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ABSTRACT

A review of the literature indicated that few empirical studies have been conducted on either what factors influence or what factors deter women from pursuing information technology (IT) careers. Much of the information that is available is anecdotal. Several studies have focused on broader areas of women in science and/or technology; however, information technology is rarely separated out as a specific field of study, possibly because it is a relatively new field. Further, most studies have focused on girls and young women in the K-12 education system. There are few studies of college women and even fewer of special populations such as re-entry women or minorities. Additional research on women's career choices relative to information technology is needed. (Contains 84 references.) (Author)

Women in Information Technology Literature Review:

Recruitment, Retention and Persistence Factors

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Abstract

A review of the literature indicated that few empirical studies have been conducted on either what factors influence or what factors deter women from pursuing IT careers. Much of the information that is available is anecdotal. Several studies have focused on broader areas of women in science and/or technology; however, information technology is rarely separated out as a specific field of study, possibly because it is a relatively new field. Further, most studies have focused on girls and young women in the K-12 education system. There are few studies of college women and even fewer of special populations such as re-entry women or minorities. Additional research on women's career choices relative to information technology is needed.

Women in Information Technology Literature Review:

Recruitment, Retention and Persistence Factors

Few women pursue careers in information technology (IT) despite training that is readily available and an abundance of high-wage, high-demand jobs. Of those who do complete IT training, many do not persist in the career field. The purpose of this literature review is to examine the factors that influence women to pursue college majors in IT (recruitment factors), persist in college majors in IT (retention factors), and persist in careers in IT (persistence factors).

In studying the factors that have contributed to the success of women in technology careers, Ashton (2000) created a model showing how a combination of factors related to the academic institutions which women had attended and personal factors interact to contribute to success. Factors were categorized as pertaining either to "institutional ecology," a term coined by Byrne (1993), or "personal ecology." Institutional ecology is defined as the environment that an institution provides, including both the physical and psychological aspects of the institution, and personal ecology is defined as the internal make-up of an individual. As virtually all factors affecting the recruitment, retention, and career persistence of women in technology fit into Ashton's schema, each section of the literature review will be organized by factors of institutional ecology and personal ecology. Because recruitment, retention, and persistence are widely interconnected, many of the factors identified will be discussed throughout the paper.

Recruitment Factors

Although some progress has been made in recruiting women into careers in technology, males who work in the technology field outnumber females four to one (Sciannamea, 1997). Majors leading to careers in technology continue to be dominated by men and young men are five times more likely than young women to choose computer science or computer engineering majors

(Cohen, 2001). According to Olsen (2000), half of college students are women, but they earn less than 20% of bachelor's degrees in computer science and computer engineering. In fact, participation has actually been dropping since 1984 when 37% of such degrees were awarded to women. According to Smith (2000), only 16% of scientists, 6% of engineers, and 4% of computer scientists in the United States are women. Women continue to pursue careers that have been traditionally associated with women, particularly within the health professions, education, and the social and behavioral sciences (Larsen, 2001). A wide variety of factors, ranging from institutional factors such as access to personal factors such as pre-college preparation, may influence a woman's decision whether or not to pursue a career in technology.

Institutional Factors

Access. One of the reasons cited by several authors (Brown, 2001; Gefen & Straub, 1997; Neuman, 1991; Roger, Cronin, & Duffield, 1999; Weinman & Pamela, 1999; Van Dusen, 2000) as a deterrent to women majoring in technology is lack of basic access to computers and software. According to Van Dusen (2000), a "digital divide" exists among various income levels, demographic groups, and geographic areas. Specific barriers to access to technology are gender, race and ethnicity, age, income, previous education, geography, household type, physical disabilities, and learning disabilities.

Neuman (1991) noted in her review of literature on computer equity that inequitable access to computers and widespread patterns of inequitable distribution of computers in schools has hampered many students, for example, by limiting access to computer labs to the more advanced students. Besides wealthier school districts having access to better technology, while more affluent students are learning programming and tool applications, socioeconomically disadvantaged students in need of remediation are learning instead to do what the computer tells them to.

Consequently, socioeconomically disadvantaged females have less opportunity to achieve equity in technology than affluent females. Finally, Neuman noted that once young women are given access to computer technology, they encounter software that incorporates stereotypes and masculine "drill and kill" teaching methods which reinforce negative attitudes about computers.

Brown (2001) attributed the lack of women and minorities in technology careers, in part, to lack of access and recommended that schools ensure that computer labs are accessible to each gender, ethnic and socioeconomic group; use software that is free of gender and ethnic bias; and review and revise equity policies periodically. According to Weinman and Pamela (1999), gender gaps in experience with and attitudes toward computer technology in K-12 classrooms reverberate into postsecondary education and the job market. In looking at how to recruit women into science, engineering, and technology majors, Roger et al. (1999) noted that the low participation of women in these majors does not begin at the point of access to higher education, but is related to historical and cultural factors that predate the decision to enter college.

Getting females interested. Crombie, Abarbanel, and Anderson (2001) explored the need for proactive recruitment strategies targeted at potential female computer science majors. Brunner and Bennett (1998) suggested that technology, as it is currently presented, is not very appealing to females, and it could be made more to interesting to women by emphasizing the more human communications aspect rather than just the retrieval of information. Olsen (2000) suggested outreach to teenage girls which focuses on teamwork, creativity and applying IT concepts to social problems. Considering that recruitment efforts begin when students are in high school, Clark (1999) recommended summer science and math programs for school age children, and Smith (2000) suggested sponsoring career fairs that include math, science, and technology professionals. Brown (2001) suggested connecting technology to the interests of females and minority students, introducing technology in middle schools, using cooperative and collaborative techniques to promote learning through social interaction, working to change social attitudes, and providing promising female students with mentors and role models.

Several authors cited the need for single-sex classes (Bowden, 2001; Crombie et al., 2001; Thom, 2001). Thom (2001) suggested that the confidence of young women majoring in traditionally male-dominated fields can be enhanced by single-sex classes and study environments. Crombie et al. (2001) recommended that such courses be offered as early as high school, especially in computer science. Bowden (2001) noted that one way to enroll more girls in computer science classes would be to offer single-sex classes, but suggested such a practice to be cost-prohibitive.

Support programs and services. Authors have long suggested the need for support services. Epps, Pisano, and Allender (1982), in looking at strategies to increase participation of minorities in medicine, emphasized the need for services such as tutoring, workshops on study skills and test-taking, mentoring via matching upperclassmen with freshmen, personal interaction with faculty and students, the provision of role models, and counseling. The National Research Council (1991) suggested several strategies to increase the number of women in science and engineering: undergraduate intervention programs that provide academic support such as tutoring or the development of study skills, "bridge" programs that serve as a transition from high school to college, recruitment and retention programs that offer scholarships, campus chapters of professional societies, offices of minority affairs and cultural centers that provide services to specific racial and ethnic groups, and offices that provide services to women.

In discussing strategies that increase the participation of college women in mathematics-related fields, Blum and Givant (1982) offered a successful program at Mills College as a model. As more men than women were prepared to take calculus upon their admission to college, the goal was to change women's avoidance of math. At the entry level, goal-oriented courses were offered along with peer-taught workshops. At higher levels, interdisciplinary courses were offered that stressed application. Students were actively involved as peer teachers and lecturers, and students received career experiences through internships. To stimulate interest in the program, career information was provided to incoming students through a brochure which included non-threatening self-placement quizzes. Orientation and group-advising sessions were held to emphasize the importance of math within various careers. A variety of career events, including panel discussions, guest speakers who served as role models and potential mentors, films, student discussions of their own experiences, and field trips, were offered in cooperation with the college's career planning center. Although the provision of such support services has face validity, empirical evidence of the value of each of these support factors was not presented.

Personal Factors

Comfort with technology. Two studies found gender differences in applying the Technology Acceptance Model (TAM), which is based on the premise that user acceptance is determined by perceived usefulness and perceived ease of use. Venkatesh and Morris (2000) studied participants' reactions to a new technology system that was introduced in a one-day training program. The reactions of 445 participants from five different organizations were measured at three points in time. Results indicated that men are more driven by perceived usefulness, whereas women are more motivated by perceived ease of use and "subjective norm," (defined as the degree to which individuals believe that people who are important to them think they should perform the behavior in question).

In studying application of the TAM and gender differences in the perception and use of e-mail, Gefen and Straub (1997) found that women rated the perceived usefulness of e-mail higher than men did, but found e-mail more difficult to use. A research questionnaire measuring self-reported e-mail use, perceived ease of use, usefulness, and social presence was sent to employees of three similar organizations in the U.S., Switzerland, and Japan, all of which had used e-mail systems for several years. The sample included managerial, professional and technical employees. A total of 392 questionnaires were returned. The researchers' hypothesis that women will perceive the social presence of e-mail to be higher than men will was confirmed ($p=.05$), as was the hypothesis that women will rate the perceived usefulness of e-mail higher than men will ($p=.05$). The authors' hypothesis that women's perceived ease of use of e-mail will be higher than men's yielded a statistically significant difference in the opposite direction ($p=.05$), and the hypothesis that women's use of e-mail will be greater than that of men was not confirmed.

Pre-college achievement. There continues to be a large gender gap in the choice of college majors by males and females (Turner & Bowen, 1999). This gap begins to appear at an early age. Boys and girls have similar proficiency scores in math and science until age nine, but girls score lower than boys on standardized science exams by seventh grade and on math exams by tenth grade ("Girls Math/Science Education," 1998).

A study by Turner and Bowen (1999) focused on the extent to which pre-college achievement in math, as measured by SAT scores, accounted for the differences in choice of major at the college level. Data were taken from the College and Beyond database of 34 colleges and universities. Analysis was completed on cohorts of students who first started college in 1976 and 1989 at selective schools, including three universities (Princeton, Stanford, and Yale), six coeducational institutions (Hamilton, Kenyon, Oberlin, Wesleyan, Williams, and Swarthmore), and three women's colleges (Bryn Mawr, Smith, and Wellesley). Findings indicated that the higher the student's math SAT, the higher the probability that he or she would major in a field other than humanities. Although the authors noted that differences in academic preparation of women and men do help explain observed differences in choice of major, they found that differences in SAT scores accounted for less than half of the total gender gap. While men generally scored higher on the SAT than women, even women with high math SAT scores were more likely to major in life sciences and the humanities rather than engineering, math, or the physical sciences. The higher the math SAT score, the more likely a woman would major in economics or life sciences rather than the humanities, but higher SAT scores did not have as large an effect on the probability of choosing engineering or physical sciences as a major. In this study, few women who had strong math ability were inclined to pursue a technical science major.

Like Turner and Bowen, Grandy (1990) found that judging from SAT scores, many highly capable students were not interested in majoring in the sciences. In looking at the SAT scores of high school seniors between 1977 and 1988, Grandy noted that even though male students continued to express more interest in math, science, engineering, and computer science than female students, the interest of males seemed to be declining in these areas while the interest of females was increasing slightly. Still, considering that fewer than 15% of females scoring at the 90^{th} percentile or above on the SAT selected a major in a highly quantitative science, many of the students who had the greatest quantitative skills chose not to use them.

Ethington (2001) also studied differences among women planning to major in quantitative fields of study. Data were taken from the College Board Admissions Testing Program's sample of 10,000 college-bound high school seniors in 1982-83, including SAT scores and information from the Student Descriptive Questionnaire (SDQ). The SDQ was completed by students when they registered for the SAT and included information on personal characteristics, family background, high school experience, and educational aspirations. Findings indicated that choice of major was affected by race, years of math and science studied in high school, perceptions of math and science ability, high school rank, and parental income. The author noted that even women who are proficient in math are less likely than males to attribute their success in math to their ability.

Crombie et al. (2001) also noted that the failure of girls to take elective computer science courses in high school may limit their career options, both in IT and in other career fields. Because positive experiences with computers are good predictors of positive attitudes toward computers, which are good predictors of future enrollment in computer science classes, Crombie et al. suggested that increasing female enrollment to having a critical number of females in computer science courses will help build positive attitudes toward computer science.

Another factor affecting the recruitment of women into technology careers is the perception that only the best students should pursue such careers. Studies show that while men with average grades enroll in college computer science programs, women with average grades are much less likely to pursue such a major (Camp, 2001). Vetter (1996) noted that self-selection plays an important role in determining which women major in traditionally male-dominated fields such as engineering, science, and business. The researcher suggested that despite having consistently higher grades than males in whatever they studied, females lack confidence in their abilities and may drop out to avoid disgracing themselves. Students might also be put off by the prerequisites for taking computing courses (Neuman, 1991) with unnecessarily high prerequisites for computer courses depriving average and slower students of computer opportunities.

The perceptions that only the best students should pursue computer careers and that males will do better in these fields begins in high schools. About 15% of college-bound seniors opt to take at least one Advanced Placement (AP) exam, but males are more likely than females to take AP exams in computer science and more likely to score "3" or higher, qualifying them for college credit or appropriate placement ("Girls Math/Science Education," 1998). According to Weinman and Pamela (1999), in 1999 only 17% of high school students taking the advanced placement exam in computer science were female.

Career decision-making. Lack of career information was cited by Brown (2001) as one reason why women do not pursue careers in technology. Crombie et al. (2001) also cited the need to provide career information about computer science to women, as did Kahle (1986). Other authors have suggested that making females aware of the high salaries in the IT field may encourage more females to pursue such careers. Bowden (2001) noted that IT careers are among the best-paying careers available, and Sciannamea (1997) noted that females now earn just as much money as the males. Turner and Bowen (1999) pointed out that women may prefer fields in which their skills are unlikely to become obsolete, as many women take several years off work to raise their children. If a woman in the computer science field takes a five-year leave of absence, her computer science skills will be outdated when she returns to the workforce, which may be why women who pursue careers in science gravitate toward the life sciences. Larsen (2001) noted that women who pursue careers in technology, in particular, must be lifelong learners, and educational equity can no longer be addressed only in regard to what happens in schools and colleges, but throughout women's lives.

Woodka (2001) objected to suggestions that long hours and lack of flexibility are scaring young women away from the IT field and pointed out that women continue to be attracted to careers in law and medicine which are just as time-consuming. Woodka did note, however, that careers in law and medicine are perceived as helping professions characterized by a great deal of personal interaction, whereas IT careers are not.

Post, Stewart and Smith (1991) studied career decision-making factors for African-American males and females. A math/science self-efficacy questionnaire was administered to a sample of 82 female and 29 male first-semester freshmen who were enrolled in an academic support course for minority students. Students rated themselves regarding educational self-efficacy, educational confidence, job efficacy, job confidence, interest, and consideration for 24 potential careers, half of which had a math/science orientation. The researchers' findings suggested that interests play a more important role in career decision–making for women, with men finding self–efficacy and confidence more important. Men choose careers they feel confident in whereas women choose careers they are interested in. Post et al. suggested that gender rather than race may be the reason African-American females are underrepresented in math and science careers.

Other authors go so far as to offer a word of caution about encouraging more women to pursue such careers because not everyone is suited for them (Farmer, Wardrop, Anderson, and Risinger, 1995). These researchers studied 173 participants, 97 women and 76 men, who had aspired to a science, math, or technology career when they were in high school in 1980. The researchers found that by 1990, only 36% of women and 46% of men had persisted in a science-related career. In fact, their findings indicated that women who had high career commitment were even more likely to switch away from careers in science, math, and technology. One suggested explanation for this was that women's career development is more complex such that career interests crystallize later in women. These authors found that career persistence among women was most related to the number of high school science courses taken and that math self–efficacy had an indirect effect on persistence, which was mediated by math–science utility.

Attitudes, interests, and personality factors. Joyce (2000) found that girls' selection of science courses may be related more to gender than academic abilities. The purpose of Joyce's study was to determine science-related attitudes, as measured by the Test of Science-Related Attitudes (TOSRA), and their relationship to the number of science courses selected by high-ability and average-ability girls. The TOSRA was administered to 55 high-ability and 55 average-ability girls ages 9 through 13. Results of the t-test indicated that there were no significant differences between the number of science courses selected by high-ability (M=2.38) and average ability girls (M=2.18), which suggests that selection of science courses may be more related to gender than academic abilities. Joyce suggested that certain childhood experiences influence the formation of future personality traits and that differences in the socialization process of young children appear to favor young boys' achievement, interest, and attitude toward science. This author noted that while some research demonstrates that high-ability girls tend to be more like high ability boys than average-ability girls, other research indicates that high-ability girls are different from high-ability boys in terms of their attitudes toward science, future participation in science, and science-related experiences.

Beyond math attitude and interest, women who choose careers in science and technology may score differently from other women on personality factors. Herbster, Price, and Johnson (1996) administered the Myers Briggs Type Indicator and the Thinking and Learning Styles for Adolescents to 71 community college science students and 119 teacher education students at a four-year university. Their findings indicated that the majority of science students were introverted, sensing, thinking, and judging. Math students scored highest in thinking, but were equally divided between introverts and extroverts.

Francis, Katz, and Evans (1996) administered the Revised Eysenck Personality Questionnaire and the Attitude Towards Computers Scale to a sample of 298 female undergraduate students in Israel who were enrolled in an introductory psychology class in their first year of a teacher education program. They found that a positive attitude toward computers was related to venturesomeness and risk-taking, both personally and professionally. These authors suggested that the significant negative correlation between extraversion scores and attitudes toward computers may be related to a preference for solitary activity and avoidance of social activities.

Saleh (2001) studied the relationship of brain hemisphericity to academic major. Participants included 402 undergraduates and 27 graduates, 66.43% of whom were female, and data were collected over a two-year period. Participants completed a demographic survey and McCarthy's Hemispheric Mode Indicator (HMI) instrument to determine brain hemisphericity. Results of the Tukey post hoc test indicated that there was a statistically significant ($p<.05$) difference between students with majors other than education, arts, literature, business, engineering, and science. Engineering/science, business, and commerce students showed a tendency toward left-hemispheric dominance while nursing, communication, and law students showed a tendency toward right-hemispheric dominance. The author suggested that students choose to study subjects that accommodate their cognitive/learning styles and understanding the concept of brain hemisphericity could give students better insights into career choices. Such an understanding could possibly decrease the number of students dropping out or changing majors because of the lack of fit between their chosen major, the requirements of certain fields, and their cognitive styles.

Cooper and Robinson (1985) studied gender differences in interpersonal characteristics and vocational identity of students in highly technical careers. The Leary Interpersonal Checklist was administered, along with a questionnaire, to 268 male and 57 female freshmen in college. The authors conducted a 2 x 2 chi-square test of vocational certainty by gender to examine the relationship of gender to certainty about vocational choice. Female students' scores indicated that they were significantly less certain of their career choices than the male students ($X^2 = 8.65$, $p<.01$). As women entering male-dominated technical careers are less certain of their career choices, the authors suggested that strategies be devised to better help women make career choices, including an expanded approach to life planning, value clarification, goal setting, decision making, and time management strategies.

Farmer, Rotella, Anderson, and Wardrop (1998) studied gender differences in science, math, and technology careers with regard to prestige level and Holland interest type. Participants were 113 young adults, 62 female and 51 male, who were followed up in 1990 from a study involving high school students in 1980. Their occupations (n=71) or college majors (n=42) in 1990 were coded for Holland occupational interest type and prestige. Gender differences were found for occupational prestige ($p<.001$) and men were 18.7 times more likely than women to be in occupations and majors with high prestige levels. The authors suggested that it is not necessary for women to give up their social interests in order to pursue high-prestige science careers, as many of them combine social interests with realistic and investigative interests as categorized by Holland's interest types.

Overcoming negative stereotypes. Overcoming negative stereotypes of the IT field has been cited as a way to recruit more females into the field. According to Woodka (2001), young girls see computer jobs as "nerdy" and to them, image is everything. To overcome this negative stereotype, Woodka suggested having IT professionals speak at schools and bringing high school girls onto college campuses to participate in hands-on training programs in which girls tear down or build computers.

According to Sylvia Paull, founder of GraceNet, a San Francisco-based network for women in technology, math and science teachers cannot get young women interested in these subjects because of the negative image of women in the IT industry (McDonald, 2001). In order to combat negative stereotypes, GraceNet started the practice of awarding DisGraceful Awards to companies who depict women negatively in advertising. One such recipient of the award was an ad by IBM which depicted two executives in an airline lounge. A man was working on a laptop with the caption, "just learned discounted cash-flow techniques with 40 other analysts," while a woman was working a crossword puzzle, with a caption that read, "just learned a five-letter word for 'belly button'" (p. 48). Another recipient of the DisGraceful Award was an ad by infoUSA.com depicting a dominatrix flogging its phone database with a whip. As some companies have pulled their ads after receiving such negative public attention, the practice helps to overcome negative stereotypes of women in IT.

Family support. Braus (1993), noted that in a study of 577 science and math graduates at Wellesley College, the likelihood of a woman staying in science goes up considerably with multiple sources of encouragement, for example, from parents and teachers. Females who received encouragement from their mothers as well as their fathers were most likely to take more science courses.

Retention Factors

Even when women are successfully recruited into technology majors, it is difficult to retain them to completion of a degree and persistence rates of women in science-related fields are significantly lower than those of men. According to Strenta, Elliott, Matier, Scott, and Adair (as cited in Seymour, 1995), the persistence rate of men in math, engineering, and science majors was as high as 61 percent at highly selective institutions, with an average of 39 percent for national samples, whereas the persistence rate of women was only 46 percent at highly selective institutions and 30 percent nationally. Camp (2001) noted that the numbers of computer sciences degrees awarded to women are decreasing, with 37.1% awarded to females in 1984, but only 26.7% awarded to women in 1998. According to Vetter (1996), women do, however, earn a greater percentage of the engineering degrees awarded to minorities and among African-Americans, women earn about twice the percentage of engineering bachelor's degrees as do women of other racial and ethnic groups.

In 1991, the National Research Council noted that in spite of data indicating the lack of enrollment and poor retention of women in science in engineering, few programs had been implemented to remedy this problem. In fact, prior to a study by the American Association for the Advancement of Science in 1991, no comprehensive studies of intervention programs targeting women majoring in science or engineering at the undergraduate level existed. The results of that study by Matyas and Malcom (as cited in National Research Council, 1991) found that although intervention programs in existence targeted primarily minorities and few targeted only women, 51% of the participants in those programs were women.

In one of the few studies of factors that increase persistence of female undergraduate students in science, Hyde and Gess-Newsome (2000) studied participants of Western University's Project Access program. Project Access, which was initially funded by the National Science Foundation, recruited approximately twenty female high school seniors who were top students and brought them to the university for an 8-week summer session prior to their freshman year of college. The objective was to acclimate students to college life and develop beneficial relationships with peers, professors, counselors, and staff while providing academic content by a different professor each week. During their first year of college, each student received a $2,000 scholarship and support services including seminars, help sessions, support groups, mentoring, and lab research. In 1995-96, the researchers studied 43 students who had been accepted into the program during its first two years of existence, 1991 and 1992. At the time of the study, seventeen were juniors, twelve were seniors, and three had graduated. Eleven had left Western University and, of those, some had transferred to other institutions while others were not attending college. All of the 43 were contacted by letter or phone and asked to participate. All 29 still attending Western University and the three graduates opted to participate in interviews about their experiences. Of the 29, twenty participated further in a roundtable discussion. Both qualitative and quantitative data were collected.

The researchers first collected and analyzed demographic and academic information on all 43 students admitted to Project Access in the first two years. Data included current status in science, changes in declared majors, high school performance records, high school science courses taken, scholastic achievement tests scores, AP test scores, high school class rank, high school GPA, high school achievements and awards, college academic history, laboratory assistantships, college GPA, and total credit hours earned. In the next phase, the researchers interviewed each participant from one to five times over a two-month period with the objective of determining critical factors in math, engineering, and science (MES) persistence. Employing symbolic interactionism, the researchers examined what interactions and events affected students' persistence including their interpretations of academic and personal experiences and relationships that impacted their success. In the final phase, roundtable discussions were conducted with 20 students to further discuss their experiences.

Results of the demographic and academic analysis indicated a consistent pattern of backgrounds and accomplishments with no statistically significant differences between the total group of 43 and the subgroups of participants in the study. Students had an average high school GPA of 3.9, ACT of 29, and 3.5 college GPA. They had taken extensive math and science courses in high school, which led the researchers to suggest that grades and high school course work may be a good indicator of success in MES disciplines in college. Of the 32 interview participants, 25 (78%) eventually graduated in a MES major, while six changed majors. Of the 25 graduates, seven (28%) indicated a desire to pursue graduate studies in MES. As the authors noted that persistence of students in Project Access was higher than persistence statistics reported for both women and men in highly selective institutions, they suggested that the program and possibly other factors at Western University had an impact on their persistence. Of specific interest were the factors that, according to the authors, have a great impact on the participants' academic success and persistence and have a high degree of potential for intervention by the institutions. These factors included personal associations, collaborative teaching methods, internships, and work-related programs.

The researchers then coded factors that increase the persistence of female undergraduate science students into three areas: school factors, external factors, and personal factors. School factors included: positive association with professors, role models, curriculum plan (tracks, good labs, study groups), lab research (related to area of interest, professor available, support, coordinators as mentors), good teaching (good explanations, problem-centered, interesting), special programs (Project Access, Minorities in Engineering, Undergraduate Research Opportunities Program), support agencies (Women's Resource Center, career services, financial aid), scholarships, on-campus living (roommates, positive association with others in same major), high-school preparation (AP classes, honors, math foundation, science fairs, gifted program), and secondary education teachers (mentors, academic foundation, confidence-building, advisors). External factors included: family support (science and academics valued, financial assistance, similar background, encouragement), work-related experience, study groups (crucial for freshman year), female friends (support network, emotional and academic), role models (family, advisor, boss, career-day speaker, or friend), and multidimensional experience (well-rounded, balanced, good perspective, open-minded). Personal factors included inclination, natural ability, confidence, determination, and career outcome.

Another author (Ashton, 1999) focused specifically on factors that contributed to the success of women in technology careers. Ashton's (1999) dissertation examined both factors related to the academic institutions which the women had attended and personal factors. She incorporated seven of the factors of institutional ecology suggested by Byrne (1993) (student, staff, and faculty acceptance; curricular conversations; mentors and role models; career counseling; support services; bridge courses; and gender neutral structure, content and curricula), identified five factors of personal ecology through a review of literature (social/cognitive barriers, self-esteem, motivation, preparation, and cultural barriers), added financial support as an additional factor, and created a model of how these factors interact to contribute to success. Ashton's qualitative study focused on eight women who had completed degrees in technology and were currently employed in the technology field. Four of the women had attended traditional universities and the other four had attended a nontraditional institution which was chosen because of its emphasis on an applied curriculum, interactivity in the classroom, and group work. All participants were interviewed twice, the interviews were recorded and transcripts were created. Data from the transcripts were then sorted by factors of institutional and personal ecology. Ashton concluded that personal ecology was the overriding reason for a woman's success in a technology field and found no evidence that women were more successful because of institutional factors.

Institutional Factors

Female-friendly environment. In order to foster the retention of females in IT majors, the perception of a supportive environment is essential. Elements of an environment that supports the learning of women include eliminating biased instructional practices, incorporating female-friendly methodologies, positive associations with professors, the absence of "weed out" classes, mentors, role models, and peer support. Instructional techniques that are especially conducive to the success of females include cooperative and collaborative learning such as small group work (Bauer, 2000; Camp, 2001; Chapman, 1993; Kruschwitz & Peter, 1995; Thom, 2001), illustrating abstract concepts concretely by incorporating hands-on experiences and demonstrating real life applications (Chapman, 1993; Jackson, 1993; Kruschwitz & Peter, 1995; Olsen, 2000; Thom, 2001), and allowing the longer response time many females need to formulate an answer (Bauer, 2000; Kruschwitz & Peter, 1995).

According to Pascarella, Whitt, Edison, Nora, Hagedorn, Yeager et al. (1997), the "chilly climate" of coeducational postsecondary institutions, which was first identified by Hall and Sandler in 1982, persists to some extent today. These authors investigated how perceptions of a chilly campus climate affected the cognitive outcomes of women in their first year of college. A total of 23 institutions in 16 different states participated, including 18 four-year colleges and universities and five two-year institutions. Out of a target sample of 5,000 students, 3,840 participated. During the initial data collection in Fall 1992, students completed a pre-college survey and the Collegiate Assessment of Academic Proficiency (CAAP). The survey included demographic characteristics and background, aspirations and college expectations, and orientation toward learning. The CAAP included three modules on reading comprehension, mathematics, and critical thinking. Follow-up data were collected during Spring 1993. The CAAP was re-administered, along with the College Student Experiences Questionnaire (CSEQ) and a follow-up instrument which had been developed by the National Study of Student Learning (NSSL) to measure a wide range of both in-class and out-of-class experiences in the first year of college. Included in the NSSL instrument were eight Likert-scale items which together constituted the "Perceived Chilly Climate for Women" scale, which yielded scores with a mean of 26.98, standard deviation of 5.48, and an internal consistency reliability of .81. Analysis of data was limited to the 1,636 women in the sample, which represented a population of the 18,129 female freshmen in the participating institutions.

Results at the two-year colleges indicated that students' perceptions of a chilly climate had statistically significant negative associations (p=.05, n=176) with end-of-first-year cognitive development and self-reported gains in academic preparation for a career. At four-year colleges, the perception of a chilly climate had a statistically significant negative association only with self-reported gains in academic preparation for a career (p=.01, n=1,460).

In a study conducted by the Higher Education Research Institute (HERI) at the University of California, Los Angeles on the influence of college environment on science recruitment and retention, five institutions were visited that had been successful in attracting and retaining women and minorities in science majors (Astin & Sax, 1996). These institutions, which were selected as they represented a cross-section of higher education, included: Johns Hopkins University, Case Western Reserve University, Albion College, Santa Clara University, and Georgia Institute of Technology. Observations from their site visits led the researchers to believe that factors contributing to the success of these institutions were a supportive campus climate, a high priority on undergraduate education, an emphasis on teaching, high levels of faculty-student interaction, and undergraduate research opportunities.

Biased instructional practices which females experience from an early age on may have an impact on retention, but most of the research in this area has focused on young girls as opposed to adult women. According to Bauer (2000), gender inequality in the K-12 classroom takes the form of females being "invisible" with teachers calling on females less frequently and interacting more with male students both during and after class, whether verbally reprimanding them, answering their questions, helping them with schoolwork or elaborating on their comments. She noted that boys tend to control conversations, ask more questions, and receive more praise and correction. Bauer also noted gender differences on the playground where girls have less access to bigger, more active toys like balls and bats, their games take up less space, and they learn to be spectators and cheerleaders for boys' games, as well as in the lunchroom where boys who sit with girls tend to be rejected by their peers. She concluded that the resulting "invisibility" leads to low self-confidence and self-esteem in girls and recommended that teachers demonstrate confidence in students, incorporate cooperative learning, allow girls more wait time when answering questions, give them equal access to computer equipment, and expose them to role models.

According to Kruschwitz and Peter (1995), a decade of research has documented that girls assimilate information differently from boys. These authors indicated that coeducational classes shortchange girls, as widespread classroom bias favors boys. To counteract this effect, they advocate "girl-friendly" techniques including cooperative and collaborative learning, peer teaching, allowing a response time of ten seconds or longer to allow girls the time they need to formulate an answer, creating a safe environment in which girls can ask questions and develop self-esteem, illustrating abstract concepts concretely by giving real life examples, giving girls hands-on experiences and the opportunity to tinker with equipment, and employing more gender-friendly metaphors in the classroom, away from war themes and more toward more people-friendly themes.

According to Drew and Work (1998), research has indicated that young females in primary and secondary-level public schools may benefit from separate but equal learning experiences, but similar research regarding post-secondary settings is less clear about such benefits. These authors looked specifically at higher education environments and found no evidence that women suffer from a "chilly classroom climate," but did find that women interact less frequently with faculty after class and during research assignments. Also, female students did not report gains as high as male students in the science, technology and quantitative skills areas.

According to Thom (2001), in order to interest young women in technology, educators need to recognize and address their learning styles and interests. This author noted that female-only labs or study environments can enhance the confidence of young women majoring in traditionally male-dominated fields and also suggested that female students do well via active, hands-on and cooperative learning experiences, teaching methods which have been found to work for males as well. Jackson (1993) noted that for females in non-traditional areas like science and math, making a connection with personal experiences is especially critical because their alienation from the subject matter is high and their self-confidence is low.

Olsen (2000) suggested that rather than having computer science classes begin with abstract concepts, discussing how computer science could be used to solve real-world problems would be more appealing to women. She also recommended that colleges develop and publicize programs that combine computer science with other fields that appeal to women, for example, psychology, biology or fine arts, and involve female undergraduates in interdisciplinary computer science research projects.

Belenky, Clinchy, Goldberger, and Tarule (1986) noted that women are more socialized to be "connected" learners. Males, on the other hand, tend to be what these authors referred to as "separate" learners. Separate learning, which is the approach found more commonly in high school and college classrooms, is more rational, analytical, impersonal, and competitive. Students attend lectures by an authority figure, listen, and do homework. In connected learning, knowledge comes from experience rather than from authority. Connected learners try to understand another person's perspective, apply classroom experiences to other areas of life, are accepting as opposed to judging, and empathetic rather than adversarial (Jackson, 1993). According to Belenky et al. (1986), women are not limited to one mode or the other. Most women in their study employed both at one time or another and some had achieved a balance between them, but connected knowing was important to virtually all of them.

Chapman (1993) also noted that women prefer "connected knowing," as opposed to "separate knowing," as their primary mode of functioning and are more oriented toward interpersonal relationships. As cooperative, small-group learning is most relevant to connected knowing, she recommended that classroom practices be revised to incorporate the concept of the classroom as a mathematical community rather than a collection of individuals. In a case study of three first-year community college females ages 18 and 19, Chapman concluded that the manner in which math is traditionally taught does not serve students whose way of knowing is more connected than separate. She suggested three ways to facilitate the learning of connected knowers in math classrooms including relevant problem text, allowing time to construct both social and mathematical connections, and being sensitive to appropriate times to intervene in discussions so as not to silence the group. Camp (2001) also suggested that faculty adopt cooperative learning techniques such as group problem-solving activities in the classroom to discourage the stereotype that computing is a solitary and antisocial activity.

Jackson (1993) focused her dissertation on how to enhance the learning environments of all female students in training institutions, but re-entry women in particular. She cited Lewis in defining re-entry as "someone who has left school to take a job or to assume family responsibilities and who is currently seeking to return to school or work" (p.4). In Jackson's study, 14 graduates of a pre-technology bridge course for re-entry women at a community college in Canada were interviewed about their experiences. Beyond recruiting more re-entry women into technology majors, the purpose of the ten-month academic upgrading or "bridge" course was to build up their math and science proficiency and enable them to return to mainstream education and training. After completion of the program, 11 of the 14 participants (78%) went on to traditional technology programs. Whereas their classroom in the bridge program was "woman-only," in the technology classes that followed, many found themselves in the opposite situation in which they were the only female, which Jackson referred to as "only-woman." Hence, these women were able to compare and contrast their experiences between the two environments.

The research was conducted over a five-month period. At the time of the study, the program had been in existence for nine years and had approximately 150 graduates. Participants were selected from a list of 40 graduates who were believed by the instructors to reside in the local area and the final sample included at least one woman from each graduating class from 1984 to 1992, with the exception of 1986. As most had kept in contact with the instructors, Jackson noted that a favorable bias probably existed toward the program and the instructors. The researcher selected 14, as that number would divide easily into two focus groups. Twelve of the participants participated in two intensive interviews which were usually less than two months apart; the other two participated in one. Nine of the 14 participants went on to attend one of two focus group discussions. The program employed two instructors, one male and one female instructor at all times, with the same female teaching for nine years with two different males. The instructors were also interviewed to provide additional data.

Judging from information obtained in the interviews, the author determined that virtually all of the women in her study would be identified as "connected learners" by Belenky et al. (1986). The author concluded that enhanced self-confidence was the primary outcome of the course and the one most valued by the participants. There was consensus that the "woman-only" aspect of the program was positive, as it helped to build their confidence upon returning to school, but participants also felt that it should be time limited, as they needed to be prepared to deal with men. Participants cited two aspects of the downside of the "woman-only" environment as too much of a focus on personal issues at times and overprotection. Their experiences in "only-woman" classrooms were a combination of isolation and too much attention. Participants also indicated that having a female instructor was no guarantee of a female-friendly environment, as individual teaching styles vary. Most of all, it was the attitude of the instructor that shaped the relationship with students. Jackson indicated that it was the combination of the "woman-only" class format plus a connected teaching/adult education approach that created the positive culture.

Etzkowitz, Kemelgor, and Uzzi (2000) advocated for changing the "weed-out" system in universities in which certain courses are designed to eliminate unwanted students through a competitive system which is especially harmful to women. These authors suggested that faculty who teach weed-out courses discourage the type of personal contact that young women came to rely upon in high school, and loss of such contact is damaging to their self-confidence. Neuman

(1991) suggested the elimination of unnecessary prerequisites in college, as they deprive average and slower students of opportunities in computer programs. Astin and Sax (1996) noted that "weeder" courses, which are often introductory courses, tend to drive students out of science, as does the competitive nature of grading on a curve.

A relationship with faculty in which students receive positive reinforcement for their ideas has been cited by several authors as critical to the success of women in technology programs (Camp, 2001; Etzkowitz et al., 2000; Flowers, 1998; Max, 1982; National Research Council, 1991). In examining how to recruit more women into technology careers, Flowers (1998) surveyed women who had made a professional commitment to technology education regarding their attitudes toward their career choice. Suggested areas for improving recruitment was to change the attitudes of male teachers in technology programs, make the climate more female–friendly, and having technology teachers help improve self–concept and build self–confidence in their students. Camp (2001) suggested that, as women who earn computing degrees usually have high grades while many males with only average grades earn degrees, faculty should give extra encouragement to females, especially those receiving average grades in their classes. Etzkowitz et al. (2000) noted that, "The system for intellectual and moral education of young men in the sciences and engineering contradicts female expectations. Young women, who worked hard in high school and used their teacher's praise and encouragement as the basis for their self-esteem become disoriented in college…"(p.53). The National Research Council (1991) noted the sometimes negative effect that non-U.S. citizen faculty and graduate students, from cultures where women are not as liberated, on the recruitment and retention of female students in science and engineering, from the undergraduate through postdoctoral levels. As early as the 1980s, Max (1982) noted that women received considerably less encouragement in math than males, even males who were majoring in liberal arts, and "these data suggest that even modest programs to encourage women to enter quantitative areas of study may have a large return. Day-to-day positive feedback from professors can be very helpful, considering that women have typically received only minimal reinforcement in the past" (p.107).

Some authors noted that textbook bias may subtly influence females to expect less of themselves in the classroom. According to Bauer (2000), some textbooks continue to depict stereotypical characteristics and behaviors of males and females. Besides being pictured less often, girls tend to be portrayed in needy positions with males offering help and are more likely to be the spectators rather than active participants in textbook pictures. Kruschwitz and Peter (1995) suggested employing textbooks in which women are portrayed as often as men. A related issue is lack of attention in textbooks to the historical importance of females. Even as textbook producers work to eradicate these inequalities, many teachers were influenced themselves by stereotypical images of the past and may unknowingly perpetuate gender inequality in the classroom.

Support Services. Beyond the female-friendly classroom environment, institutions may be able to increase the retention of women in technology majors through a variety of support services including the provision of mentors and role models, internships, career counseling, financial aid and scholarships, study groups, tutoring, and child care. Services may be provided either by specialized support departments such as women's resource centers or career development centers or as part of general student services. It is also recognized that support services may come from sources external to the academic institution.

Several authors have cited the need for women to have role models and mentors (Brown, 2001; Camp, 2001; Smith, 2000; Etzkowitz et al., 2000; Astin & Sax, 1996; Epps et al., 1982). Among the strategies that can increase the number of women and minorities in technology careers, Brown

(2001) stressed the importance of providing mentors and role models, as did Smith (2000). Camp (2001) emphasized the need for same-sex role models and the need, consequently, to hire female faculty. She also suggested inviting women as speakers on computing topics, encouraging students to participate in online female computing communities such as Systers, and paying for them to attend technical conferences for women such as the Grace Hopper Celebration of Women in Computing where they would meet professional role models. Etzkowitz et al. (2000) also cited the need for professional mentors. Astin and Sax (1996) noted that role models are among the factors that increase the persistence of women in undergraduate science education, but that women have fewer opportunities for same-sex mentoring than men. Byrne (1993) made a clear distinction between role modeling and mentoring and noted that, "much of what has been described as role modeling is no more than the actual, passive, presence of a woman. More serious is the constant and widely occurring use of the term role modeling to describe processes which are clearly mentorship" (p.88). Etzkowitz et al. (2000) advocated for providing a more supportive environment in which women in science and technology can build confidence. Rather than one-on-one contact with an advisor when there is a crisis, they suggested developing support networks including senior women students, female faculty as well as supportive male faculty, and professional mentors.

Financial support is also of particular concern to women. According to the National Research Council (1991), women do not receive the same kinds and amounts of financial aid as men, which may inhibit their entry into science and engineering majors, and suggested that increasing financial aid could increase their numbers, which would eventually affect retention of these students. As their research suggests that women who are offered financial aid at the beginning of their undergraduate education are more likely to have higher retention rates in science and engineering, they promote equal access to scholarship resources and offering women more teaching and research assistantships. College financial aid offices may discriminate against women in that women are more likely to attend college on a part-time basis than men and scholarships are generally offered only to full-time students.

Personal Factors

Pre-college preparation. Pre-college preparation has been shown to be important and Astin and Sax (1996) cited the need for women to overcome early deficiencies in their preparation. They suggested that, beyond working with local high schools to improve science preparation, colleges and universities could provide bridge programs for women that includes prep courses, reviews of new material, and discussions of how to combine a career with family responsibilities.

Whatever their preparation, research shows that females are less confident than males in their math ability. According to Odell (1998), although females score lower in math on standardized tests such as the SAT, they seem to do as well on college math placement tests, and females' grades are as good as or better than those of males in college. Males, however, have more confidence in their math ability and are generally more positive about math. Females are more likely to blame teachers for poor performance, possibly because they study more than males.

Wright, Pamler, and Miller (1996) also found that although women scored lower on math SAT scores at a variety of colleges and universities and across levels of math courses, they earned higher grades in math than males and completed their course of study with higher GPAs, discounting the usefulness of the SAT in predicting actual math performance. One researcher found the SAT to be the best predictor of course grades, with a .58 correlation noted between SAT scores and first–year college grades (Murray, 1998). Lawlor, Richman, and Richman (1997), however, found that the SAT was not a good long–term predictor of success in college. This study of students who graduated from college indicated that even though African-American students had lower SAT scores, they graduated with the same college GPAs as white students.

Campbell and McCabe (1984) studied the statistical relationship between a student's SAT scores, high-school rank, and high-school science and math background upon entrance to college and his or her success in the first year of a computer science major. The sample consisted of 256 first-semester freshman computer science majors. Of the 98 women in the sample, only 38 (39%) persisted in science and engineering majors, whereas 96 of the 158 men (61%) persisted. The authors found that the observed differences were not indicative of differences in academic achievement or potential. They suggested that differences might be due to the demands of the major, as girls are socialized to avoid demanding situations whereas boys are socialized to deal with them. In order to counteract this effect, Campbell and McCabe suggested that "overt evidence of support for women majors is probably necessary to modify social forces. With such support, sex may cease to be a significant variable in future classification models" (p.113).

Despite its popularity, the Computerized Placement Test (CPT) of the College Board and Educational Testing Service, which is administered to community colleges students at the time of admission, is also not the best predictor of math grades. Predictive validity correlations on the CPT math score with grades in General Mathematics, Arithmetic, Elementary Algebra, and Intermediate Algebra ranged from .31 to .38 (The College Board, 1993).

A poor attitude toward math has been associated with low self–concept, math anxiety, and poor math performance, but the reasons why some people develop a positive attitude toward math and others develop a negative attitude are not completely clear. Some studies have shown that attitude toward math is related to experiences with math teachers as children, with the teacher's perceived attitude directly impacting the students' attitude (Sherman, 1999). Other studies have linked math attitude to the students' perceptions of the teaching method employed (Quinn, 1997).

Socialization. Some authors attributed socialization factors to the attrition of women in quantitative fields of study (Campbell & McCabe, 1984; Seymour, 1995). In searching for reasons why high-ability women drop out of undergraduate majors in science, mathematics, and engineering, Seymour (1995) conducted a three-year ethnographic study of 460 students on seven college campuses and found a misfit between the expectations of female students in these majors and those of faculty and male peers. Whereas males are socialized to develop an intrinsic sense of self-worth, females are socialized to attach feelings of self-worth and confidence to signs, such as praise, from others that they are pleased. According to this author, "What young women bring to their experience of SME disciplines is a pattern of socialization which is entirely different from that of young men. Many aspects of SME majors, which have evolved largely to meet the needs of young men, force women into conflict with their own socialization experiences. The resolution of these conflicts is sometimes accomplished by leaving the major; sometimes by making personal adjustments to the dominant male social system. These adjustments tend to be psychologically uncomfortable, and some coping strategies provoke disapproval from other women, male peers, or both" (p. 463).

Peer factors. Peer influence has been shown to be both positive and negative. In a longitudinal study of university women from 1979 to 1987, Eisenhart and Holland (2001) found career commitment to math and science remained low or diminished during college and that peer groups and cultures play an important role in keeping women in traditional occupations. According to these authors, peers actively encourage women to see themselves as romantic partners of men, but say virtually nothing about academics or future careers. Consequently, academic work and careers are devalued and the peer culture essentially pulls them away from their career commitment.

On the other hand, Epps et al. (1982) noted that supportive peers within the same major can have a positive influence, as incoming freshmen can be matched with upper classmen in a buddy system, and upper classmen can be helpful in answering questions at orientation sessions for new students. Hyde and Gess-Newsome (2000) noted that the women they interviewed "relied heavily on the emotional support that came from knowing other MSE majors" (p.122). Some institutions such as Smith College offer official peer mentoring programs (Clark et al., 2000). In the Smith program, peer mentors receive a small stipend and six hours of training with the purpose of developing a support network for the mentors themselves, ensuring that they understand their role, alleviating their anxieties, developing their interpersonal skills, and connecting them to available campus resources.

Persistence Factors

Studies have shown a high degree of career dissatisfaction among women in IT careers. According to the Women in Technology Leadership Survey (Deloitte & Touche, 2001), which was conducted online with 1,000 male and 500 female IT professionals, 60% of women currently working in the high technology field would choose a different profession if starting out in a career today. Further, while 69% of the men surveyed indicated that they were very interested in continuing on an IT career path, only 56% of women indicated that they were. In another online survey of IT professionals, WorldWIT found that 41% of the 265 members who responded were either currently considering or had recently considered leaving their jobs (Cohen, 2001).

Barbercheck (2001) discussed two models explaining why women are less likely than men to complete degrees in science and be successful in science careers, namely, the deficit model and the difference model. According to the deficit model, there are fewer women in science because they are treated differently from men due to formal and informal structural barriers. These barriers would be considered factors of institutional ecology in Ashton's (2000) model. The difference model, on the other hand, suggests that the obstacles to a successful career lie within women themselves and are innate or result from gender-role socialization and cultural values. These obstacles would be considered personal ecology factors in Ashton's model.

Institutional Factors

Male versus female culture. Panteli, Stack, and Ramsay (2000) noted two different approaches to the equal treatment of women and men in the workplace, the sameness approach versus the difference approach. According to the sameness approach, which is the approach of liberal feminism, men and women should be treated equally, but the implication is that women should fit into men's ways of working. Radical feminism, on the other hand, promotes the difference approach which suggests that "it is by replacing masculine culture with feminine culture that women will find justice and equality in the workplace" (p.5).

Panteli et al. (2000) citing Hemenway (1995), noted that there are four forces which create discrimination and pressure for women in fields such as IT: (a) the "catch 22" that women with traditional feminine work styles, seeking consensus and team effort, are seen as less confident and capable than men, while those who emulate masculine behavior are seen as aggressive and disliked by men for not conforming to feminine stereotypes; (b) the tendency for employees to cluster with others like themselves, which is a disadvantage for women and an advantage for men; (c) the tendency by observers to hold senior males as "mental models" of success, leading women to devalue their own potential through such comparison; (d) the presence of male culture behaviors such as "harmless joking" which undermine the importance of women in the workforce (p.11-12).

The Glass Ceiling. According to Deloitte & Touche's Women In Technology (WIT) Leadership Survey (2001), 62 % of women surveyed, but only 39% of the men, believed that the glass ceiling that limits the upward mobility of women in an organization is a reality for women in IT. However, a majority of women (56%) in the survey agreed that there is greater gender equality in high technology than in other fields. Reasons cited for the glass ceiling included gender bias, sex discrimination, stereotypes, women being perceived as less knowledgeable and/or qualified than men, and a lack of women leaders in technology. In fact, 84% of women, but only 43% of men, indicated there were too few women leaders. According to a Business Week survey ("The net: A loser on race," 2001), whereas only 9.8% of CEOs at 56 top U.S. technology companies are women, 12.5% of CEOs of the 500 largest companies are women In looking specifically at women's barriers to career success, Melamed (1995a) attributed 55% of the gender gap in overall career success and 62% of the gender gap in salaries to sex discrimination. Kealey (1999), in examining gender as a predictor of career success in the high technology industry, found that the best predictor of women's salaries was mobility across organizations, whereas the best predictors of men's salaries included education and job experience, in addition to mobility across organizations. Kealey suggested that for women in IT to achieve higher salaries, they must avoid moving across organizations.

The salary issue is one aspect of the glass ceiling concept, but wage parity is high in IT compared to other fields. The National Science Foundation (2000) noted that salary inequities in the past may have led some women to believe they were not welcome in the science, math, engineering, and technology (SMET) fields. Nevertheless, although men still earn more than women in these fields, NSF (2000) attributed salary differences to differences in age, occupation, and highest degree attained. Similarly, Dalton (1999) found that although the median salary for women engineers is 13% less than men's (women earn 87 cents for every dollar men earn), women also have an average of five years less experience in the field. When experience was factored into the formula in a regression analysis, women earned 97 cents on the dollar compared to men. According to a techies.com survey of 106,000 IT professionals, women earned 92 cents for every dollar earned by male counterparts (Rupley, 2001). However, Cohen (2001) citing the same techies.com survey noted that while salaries of women essentially equal those of men during their first five years of employment, after five years women earn 8% less than their male counterparts. McGee (2000) suggested that salary differences are due, in part, to women asking for flexibility and lifestyle benefits.

Melamed (1995b) studied gender differences in career success as measured by salary and managerial level. Predictors of success that were assessed included human capital attributes, career options, and opportunity structure. A sample of 457 full-time employees, 233 women and 244 men, was taken from the British general workforce. Human capital measures included mental ability, education level, job experience, a personality profile, marital status, and parenthood. Measurements of career options included job type, occupational level, number of different employers, and the number of job titles held throughout the career. Opportunity structure was measured by unemployment rates, average regional wage, organizational size, industrial sector (public or private), organizational function (service or manufacturing), openness of internal labor market, cohort competition, job function, and occupational economic state. Results indicated that women's overall career success was due to merits, lack of domestic responsibilities, and favorable features of organizational and occupational opportunity structure. Men's career success was related to personality and societal opportunity structure. While women's salaries were related to job-relevant human capital, home environment, and micro-occupational opportunity structure, men's salaries were related only to personality.

On the other hand, salary may not be as important as other factors to career persistence. In one survey of IT consultants (Sciannamea, 1997), both males and females ranked reputation, a balanced life, technical skills, and earnings, in that order, as the most important issues in their lives. Panteli et al. (2001), found that the top four factors rated as very important in choosing jobs for women were job interest, challenge, location, and salary, with job security and career prospects tying for fifth place. The top five factors for men, which were quite similar, were job interest, challenge, salary, location, and job security. Women ranked location higher than did men, and men ranked salary higher than did women. In a WorldWIT survey of factors that women IT professionals indicated kept them from changing employers, the most important factors were "exciting work" and "gaining experience and skills," which were lumped together as one category (Cohen, 2001). In second place was the opportunity to have impact and more responsibilities. Compensation tied with a "family-like, supportive, and fun environment" for third place. Flexible work hours was ranked fourth, with owning the company ranked last (p.56).

Mentoring and support. As previously discussed, several authors have cited the need for mentoring of women in IT. In recent years, professional organizations for women in IT have been formed which provide support and offer a mentoring function, much of which is conducted online. Women in Technology International (WITI), for example, was founded in 1989. WITI's goals are to increase the number of women in key technical and management roles, help women become more financially independent and technology-literate, and encourage young women to choose careers in science and technology (Van Raaphorst-Johnson, 1997). Other such organizations include African-American Women in Technology (AAWIT), World Women in Technology (WorldWIT), and Chicago Women in Technology (ChicWIT) (Cohen, 2001).

Some corporations now offer support networks, such as Microsoft's Hoppers, for their female employees (McGee, 2000). According to Van Raaphorst-Johnson (1997), many women in IT could benefit from a support structure that includes formal or informal mentoring. Some women, however, expressed concern that "formal mentoring within a person's own management chain doesn't work well" and that "a poor mentor is worse than no mentor at all." (p.11).

Personal Factors

Success factors. Women in Technology International conducted an online poll on their website of characteristics considered to be important for professional success (Van Raaphorst-Johnson, 1997). Of the 134 respondents, 83% were women, although responses were not separated out by gender. Respondents were asked to rate which of seven factors were "very important" or "important" to professional success. Results were: analytical ability (91%), integrity (85%), communication skills (83%), creativity (82%), teambuilding skills (82%), decisiveness (81%), vision (79%), and a proven track record (67%). When asked who rated higher as a group in these skills (women, men, or both equally), results were: analytical ability (women 18%, men 17%, equal 63%), integrity (women 50%, men 6%, equal 43%), communication skills (women 62%, men 7%, equal 29%), creativity (women 48%, men 9%, equal 42%), team building skills (women 52%, men 13%, equal 33%), decisiveness (women 16%, men 41%, equal 41%), vision (women 25%, men 24%, equal 49%), and a proven track record (women 5%, men 44%, equal 49%). According to the results of this survey, women's greatest strengths are their communication skills, team building skills, integrity, and creativity. One result that stands out is that women were rated slightly higher than men on analytical ability, which would not have been expected, given what is known about women's confidence in their math abilities.

Barriers to success. The WITI survey went on to ask respondents to rate barriers as "very important" or "important" to professional success. Results indicated: lack of communication skills (87%), inability to meet business objectives (84%), unfocused thinking (81%), indecisiveness (81%), lack of strategic vision (70%), lack of creativity (62%), inability to lead (56%), and emotionalism (48%). When asked who was more prone to these characteristics as a group (women, men, or both equally), results were: lack of communication skills (women 10%, men 62%, equal 26%), inability to meet business objectives (women 10%, men 5%, equal 83%), unfocused thinking (women 21%, men 12%, equal 65%), indecisiveness (women 41%, men 15%, equal 42%), lack of strategic vision (women 24%, men 15%, equal 60%), lack of creativity (women 7%, men 44%, equal 47%), inability to lead (women 20%, men 8%, equal 70%), and emotionalism (women 63%, men 2%, equal 34%). According to these results, some of the greatest barriers to women's success in IT are the perceptions of women being emotional and indecisive. About those perceptions, respondents commented:

"Emotionalism is something I have found is not tolerated in a male-dominated work environment." (p.19)

"If a man gets angry, people don't think he's being emotional. However, if a women gets angry, they think she's being emotional." (p.19)

"I was formerly in a technical area where creativity and efforts at team-building were viewed as indecisiveness and inability to lead. I was the only female employed in a group of 8 to 12 men. I quit that job and went to another job at a company with more women in general and [also] in leadership positions. My creativity has been praised and rewarded, and I think we produce impressive products. I am so fulfilled [in my new job] that I don't mind the 12-hour days and all-nighters." (p.20)

"A woman with a product or business vision is 'dominating' and 'not a team player'; a man with the same characteristics is a 'visionary' and an 'individual thinker.' A woman who shows leadership and decisiveness is a threat; a man who does the same is a born leader. Men and women aren't really different in these characteristics, but the way they are perceived and treated is completely different." (p.20)

Career selection. In looking at gender patterns in computing-related jobs in the United Kingdom, Panteli, et al. (2001), examined factors rated by respondents as being very important in job selection. Data were taken from attitudes measured in the 1996 Computer Weekly survey on IT skills and employment issues. A total of 2236 respondents completed the survey, of which 301 (13.5%) were women. Factors that were rated as being very important in jobs included: job status (11% of males, 12% of females), responsibility (28% of males, 35% of females), job interest (79% of males, 87% of females), work environment (32% of males, 38% of females), employer reputation (26% of males, 33% of females), job security (42% of both males and females), job type (25% of males and 28% of females), sector (6% of males and 5% of females), salary (50% of males and 44% of females), fringe benefits (9% of males and 10% of females), location (44% of males and 58% of females), career prospects (40% of males and 42% of females), challenge (51% of males and 61% of females), and ongoing training (22% of males and 34% of females). Location was notably much more important to women than men as a factor in job selection in IT.

In discussing a stage model of career success, Melamed (1996) noted that, "attributes such as mental ability, education, work, experience, and being single facilitate entry to prestigious and professional jobs, and influence decisions regarding tenure and change of jobs. These career choices facilitate in turn higher salaries and achievement of higher hierarchical positions" (p.61).

Balancing career and family. Balancing work and family is a major concern for many women in the IT field (Prencipe, 2001). Even today, women who work full-time still have major responsibility for childcare and domestic work (Henwood & Wyatt, 2000), and dual-career couples struggle to balance work and childcare (Solomon, 2000). When women take career breaks to have children, employers may interpret these breaks as a lack of career commitment, and, likewise, there may be tension over women asking to work part-time at home after the birth of a child (Panteli et al., 2001).

To further their careers, some women may opt to delay starting a family. In attempting to explain why women's career attainments in science do not equal men's, Zuckerman (2001) noted the impact of marriage and motherhood and their consequences, in addition to gender differences in career commitment. Kealey (1999) suggested that in order for women to become managers, they need to delay having a family and be willing to relocate geographically.

In looking at gender equity in technology, the Gender Working Group (1995) suggested that employers incorporate policies and practices to ensure that employees are able to balance family and work responsibilities. Recommendations included job-sharing opportunities, on-site child-care facilities, flexible work hours, flexible locations, maternity and paternity leave policies that do not adversely affect career progression, as well as policies against discrimination and harassment in the workplace, and efforts to increase societal awareness of the need for greater sharing of family responsibilities.

Staying current in the field during a leave of absence from work is a concern for many career women, but is of special concern in the IT field where changes occur rapidly. In considering the development of programs to help women scientists re-enter the field after an absence, Lantz, Whittington, Fox, Elliott, and Sackett (1980) discussed four models: the retraining model which involved a practicum or internship experience; the refresher model in which women completed refresher courses on an independent study or self-paced basis; the career-advancement model which focused on increasing knowledge and skills, and eliminating structural and experiential barriers; and the prevention model which involved having women use career breaks to their best advantage by maintaining professional friendships and memberships and by continuing their reading in the field. These authors found that most women scientists who were not currently employed reported being out of the workforce in order to care for their families.

On returning to work after a leave of absence in the IT field, Doug Berg of techies.com suggested, "Many women find consulting a good way to return to work after taking time off to raise children, enabling them to test what kind of company they want to join, what the hot skill areas are, and whether they want or need new training. Independent consulting can be a great way to recapture those skills" (Murphy, 2000, p.66).

Summary, Conclusions, and Recommendations

Much has been learned from the extant research on women pursuing careers in information technology. Few women pursue careers in IT and, of those who do, many do not persist in the IT career field. Factors that impact the recruitment of women into the IT field include access; getting females interested; comfort with technology; pre-college achievement; career decision-making; attitudes, interests, and personality factors; overcoming negative stereotypes about the IT field; and family support.

Once women have enrolled in IT majors in college, many of the factors that can increase their retention are grouped under the term "female-friendly environment." These factors include: eliminating perceptions of a "chilly climate"; eliminating biased instructional practices such as calling on males more than females; incorporating female-friendly methodologies such as cooperative and collaborative learning, hands-on experiences, demonstrating real life applications, and allowing the longer response time many females need to formulate an answer; positive associations with professors; the absence of "weed out" classes; eliminating textbook bias; provision of mentors and role models; the provision of support services such as career counseling, internships, financial aid, study groups, tutoring, and child care. Pre-college preparation, socialization factors, and peer support also affect retention of women in IT majors.

Factors that impact the persistence of women in IT careers include: career dissatisfaction; male versus female culture; the glass ceiling which limits the upward mobility of women; mentoring and support; personal success factors including analytical ability, integrity, communication skills, creativity, teambuilding skills, decisiveness, vision, and a proven track record; barriers to success including lack of communication skills, inability to meet business objectives, unfocused thinking, indecisiveness, lack of strategic vision, lack of creativity, inability to lead, and emotionalism; career selection factors including job status, responsibility, job interest, work environment, employer reputation, job security, job type, sector, salary, fringe benefits, location, career prospects, challenge, and ongoing training; and women's need to balance career and family.

As few empirical studies have been conducted on what factors influence or what factors deter women from pursing and persisting in careers in information technology, there is a need for empirical studies focused specifically on IT. Of the studies that have been published, most have been conducted with a limited number of participants at a single site. It is therefore recommended that future research include a greater number of participants at multiple locations. There is also a need for studies targeting special populations including re-entry women and African American women. Given that girls' experiences with and choices regarding math and science in middle school have a great impact on future career directions, longitudinal studies which follow participants from middle school through their career entry and beyond would lend insight into factors affecting recruitment, retention, and career persistence. The number of studies on factors affecting the career persistence of women in IT is especially limited, and much of the information available is the result of member surveys completed by professional organizations in the IT field.

Consequently, empirical studies on career persistence of women in IT would be of particular value.

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