in IT-related disciplines?

2. How effective are higher education programs and curricular changes aimed at increasing the retention of women in IT-related disciplines?

3. What factors that affect retention of women are specific to IT? Which factors could be ameliorated by practices that have contributed to the increase of representation of women in other disciplines?

4. What is the status of women faculty members in IT-related disciplines?

III.3 Environmental Factors: Workplace

Research on women in technology has been performed primarily through studies focusing on women in academia. It is easier to conduct this type of research in academia than to conduct studies on women in industry since universities are required to produce statistics and industry is not. In addition, NSF has traditionally focused on educational institutions. However, due to the IT worker shortage and alarming decreases of women in computer science that we see today, academia is feeling the impact of the problems industry is experiencing. Ultimately, a large percentage of computer science graduates will work in the IT industry, and computer science departments need to attract more

students; therefore, students must be made aware of the importance of the IT industry and the opportunities afforded by IT careers. It behooves NSF to undertake studies that focus on women in IT companies and attempt to influence IT companies to make changes in their policies that will attract and retain more women. We realize that these changes will not be easy since most IT companies do not keep the gender statistics that would be ideal for such studies. One source of statistics is the Department of Labor, but these statistics do not have the detail necessary for studying why women do not enter or do not stay in the IT industry. Companies must be approached individually and human resource divisions solicited. Data should be solicited from other sources such as from interviews with IT women directly through organizations such as Systers (an on-line community of women in computer science) or through collaboration with industry focused centers such as the Institute for Women in Technology in Palo Alto, California.

The issues considered in this track revolved primarily around working hours, temporary workforce, and the image of IT workers.

Working Hours

We focused on the impact that the time and inflexible hours required for IT workers have on the recruitment and retention of women. These factors impact women particularly since they are frequently responsible for taking care of children and aging family members. Many participants argued that most IT companies require or assume a 60-hour work week. One hypothesis is that in order to attract more women to IT, the workplace must have more flexible hours, not require a 60-hour work week, provide viable part-time work career options, provide telecommuting options, and provide on-site daycare facilities. We should affirm of disprove this hypotheses.

Temporary and Part-Time Workforce

The IT industry is moving towards using temporary workers rather than full time workers. This trend is impacting the quality of the IT worker in general and also the ability to attract women. Employers often hire only those who have the exact vendor-specific brand and type of training needed to solve an immediate problem. This type of hiring is often accomplished by using temporary workers until the project or problem is solved. As a result, workers are hired who may not have a college foundation to their training. They are not afforded the perks that full-time employees gain. The expectations are that the temporary worker will get the job done but will not contribute to the future of the company. Thus the company does not expend any resources to these temporary workers such as education, health care, and retirement benefits. This hiring trend may lower the quality of the IT worker and discourage women. Women tend to be attracted by the flexibility of full-time jobs that provide flex time, health care, and other benefits that allow them to manage their outside responsibilities such as children, family, and volunteer work.

Part-time workers are also very common in today's workplace. In many cases, these part-time workers are women who have taken time off of their full-time positions to take care of family or pursue other interests. We need programs to help women get back up to speed in their technical area and to find new positions. This type of program is especially needed in the IT industry where technology changes very rapidly.

IT Image

The IT image is decidedly male and anti-social (i.e., nerdy). In general, this image discourages girls and women from choosing IT as a career option. IT work is not seen as helping society or as inherently creative. One view is that programming became "dumbed down" when it was taken from a very creative activity to an assembly-line approach. For this reason, programming is seen as an activity that does not require much creativity or expression. These perceptions are not correct, and we should seek ways to change them.

Research Questions:

1. What is the correlation between the attraction and retention of women workers and policies such as flex time, telecommuting, part-time career paths, and on-site daycare? Is the possibility of a 40-hour work week a viable option for IT companies?

2. What is the effect of temporary workers on the IT industry and on women in particular? What are the differences between women and men as temporary workers, including salary, hours worked, and benefits from the temporary agency? Is there a correlation between the number of temporary workers at a company and its attraction and retention of women?

3. Why were women who are in the IT field attracted to the field? What factors influenced them to choose the IT field as a career?

4. Will online programs that allow children (K-12) to have fun with computer science related projects have an impact on career choice?

5. How can we introduce girls to everyday IT workers who do not work excessive hours, enjoy life outside of work, and have successful professional lives as well?

6. How can we raise the awareness of IT managers of the need to actively recruit and retain women IT workers?

7. How can we create and disseminate information about "how to" activities to help IT companies attract and retain women workers?

8. How can we increase the interaction of industry and academia? Most interaction with industry involves an internship relationship with a university (the university provides the interns and the company provides the jobs). We need to go one step further and integrate industry with students more directly.

9. How can we facilitate the transition of part-time workers to full-time workers?

III.4 Academic Paths

In this track, we explored the topic of women as junior faculty members. We analyzed some pedagogical variations between different fields, and we explored different approaches to IT. We also identified fields that serve as common bridges to IT.

Junior Faculty Experiences

Although this topic does not appear to fit in this cluster, the discussions that it provoked did shed light on reasons that women do or do not go into IT fields. The issue of "having time for a life" outside of work was of interest. Several strategies for coping with the challenges of the IT world emerged. One strategy is that women opt for less competitive positions, and another strategy is that women become self-employed. While these strategies may be best in individual situations, they may not offer good long-term solutions. These strategies highlight the perceptions that women must make greater sacrifices than men to succeed in the IT world.

Are these issues unique to IT fields? Are other academic areas really so different? Is part of this perception of the difficulty of life in IT just that, a perception not necessarily based on fact? It is informative to compare IT with other fields, such as medicine and law, where women are well-represented and where demands for long working hours exist. Do these fields enjoy a better support infrastructure? We note that women are not well represented at the upper echelons of these fields, and for much the same reason as in the IT field. Still, the percentages of undergraduates studying biology or pre-law and pursuing related careers are dramatically higher than the percentages of women studying IT-related disciplines.

The perceptions are not all negative. Some participants indicate that the academic career choice seems more appealing than many industry jobs that require exceedingly long hours.

Innovative Methods of Teaching IT Topics

One of the problems with attracting and retaining women to IT relates to the seemingly isolated nature of the field. There is a belief that IT is unrelated to other areas of people's lives. We should create non-traditional programs with a focus on real world applications in order to appeal to a wider audience. One example of such a program that was cited is Integrated Science and Technology offered at James Madison University. During the first two years, students take a variety of basic science courses, including an introductory computing course that includes programming using Visual Basic. During the last two

years, students increasingly specialize in one concentration area. They choose from biotechnology, environment, energy, manufacturing, IT, and telecommunications. Over one-half of the students in the program are female.

Mills College was cited as a college that offers nontraditional programs. A program, called New Horizons, prepares students for IT jobs. Another program is an MA in Interdisciplinary Computer Science. It was reported that most of the students in these programs are women. The classes tend to be small, offer a non-competitive environment, and require little formal background in mathematics or computer science.

We should assess the effectiveness of seemingly successful programs in an objective manner. The creation of new programs and the use of components of existing programs could be greatly aided by research results that assess the effectiveness of different approaches. Perhaps we already have ways of recruiting and retaining women; however, we could be wasting resources on methods that have no long-term impact.

We should define strategies to make IT-related academic programs more appealing. Some specific strategies that should be assessed include:

- IT topics related to other topics that are more compelling to the students
- IT programs structured into a number of options that accommodate different career goals
- Utilization of group projects
- Utilization of real world examples
- Use of the computer as a tool (a means rather than end)
- Job market awareness as a motivating factor
- Class size
- Specific teaching strategies

Fields that are bridges to IT

Many fields were suggested as common bridges to IT. The fields include art and design, chemistry, linguistics, math, music, nursing, philosophy, physics, printing technology, psychology, and technical writing. Since the computer is an important tool in an increasing number of fields, it appears that interest could be sparked in students in virtually any of them, especially during the early undergraduate years when few students have specific career goals. A key theme in the discussions was that IT topics should relate to other more familiar areas of interest to the students. In this way, the challenges seem related to those in the teaching of mathematics which has often suffered from similar "what's the use of this?" issues. We recommend a refurbished image and educational campaign that could help recruit women directly into IT fields, could help teachers of other fields understand the use of computing in their field, and could help make life for current IT workers more appealing.

Research Questions:

1. What factors underlie the perception that IT careers are less attractive than other career choices for women? Are such factors different in IT than other demanding fields? If so, how can we change IT academic programs and industry career paths so that they are more appealing? If these factors are not unique to IT, what caused this misperception and how can it be rectified?

2. How should we assess intervention programs?

3. How can we make IT-related programs more appealing?

4. How can we encourage students studying other disciplines to become interested in and pursue careers in IT?

5. How do students who are successful in other areas transfer their success to IT fields? What role does mentoring play? How is self-esteem involved? How can courses be designed that will widen the pipeline by encouraging women to explore IT options?

III.5 Career Paths

The discussion in this thread included the transfer to IT careers from other careers, the approach used to determine career decisions, and the impact of company benefits on recruitment and retention.

Transfer to IT Careers

We focused on actions that need to occur to facilitate the transfer of females from other fields to an IT field. Many people want to enter an IT field but do not have the resources or the family to help encourage their decision. Training courses, combined with mentoring and counseling, would work well for many people trying to re-enter the workforce. We need to understand how to structure the training courses. What topics should be included? Should these courses be housed in institutions of higher education or in vocational training? What skill set is needed for a Web Infrastructure Developer? What skill set is needed for a Data Warehouse Manager? The lack of clarity in IT career definitions is a hindrance to the development of relevant training courses.

Determination of Career Decisions

We explored whether women are reluctant to discuss career decisions. Do women tend to plan careers or do they just happen? We had divergent opinions on this issue. Arguments were made that women do in fact plan their careers while other arguments were made that in general they do not plan their careers in the same way that men do. If there is a reluctance to plan and discuss career goals, then we should pursue methods to encourage women to be more expressive of career wishes.

Company Benefits

We need more information about the relationship between benefits offered by IT companies and the desire of women to choose the company as a workplace. There are indicators that such benefits as computer technology for the home, company cell phone, and flex hours are very appealing to women, especially those women who are mothers.

Research Questions:

1. What factors lead to an IT career choice?

2. What factors contribute to a consideration to leave an IT career?

3. Why do women stay in IT careers?

4. What is the effect of male dominance of the IT workplace?

5. What is the role of mentoring in an IT career choice?

III.6 Professional Organizations

We had a low level of participation in this cluster. Most of the contributions cited examples of the types of intervention programs that professional societies are currently supporting. While the contributions were very informative, most of them do not convert directly to research questions. However, there was concern about the lack of assessment of intervention programs and the misperception of the IT profession itself. We provide the following research questions:

1. How can we assess existing intervention programs?

2. What can be done about the perceived status of IT as a profession?

IV. Workshop Findings and Recommendations

In Section III, we provided a summary of the research questions that were discussed in each cluster. From these questions, we developed recommendations for research directions. In order to eliminate duplicate recommendations across clusters, we regrouped the recommendations using the classification given in Table 6. Two factors should be considered in each of the research recommendations. One factor is that the research should emphasize the aspects of the topics that are unique to IT. The second factor is that the research should address the diversity among women, including race, socio-economic status, and ethnicity.

Table 6

Classification of Recommendations

1. **Environment and cultural issues**
2. **Pre-college IT experiences**
3. **Social relevance issues**
4. **Higher-education IT experiences**
5. **Assessment of existing intervention programs, methods, and models**
6. **Environment of the IT workplace**
7. **Characterization of the IT field**

IV.1 Environment and cultural issues

The impact of the environment on the career choices of women remains an open issue. There is evidence to suggest that environmental factors do indeed play a key role, but as yet we have been unable to measure the true effect of cultural factors on career decisions. These environmental factors, which are quite varied, include social expectations, computer games, family, ethnic values, and the Internet. The goal of the following recommendations for research support is to provide a more in-depth understanding of the impact of these environmental factors.

Recommendation 1
Conduct an in-depth, long-term study of the impact of computer games on the career choices of girls. The study should include analysis of playing patterns, game content, and creative aspects of the games.

Recommendation 2
Determine the role of social expectations, cultural factors, and ethnic values on the educational and career choices of girls.

Recommendation 3
Support research efforts to understand the influence on career choices of environmental factors such as family, peers, teachers, media, and counselors.

Recommendation 4
Conduct a study to determine the impact of the Internet on career choices of women.

IV.2 Pre-college IT experiences

If we are to attract more women to IT related fields, then it is important that early educational experiences provide accurate and positive indicators of these fields. As students progress through elementary and high school, they are exposed to courses from numerous technical disciplines. They develop a perception of areas that are appealing to them and those that are of little or no interest to them. Given the nature of computing and its increasing popularity at the elementary and high school levels, we need to understand whether computer-related course content and associated teaching styles are appealing to girls. We also need to understand the connection between the perceptions formed at the pre-college level and the eventual career choice. To better understand the impact of pre-college educational experiences on the recruitment and retention of women, we propose the following recommendations:

Recommendation 5
Investigate the impact of computer science courses in the high school curriculum on student perception of IT careers.

Recommendation 6
Support research to determine the essential elements of teacher training programs that can change teacher perceptions and teacher behavior about women in IT.

Recommendation 7
Support research to identify learning styles, teaching styles, and tools that will encourage female interest in computer-related fields.

Recommendation 8
Support research to track the relationship between female student interests at the high school level and their eventual career choices.

IV.3 Social relevance issues

Indicators suggest that one reason women do not choose IT careers is because they do not perceive such careers as socially rewarding. The indicators suggest that careers such as medicine and law have more appeal because women perceive such careers as socially valuable and thus more enticing. The following recommendation is based on the assumption that the social impact of IT careers is not promoted or well understood.

Recommendation 9
Support research that measures the social relevance of curriculum content, determines its impact on recruitment and retention of women, and identifies teaching methodologies that will promote the inclusion of the social context with the technical content.

IV.4 Higher education IT experiences

There are many factors in the higher education environment factors that impact the decision to choose an IT-related discipline. Some of the factors relate to the perception that IT disciplines are boring and lacking in creativity. We need to understand how to make IT more enticing. We should investigate whether there are methods by which we can be more pro-active in making the field appear more appealing. We should understand whether strategies such as relating IT topics to topics in other fields, providing better awareness of job potential, increasing the use of real-world examples, and employing specific teaching approaches will enhance the recruitment of women to IT disciplines. We also need to investigate specifically the potential of two-year colleges to recruit women to the IT field. Very little research has been done in the two-year college environment. We recommend the following research initiatives:

Recommendation 10
Support research to identify strategies that will make IT-related academic programs more appealing.

Recommendation 11
Support research to identify methods to attract students to IT disciplines from non-IT disciplines. Investigate the process by which students who are studying a non-IT discipline become interested in an IT discipline.

Recommendation 12
Investigate the impact of two-year colleges on the recruitment and retention of women in IT, including articulation policies.

IV.5 Assessment of intervention programs, methods, and models

Intervention programs have been in existence for many years. These programs include computer camps for girls, summer institutes, and formal mentoring programs. We have also seen degree programs that have implemented changes to encourage female participation. There are individual success stories across different environments; however, there is in general no effective way to assess the benefit of intervention programs over an extended period of time. To that end, we offer the following recommendations:

Recommendation 13
Develop techniques to objectively assess the effectiveness of seemingly successful programs that recruit and/or retain women in IT related majors and IT related careers.

Recommendation 14

Study the comparative effect of intervention programs on the recruitment and retention in IT of women in contrast to men.

Recommendation 15
Document with longitudinal studies the effectiveness of higher education programs and curricular changes aimed at increasing the retention of women in IT-related disciplines.

IV.6 IT workplace environment

In order to enhance the recruitment and retention of women to the IT workplace, several issues should be investigated. These issues, affecting both academia and industry, include career path opportunities, company policies, and working climate. Part-time and temporary workforce hiring may also have an impact. We need to understand the role of temporary workers on the long-term retention of female workers. Since most temporary workers do not receive company benefits, we need to understand whether companies that rely heavily on part-time workers are unattractive for females. With respect to part-time workers, many women find this situation appealing because they can better manage job and family commitments; however, part-time workers often have difficulty taking advantage of career advancements, particularly in a field such as IT that is changing at such a rapid pace. To address these issues, we offer the following recommendations:

Recommendation 16
Investigate the role of university policies on the retention of women faculty members.

Recommendation 17
Conduct a thorough study to provide both qualitative and quantitative information about the status of women faculty members in IT-related disciplines.

Recommendation 18
Conduct longitudinal studies that compare career paths of men and women.

Recommendation 19
Support research in both academia and industry to correlate recruitment and retention of women with workplace climate and company policies

Recommendation 20
Encourage comparison studies to determine which factors affecting retention of women are specific to IT and to identify methods to help ameliorate the impact of the factors.

Recommendation 21

Support research to examine the effect of the temporary and the part-time IT workforce on the recruitment and retention of women.

IV.7 Characterization of the IT field

There is evidence that the general status of IT as a profession is an issue that affects the recruitment of women. Professionals who choose IT careers are often stereotyped as "techies". It is important to understand the stereotypes and to educate the public about the profession itself and about the types of professionals who are attracted to the field. The field has exploded at such a pace that we do not yet have comprehensive data to suggest what aptitudes and skills are needed for successful IT careers. In particular, we do not have data that characterizes women who are highly successful in the field. Such data would provide assistance for mentors and guidance counselors who are in a position to work with women who are considering or who are already in an IT field. An educational campaign could help recruit women directly into IT fields, could help teachers of other fields understand computing as a field, and could make IT careers more appealing for current IT workers. We offer the following recommendations:

Recommendation 22
Support research that analyzes the effect of the status of IT as a profession on the recruitment and retention of women. The research should include identification of stereotypes associated with the field and techniques to mitigate those stereotypes that are not valid.

Recommendation 23
Study the impact of male-dominance in IT fields on the perceived access to IT.

Recommendation 24
Conduct studies that identify characteristics that are needed for a successful IT career. Include research that characterizes women who are successful in the IT field. Compare characteristics of women who are successful in IT fields with those who are successful in other technical fields.

VIII. Conclusion

As we enter the next millenium, the nation must address the critical shortage of IT workers. The shortage already exists, and it is projected to continue to grow during the next decade. The gap between supply and demand of IT workers requires an investment of resources devoted to research to help fill the gap in order to minimize costs associated with the IT workforce shortage. The under-representation of women in the IT workforce and in the pipeline that creates IT workers presents a specific challenge that must be addressed. To meet this challenge, the nation should adopt a research agenda that

investigates the under-representation problem from many aspects, including environment and cultural issues; pre-college experiences; social relevance issues; higher-education experiences; assessment techniques; IT workplace environment; and characterizations of the IT field. The research agenda should focus on those factors that are unique to information technology. The nation must then use the research results to proactively strive to mitigate factors that are contributing to the under-representation of women in the IT workforce.

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Appendix I
Position Papers by Cluster

1. Environmental Factors: Childhood to Precollege

As we enter the new millennium, women IT workers continue to be underrepresented. This situation poses several problems including a shortage of IT workers in the U.S., benefits of higher pay and demand enjoyed primarily by males, and inherent biases of technology developed by only one portion of the population. Young women are not choosing, either consciously or subconsciously, to engage in courses and activities that will provide them with the necessary background to pursue an IT career. Environmental factors such as family, peers, schools, media, toys and role models play significant roles in this decision.

Research shows that boys and girls begin with a level playing field in information technology interests. They tend to show equal enthusiasm and competence in computer-related activities and school classes. Yet in the upper-elementary years, a shift takes place as girls gradually lose interest in these activities. This trend seems to accelerate as girls transition into high school, college, and careers. The goal of this online discussion is to provide a set of research issues on the under-representation of women in the IT workplace that are related to the childhood and pre-college years

In the first week of the virtual workshop, we will focus on the socialization of young girls. A girl's understanding of what it means to be female begins to form at a very early age. It is shaped by the culture in which that child grows up. For instance, toys developed for girls often involve dolls and teacups, while toys developed for boys involve trucks, hammers, and small electronic devices. While some progress has been made in this area, toys marketed to boys and girls are still distinctly different. We will discuss other socialization factors including sex stereotyping of boys and girls, lower expectations for girls in general, nonfeminine stereotypes of women in IT fields, and extracurricular activities that girls engage in such as sports, clubs, and other recreational past-times.

In week two, we will discuss the role of peer pressure, role models, family, and religion in forming girls' perceptions of the information technology field. The discussion will include the role of interactions with other girls and boys, the use of technology in the home, the role of religion in defining girls' perceptions, and the impact of women role models. We also consider ways to make computer use "cool" for girls so that peer pressure can be used in a favorable manner to encourage girls to engage in information technology activities.

In the third week, we will discuss the role of media portrayals of females. It is generally accepted that the media (television, magazines, films, etc.) portrays women in a very stereotypical manner. We will deliberate ways to encourage the media to portray women more favorably and ways to alert children to media biases. For instance, the Girls Inc. website (http://www.girlsinc.org) has a feature that allows girls to provide input and rate movies based on their portrayal of females.

In week four, we will consider the impact of computer games. Industry analysts say that less than five percent of video game players are female, but recently computer game manufacturers are targeting girls as a potentially huge market. An example of the potential of this market is Mattel's highly successful Barbie Fashion Designer. However, researchers question whether computer game content also affects a girl's perceptions of computer use or whether computer use (even if that means designing clothes for Barbie) is sufficient. We will consider other topics such as the impact of software developed by women for girls and the impact of portrayals of females in computer games.

The fifth week will focus on school and curriculum issues. Research has shown that girls have a tendency to defer to boys who want to be the computer expert in technology-based collaborative learning situations. We will consider the impact of stereotypes in curricular materials and ways to inform teachers and administrators about their biases. Discussants will also consider the impact of girls-only classes and ways to increase technology participation by girls in the classroom and computer clubs.

In the final week, we review the set of research areas discussed in the previous five weeks and consider which areas could lead to the most progress in improving the representation of women in the information technology workforce.

2. Environmental Factors: Higher Education

This panel considers issues of environment in higher education as they affect both students and faculty. We will utilize two threads: Academic Environment for Students and Academic Environment for Faculty.

Academic Environment for Students

A 1982 report coined the term "chilly climate" to describe a variety of subtle classroom interactions which, taken together, make the educational experiences of female students less supportive, less instructive, and less satisfactory than those of male students [Hall82]. That report resulted in an increase in research on gender-related differences in classroom experiences as well as the creation of programs and strategies to warm the climate at a number of universities and colleges. The goal of discussions in this thread is to assess the current situation for students: Does a chilly climate in computer science, mathematics, or engineering education contribute to the under-representation of women in the IT workforce? If so, how can it be changed?

Are there climate problems specific to IT-related disciplines? Female enrollments in computer science and engineering are much lower than in many of the other sciences; computer science is alone in having a significant drop in the participation of women during the last decade. To what extent is this the result of discipline-specific climate issues? A multi-institutional survey [WEPA], for example, found female students in engineering were less confident of their abilities than male students. This disparity did not exist across all sciences. Are there additional hurdles in IT-related classrooms and labs? Do women in IT graduate programs face the same obstacles? Do they participate in research projects and receive mentoring in numbers comparable to those for men? What further research is needed to identify problems?

Are there solutions specific to IT-related disciplines? A number of universities and colleges have attempted to improve the classroom climate for women and to adopt curricular changes to increase female retention. Most of these efforts have been local, limited to a single department or campus. To what extent have they been evaluated? Which of them are most effective for women in the IT-related disciplines? How should these programs be assessed/compared? What further research is needed to identify a set of "best practices" and deployment strategies?

Academic Environment for Faculty

A closely related problem is the representation of women on the faculty of colleges and universities. According to the 1997-1998 Taulbee Survey [CRA98], women in computer science and computer engineering departments held just 16% of assistant, 12% of associate, and 9% of full faculty positions. We need senior women as teachers, advisors, and role models to convince the next generation of female students of the viability of IT careers and to provide the next generation of male students with fair and balanced views of women as colleagues. A recent Study on Women Faculty in Science at MIT found "subtle differences" in the treatment of women including lower salaries, less office space, and fewer opportunities for campus leadership [MIT]. The goal of discussion in this thread is to assess the current situation for faculty. We plan to discuss the extent to which gender-related environment issues in computer science, mathematics, and engineering departments contribute to the under-representation of women on those faculties? What can be done about it?

What do we know about the environment for female faculty in IT-related disciplines? Reliable data on female faculty retention and promotion rates are not available; neither is relevant "exit information" that might account for higher attrition rates among female faculty. Are there personal, departmental, or cultural barriers to the retention of women in IT-related faculty positions? Do gender-related biases in evaluating teaching or research affect promotion rates? What further research is needed?

3. Environmental Factors: Workplace

A key potential source of intelligent, creative, and productive people in the IT industry is women, who comprise around 51% of our society. Unfortunately, over the last decade,

we have witnessed an alarming decline of women graduating with degrees in computer science (24% at the B.S. level). The decreasing percentages of female computer science graduates are especially discouraging when other science and engineering fields are considered; specifically, every other science and engineering field has seen increasing percentages of women. According to statistics from the United States Department of Education, National Center for Education Statistics, the percentages of B.A./B.S. degrees awarded to women by other science and engineering disciplines have recently increased by 45% (engineering), 37% (physical sciences), 16% (biological and life sciences), and 10% (mathematics and statistics).

Computer science has been a key source of skilled IT workers and is thus an important consideration. However, we must ask ourselves: Why is a downward trend occurring for women in computer science? How can we reverse this trend? In addition to computer science, many women enter the IT field through alternative programs and non-computer science majors, such as re-entry programs or mathematics majors. It is crucial that we take appropriate action to bring diversity to information technology. More women must be involved in engineering, designing, and deciding how technology is to be used in our society. Such involvement will give women more economic and social power and will provide more diversity to technological progress. It will provide a mechanism for technology to be fashioned for use in the home and for purposes that benefit society as whole.

This track of the workshop includes environmental factors affecting women's interest in entering the IT workplace, characteristics of IT, and the comparison of IT disciplines with other scientific disciplines. We will discuss issues related to why women are not entering the IT field, why women who are in the IT field are leaving, how we can encourage and retain women in IT positions, and how we can shatter the glass ceiling. A key objective of this workshop is to identify courses of action and areas where industry, government, and academia can provide significant progress towards the goal of bringing and retaining more women to the IT workplace.

4. Academic Paths

The Academic Paths cluster is dedicated to exploring whether most female students come into information science through interest in another field, and whether more can be done to use female student interest in other disciplines to attract and retain them in IT departments. Specific discussion topics include:

- Identify fields that serve as common bridges to IT for women and examine why
- Analyze pedagogical differences between fields that attract women and IT fields
- Compile recruitment methods for attracting non-IT majors to IT
- Share methods of retaining women in IT courses, especially methods used successfully in other disciplines
- Gather information about programs that may help provide solutions
- Identify research directions

A journey from non-IT to IT majors often includes the following stages: curiosity about how the computer relates to the student's other interest(s), exposure to course work or research, and a decision as to whether the student likes the field. If the student decides she likes the field, she is likely to either major in IT or take a significant number of IT courses. At several key points in this scenario, mentoring and encouragement play vital roles. We share one case study that demonstrate the stages:

A female student responded to a posting for students to help with design work for an art book. She was majoring in visual art and had taken the first half of the introductory computer science programming sequence to learn more about using the computer in her artwork. She had not taken the second half of the course because she said that she felt discouraged and that the struggle was not worth it. A mentor encouraged her to participate in a summer programming project to create interactive educational applets for the Web. Two male students in the group with her were extremely confident and liked to "talk technical" all the time. She appeared to be intimidated, but she did not quit. As the summer progressed and she made steady progress, she began participating in the techy conversation and often knew more about the topics than her male colleagues did. In fact, she was the only one of the group to actually finish her project and make it usable on the web.

She felt much more confident after the summer experience and decided to take the introductory graphics programming course, even though she lacked the prerequisites. Remarkably, she did quite well in the course and was obviously a strong programmer. Her performance in the graphics course was sufficiently remarkable. When asked how she could have failed or done poorly in the introductory programming course she indicated that she had gotten an A in that course. She responded that so many people, mostly male, students seemed so much better and more confident, that she just didn't feel that she had what it would take. In the end, the student kept her art major, but she did take many computer science courses. When she graduated, she took a position as an IT professional.

This case study indicates that a strong interest in the use of the computer in a different field, such as art, can serve as a powerful motivating factor in helping female students preserve through an initial struggle with IT concepts, pedagogy, and cultural issues. A secondary lesson is that the environment of many computer science departments tends to prey on the lack of self-confidence of female students in a particularly debilitating way. Encouragement is often essential to help students make a successful transition from a field in which they feel confident to one in which their competence must constantly be proven to male colleagues.

5. Career Paths

In this cluster, we will explore the perceived and real impact of career-specific opportunities, training, and mentoring. The virtual workshop will provide a forum to help identify problem areas and to clarify those areas that hold potential for further study.

There appears to be a body of literature and data available for tracking women as they navigate from high school to college to graduate school [Camp97]. There are data relating to students in higher education at particular institutions [Coho99], [Scra98], [Fish97. However, once women enter the non-academic workforce the picture becomes blurry. The "pipeline flow" of women who hold degrees in computer science, computer information systems, or computer engineering is mixed with the pipeline flow of non-computer science, computer information systems, or computer engineering degreed women who are self taught or have learned via their experiences in the workplace.

There is a plethora of evolving IT career paths, some requiring baccalaureate or advanced degrees and others not requiring degrees. The META Group has posted on the web the table of contents for its 1999 US IT Staffing and Compensation Guide. This guide lists such IT jobs as Senior Data Warehouse Engineer, Senior E-mail/Notes Architect, Manager -- Call/Customer Interaction Center, Web Customer Support Specialist, and many more. In April 1999, the Information Technology Association of America announced that it would undertake a comprehensive, multi-faceted research program focused on the availability and qualifications of IT workers as well as the skill sets most in demand by employers today. We need a better understanding of what goes on in the IT community once a women has embarked on a career path. We want to identify factors that should be the subject of research, the results of which have potential to reduce the under-representation of women.

Are women prepared to take advantage of career-specific opportunities? Why did women select a particular career path? Is family influence a factor? What happens when a female leaves the "ivory tower" realm? Is there is a gap between the perceived ability of women and their actual performance? Where does confidence come from – degree, experience, mentor?

6. Role of Professional Organizations

This topic explores the potential impact of professional societies in areas such as education, mentoring, role models, and training. We want to focus on the role that professional organizations can play in helping increase the representation of women in the IT field. Over the past several years, organizations such as ACM-W, CRA-W, SIAM, and AWM have initiated and administered programs related to women in computing. In looking to a national research agenda, we pose the following questions:

- What are examples of professional society activities that have been aimed at increasing the representation of women in IT? Which programs have been successful? Which programs have/have not been assessed? How can assessment be done? How can successful programs be sustained, replicated, and expanded?
- In what ways does participation in professional society activities affect women's careers in IT fields?
- What unique role can professional societies play in increasing the representation of women in IT?
- What are possible research initiatives related to professional organizations and women in IT?

Appendix II

CALL FOR PARTICIPATION

Research Foundations for Improving the Representation of Women in the Information Technology Workforce Virtual Workshop

September 27, 1999 - November 5, 1999

www.cise.nsf.gov/itwomen.html

This NSF-sponsored workshop will explore issues underlying the underrepresentation of women in Information Technology (IT). The outcome of the workshop will be a comprehensive research agenda that will guide future efforts for improving the representation of women in IT-related jobs.

Projections indicate that the gap between the demand and supply of IT workers will continue to widen over the next decade. One component of a solution to closing the gap is to increase the participation of women, an underrepresented group in the IT workforce. Degree statistics show that in programs such as computer science, which traditionally have produced many IT workers, the number of women graduates has been declining since the mid 1980's. The workshop is expected to produce an agenda that will guide future research efforts toward understanding and addressing the underrepresentation of women in IT.

If you have expertise in an area that is relevant to this workshop, I encourage you to become an active participant in the online discussion. Your participation will be a valuable contribution to help identify research directions that should be included in a comprehensive research agenda.

The workshop consists of 6 discussion clusters, each led by a moderator(s):

- Environmental Factors from Childhood to Pre-College - includes topics such a cultural issues, specialization of young girls, peer pressure, media portrayals, computer games, and role models

- Environmental Factors in Higher Education - includes topics such as classroom settings, research settings, and characteristics specific to IT disciplines

- Environmental Factors in the Workplace - includes topics such as industrial culture, characteristics specific to the IT workplace, and attrition factors

- Academic Paths - includes topics such as paths to the IT workplace other than traditional IT disciplines, financial opportunities, teaching methodologies, and curriculum content

- Career Paths - includes topics such as advancement opportunities, training and mentoring

- Professional Organizations - explores the potential impact of professional societies in areas such as education, mentoring, role models, and training

As a participant, initially you will need to fill out a short registration form. After you register, you will receive an acknowledgment of your registration via email. Once you have registered, you may participate in any of the tracks that you choose. The moderators of each track will post weekly summaries to help guide the discussion and to facilitate the participation of those who join the workshop already in progress.

Please join the workshop and share your expertise!

Regards
Doris Carver,
Workshop Coordinator

Appendix III
Workshop Rules and Guidelines

In order to operate the workshop in a structured manner, we established a set of rules and guidelines by which all participants should abide. The rules and guidelines, as posted on the website, are:

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All participants must adhere to the following rules. Registration in the workshop confirms acceptance of these rules. All postings not meeting these policies will be deleted from the workshop database. The workshop coordinator, Dr. Doris Carver, has the responsibility for deleting messages and attachments. She also has the responsibility for terminating participation by individuals who fail to adhere to the rules of the Workshop. In the absence of Dr. Carver, a moderator of any subgroup discussion has the right to temporarily remove inappropriate messages from that discussion group's database.

1. Postings must be under your own name, be professional in nature, and related to the workshop discussion and goals.

3. Privacy must be respected. Postings with potentially libelous content are not allowed.

4. Messages that contain a violation of a law are not allowed.

5. Messages that advertise products or services are not allowed.

5. Harassment or personal attacks on other participants will not be tolerated.

Workshop Guidelines

1. For long messages or documents, post a brief summary to the screen then use the attachment feature to attach the document.

2. When responding comments to a previous message by embedding comments, use the symbol "+" to indicate the response.

3. Each posting should contain an informative title in the subject line.

4. All responses should be directed at the subject, not the person. Strong opinions and criticisms are not disallowed; however, make sure that such postings cannot be construed as an attack on an individual or group.

5. Post URLs and other references in the References section.

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We did not identify any violations of these rules during the course of the workshop. As a general rule, the guidelines were followed. Some participants did not use the "+" to indicate the response, making in somewhat difficult to easily differentiate the response from the original message. However, overall the guidelines were followed in a satisfactory manner.

Appendix IV
Participant Information

Participation Statistics

One of the objectives of the virtual workshop format was to reach a large number of people, either through explicit participation via postings or through raising awareness by reading the postings of others. There were 234 participants who registered. On those 234 registrants, 73 posted messages. Twenty-five of the 73 posted only one message. The average number of messages per person was three.

The participation varied greatly across clusters as shown in TableA4-1:

Table A4-1

Postings by Cluster
Cluster 1 - 64 postings (32% of total postings)
Cluster 2 - 32 postings (17% of total postings)
Cluster 3 - 33 postings (17% of total postings)
Cluster 4 - 28 postings (16% of total postings)
Cluster 5 - 32 postings (17% of total postings
Cluster 6 - 12 postings (< 1% of total postings)

Participant Demographics

We did not collect detailed demographic information; however, we obtained the following information from the registration information provided by the registrants. Not all participants provided their affiliation, and some participants are included in multiple categories. In addition, we did not proactively solicit participation outside the United States. These data, given in Table A4.2 are approximate.

Table A4.2

Participation Affiliation	
Higher Education Institutions	120
Research Laboratories	10
Industry	50
International	15
Professional Organizations/Institutes	10