Gender and Technology in Education: A Research Review

Jo Sanders

June, 2005

An abbreviated version of this paper will be published in the *Handbook of Gender in Education,* Chris Skelton, Becky Francis, and Lisa Smulyan, editors,
Sage Publications, London, in 2006

A more extensive bibliography on gender and technology in education, prepared for this paper and in searchable and annotated format with keywords, can be found beginning summer or fall 2005 at www.umbc.edu/cwit/itgenderbib/

Please note that one keyword is "research review."

Jo Sanders is an internationally recognized authority on gender equity, specializing in workshops for educators, program development, and technical assistance to schools and organizations.

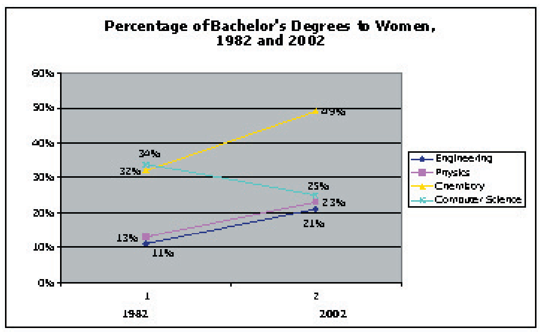
jo@josanders.com
www.josanders.com

Gender and Technology: A Research Review

Jo Sanders

In 1982, James Johnson, a freelance writer from New Jersey, published an article about inequalities in American society and its schools, optimistically entitled “Can Computers Close the Educational Equity Gap?” (Johnson, 1982). His concern was caused, in large part, by women’s low representation in the sciences. The new field of computer science (CS), though, held promise for women. In 1982 women earned a greater share of Bachelor’s degrees in CS than in engineering, physics, or chemistry. CS, unlike the other fields, didn’t have the centuries-old burden of male history, so perhaps women would be able to enter this new field more easily. (Grant & Snyder, 1986)

As it turned out, Johnson could not have been more wrong. Twenty years later, women have indeed made progress in engineering, physics, and chemistry. Computer science, however, has been another story. (Snyder, Tan & Hoffman, 2004)



While women’s representation in the other sciences rose steadily, their share of CS degrees in those years *dropped* by nearly a third.

Unfortunately, this sorry state of affairs is not limited to the United States. Women are significantly underrepresented in information and communication technologies (ICT) in most countries for which data are available, down to a level of 10 percent or less. (Charles & Bradley, 2005; ENWISE, 2004) In fact, in an analysis of data from 21 countries, researchers noted a “striking cross-national uniformity in the sex-typing of computer science programs.” (Charles & Bradley, 2005) Galpin, in her review of data from 37 countries worldwide, concludes that while women are underrepresented in CS in most countries, there is not “a clear pattern that can help to explain why the differences between men and women with respect to computing occur in some countries and cultures, and not in others.” (Galpin, 2002), p. 95) Huyer cites a Nigerian study by Ajayi and Ahbor in which women opposed ICT study because it overexposed young women to a Western lifestyle, thus endangering their chances for marriage. (Huyer, 2003)

Technology therefore earns its place as an anomaly over the past generation or two: an area in which women’s professional achievement has actually regressed, as contrasted with virtually all other areas of importance to women. In view of the growing role of technology in the world at the beginning of the 21st century — in education, communications, occupations, and entertainment, and as a tool for solving the world’s problems — women’s low and decreasing representation is a major worry.

This chapter will explore what we have learned about the intersection of gender, technology, and education: in society; age, stage and pipeline issues; experience, attitudes, and use patterns; in the classroom; and special efforts to remedy the imbalances.

As we embark upon an examination of the research on gender and technology, first a word on methodology. Several researchers have pointed out deficiencies in methods used to collect data on gender differences in computer-related behavior, resulting in inconsistent findings that may be more apparent than real. Statistically significant gender differences may not have any practical value, unstudied variables may influence students' computer-related behavior, and students' self-ratings may be especially problematic due to boys' frequently observed tendency to overestimate, and girls to underestimate, their abilities. (Bannert & Arbinger, 1996; Cooper & Stone, 1996). In reviews of the literature on gender differences in computer-related behavior and attitudes, Kay and others have pointed out methodological and construct inconsistencies that reduce comparability of studies. (Kay, 1992; Morse & Daiute, 1992) It is beyond the scope of this chapter to address these methodological issues in detail but, dear reader, consider yourself warned.

Early work on gender and Information and Communication Technologies (ICT) in education focused on a few issues that are now less relevant.

- Concerns about girls' limited *access* to computers, while well founded at the time, have receded now that schools tend to have sufficient hardware. (Anderson, Welch & Harris, 1983; Campbell & Gulardo, 1984; Sanders, 1985) Access to home computers, however, is still problematic due to competition with male family members (Gunn, 2003), important because students can get as much access to a computer in one weekend at home as in an entire year at school. (Linn, 2005)
- Concerns about girls' low interest in computers because of an association with *mathematics* have receded somewhat but not completely with girls' and women's gains in mathematics since then. (Collis, 1985b; Dambrot, Watkins-Malek et al., 1985; Gressard & Loyd, 1987; Munger & Loyd, 1989)
- Finally, concerns about college women's *physical safety* going to and from the computer lab at night have diminished as computers have become more omnipresent. (Palmer, 1989; Pearl, Pollack, et al., 1990)

In 1984 Sanders published a list of 29 "speculations" about the causes of the computer gender gap and called for research in each area. Much of the work since then has focused on issues she identified. (Sanders, 1984)

As a framework for the analysis that follows, Littleton and Hoyles posit three developmental stages with respect to gender and technology.

- Stage 1: noticing the gender imbalance at home, in school, and in attitudes.
- Stage 2: changing female participation in ICT activities through role models and collaborative groupings.
- Stage 3: challenging the dominant paradigm of ICT as culturally and historically male. (Littleton & Hoyles, 2002)

As will be seen, the majority of the research to date falls solidly into their Stage 1, with some in Stage 2. There is very little in Stage 3, although there is a good amount of published work that acknowledges the male paradigm. However, because this analysis is limited to research on gender *and technology*, it is important to remember that relevant research may exist in the related areas of science, mathematics, and engineering.

1. Societal Influences

Because gender bias pervades societies throughout the world, we can expect to find gender bias influencing girls' choices in many ways. As Vasilios Makrakis put it, "a gender-biased society teaches girls to have gender-stereotyped interests." (Makrakis, 1992, p. 285)

Parents. Parents are one source of gender stereotypes with respect to computing. In Romania and Scotland, parents had more stereotyped computer attitudes than their children. (Durndell, Cameron, et al.,

1997) In the United States, parents, especially white and high-SES parents, were found to give less computer-related support to girls than to boys (Kekelis, Ancheta, et al., 2005). Shashaani found that parents' computer stereotypes in favor of males encouraged their sons' computer involvement and discouraged their daughters' (Shashaani, 1994), and that girls who perceived their parents as believing computers were more appropriate for males were in fact less interested in computers (Shashaani, 1997). The results of another study of Iranian students echoed Shashaani's 1997 findings for American children. (Shashaani & Khalili, 2001). Finally, while not specifically about computers but relevant for our purposes, an intriguing study of family behavior in science museums found that both parents but especially fathers explained the content of interactive science exhibits three times more to sons than to daughters, even to children as young as one, while parents were twice as likely to explain the content of interactive music exhibits to daughters than to sons. (Crowley, 2000)

Media. Magazines have been reviewed for gender stereotyping and found wanting by several researchers. (Knupfer, Kramer & Pryor, 1997; Ware & Stuck, 1985). In analyzing a computer magazine written for educators, Sanders found that men were about 75 percent of people portrayed and mentioned. (Sanders, 1998) Knupfer examined computer advertisements, the Internet, television and movies and found rampant gender stereotypes about people in technical roles. (Knupfer, 1998; Knupfer, Rust & Mahoney, 1997) Hoyles wrote a good review of the literature on the stereotyped public image of computers. (Hoyles, 1988).

Race and Ethnicity. Many reports exist that students of color are afforded lesser computer opportunities than white students. (Eastman, 1995; Goode, 2005; Maxwell, 2000). Computer camps have been observed to enroll white children out of proportion to their numbers in the population. (Hess & Miura, 1985) I found two papers that specifically addressed the situation of females of color with respect to computing, pointing out that such students are subject to the double discriminatory burden of femaleness and minority status. (Edwards, 1992; Women and Minorities in Information Technology Forum, 1999) Morrell found that a day-long Saturday program for middle school girls had a stronger effect on girls of color than white girls. (Morrell, Cotten, et al., 2004). Another extracurricular program, Techbridge in California, discovered that girls were self-segregating by race and that racial tensions developed in the group. When staff tried intervention activities, it was noted that girls with lesser technical skills and lower self-confidence were at particular risk of dropping out from attempts to force them to cross racial lines. The interventions were only partially successful. (Kekelis, Ancheta, et al., 2004)

Socio-Economic Status. Often incorrectly confounded with racial/ethnic factors, studies in the United States, Australia, Iran, and the UK were unanimous in correlating high parental SES, particularly higher parental educational achievement, with greater computer encouragement of girls. (Attewell & Battle, 1999; Chambers & Clarke, 1987; Kirkman, 1993; Shashaani, 1994; Shashaani & Khalili, 2001). Children attending lower SES schools had poorer computer resources and were less likely to have computers at home. (Hickling-Hudson, 1992; Opie, 1998)

Male culture of ICT. There is a wealth of research on the male-dominated culture of computing. Among the commentators who have pointed out the negative effects of this culture on women are the Information Technology Association of America, the American Association of University Women, and the New York Times. (American Association of University Women Educational Foundation Commission on Technology, Gender and Teacher Education, 2000; Information Technology Association of America, 2003; Markoff, 1989) Thoughtful analyses of the hallmarks of the male computing culture — invisibility, exclusion, condescension, hostility, an emphasis on speed and competitiveness, and other dynamics — have been published every decade since the 80s. (MIT Computer Science Female Graduate Students and Research Staff, 1983; Seymour & Hewitt, 1997; Gurer & Camp, 2002; Margolis & Fisher, 2002) Women students speak of "the harassment of continually bumping into male egos." (Durndell, Siann & Glissov, 1990, p. 159) We are reminded, however, that "even male, experienced engineering and science students encountered computing as an alien culture," making us wonder who then is well served. (Sproull, Zubrow & Kiesler, 1986, p. 257) Elkjaer, writing of ICT in Denmark, points out that masculinity, not femininity, is the problem when boys retreat into the computer to avoid human interactions and when they consider themselves the hosts in that environment, with girls as guests. (Elkjaer, 1992)

Several researchers have indicated that the violent language of technology may be invisible to males but can be a problem for females. Consider hard disc, hard drive, reboot, cold boot, hits, permanent fatal error, and so forth. Recreational or even educational software for children often includes title words such as "attack" or "war." (Buckley, 1988; Cole, Conlon et al., 1994; Gurer & Camp, 1998; Linn, 1999; Spertus, 1991)

Students at the high school and even younger levels in the United States, Canada, and New Zealand have negative notions of the computer culture and computer enthusiasts as geeky, nerdy, social isolates who are adolescent, competitive, and exclusively focused on programming. (Johnson, Johnson & Stanne, 1985; Klawe & Leveson, 2001; Pearl, Pollack, et al., 1990; Selby, 1997). These factors have also been widely noted at the postsecondary level. (Dryburgh, 2000; Durndell, 1990; McCormick & McCormick, 1991; MIT Department of Electrical Engineering & Computer Science, 1995)

In short, one study concludes that "it is not necessarily computers and technology *per se* that females avoid, but rather the competitive, male environment that surrounds the field." (Canada & Brusca, 1991, p. 47) The male-intensive computer culture can change, however, when the proportion of women increases. This factor is discussed in Section 4, In the Classroom, below.

2. Age, Stage, and Pipeline Issues

Preschool. Gender issues in computing have been studied with children as young as three, and findings are inconsistent. Most found gender differences in preschool children' attitudes and behavior. Boys but not girls showed a preference for action-oriented software. (Calvert, Watson, et al., 1989) While preschool-age boys spent longer at the computer than girls, girls' computer use increased with time. (Bernhard, 1992; Currell, 1990) In New Zealand, three- and four-year old boys considered computers to be for boys while girls thought they were for both boys and girls. (Fletcher-Flinn & Suddendorf, 1996) One study found that boys viewed the computer as masculine but girls saw it as feminine (Williams & Ogletree, 1992), while another early study found no gender stereotyping among preschoolers at all. (Beeson & Spillers, 1985)

Gender Differences by Age. Most but not all studies have found that gender differences in attitudes and behavior are relatively small at younger ages but increase as students become older. (Hattie & Fitzgerald, 1987; Kirkpatrick & Cuban, 1998; McCormick & McCormick, 1991; Reece, 1986). Twelfth-grade girls in Canada and in China showed a decline in computer attitudes when compared to eighth-grade girls. (Collis & Williams, 1987) A study of college students showed no gender difference by age of student, but this may have been due to the short age span involved. (Koohang, 1986) In contrast, a study by the U.S. Department of Education found that use patterns did not change from elementary to high school. (Freeman, 2004) Another study found gender differences in age which were due more to computer experience than to age. (Dyck & Smither, 1994) On the whole, however, effect sizes in studies on age were larger for older students than for younger ones. Whitley, in a review of 82 studies, concluded: "[G]ender differences in attitudes toward computers result from socialization processes: the longer that children are in school, the greater the gender difference becomes." (Whitley, 1997, unpaginated copy) He noted, however, that such differences were smaller for college-level students and speculated that perhaps young women with more positive computer attitudes were more likely to go to college.

Pipeline Issues. The term "pipeline" refers to the trajectory from taking computer courses in high school on through college or graduate school and into ICT careers. Certainly the status quo, in the United States at least, gives no reason for complacency: a 2004 survey of college freshman revealed that 88 percent of students who intended to major in computer science were male. (College Entrance Examination Board, 2004). A 2005 study found that the proportion of women in the U.S. considering a CS major "has fallen to levels unseen since the early 1970s." (Vegso, 2005)

The researcher most associated with identifying the factors in the loss of females in computing from high school through careers is Tracy Camp, who suggests many causes for the "leaky pipeline". (Camp, 1997a, 1997b, 2000; Gurer & Camp, 1998, 2002) One cause frequently mentioned for the loss of women along the pipeline is lack of accurate information about ICT careers (Chan, Stafford, et al., 2000; Goode, Estrella, & Margolis, 2005; Jepson & Perl, 2002; Kekelis, Ancheta, et al., 2005). Closely related is the prevalence in many students' minds of negative stereotypes about computer workers. (Clarke & Teague, 1996; Culley, 1998; Klawe & Leveson, 2001) Sanders and Lubetkin remind us to include technician-level occupations in pipeline considerations, since most women are not college educated. (Sanders & Lubetkin, 1991)

This entire chapter is, in a sense, an explanation for the "leaky pipeline" for women in technology. However, several writers have offered additional reasons: family balance problems (Pearl, Pollack, et al., 1990), the use of freshman courses to weed out students (Bohonak, 1995), and less financial support than men have (Leveson, 1990). A particularly interesting theory comes from the analysis of data from 21 countries: women's ICT representation tends to be relatively high in countries that score low as liberal egalitarian societies. They speculate that in countries where women have a freer choice of careers, gender stereotypes lead them to make stereotyped career choices, and that "[R]estrictive government practices that minimize choice and prioritize merit may actually result in more gender-neutral distribution across fields of study." They conclude that sex segregation in computing is linked to "deeply rooted cultural assumptions about gender difference." (Charles & Bradley, 2005)

Two projects have focused on helping adult women change careers into IT. A bridge program was formed for adults with bachelor's degrees in other areas. (Davies, Klawe, et al., 2000) In a project conducted in Massachusetts, it was found that IT workers were doing the same work regardless of the educational path they had taken to get there, and that women were more likely to have gotten there because they learned programming from being shown rather than by reading programming books. (Campbell, 2004). A fascinating survey of women's career paths to IT positions found that women followed multiple academic routes. In fact, only 12 percent of them had earned undergraduate and graduate degrees in computer science, and a full two-thirds had not majored in computer science as undergraduates. (Turner, Bernt & Pecora, 2002)

3. Experience, Attitude and Use Patterns

Experience. An overwhelming majority of studies have found that boys have greater computer experience than girls, and in many countries: the United States, Australia, Norway, Canada, England, Scotland, Israel, Iran, and in multi-country studies. Boys have an edge in home computer use, school computer use, computer course-taking, games, and in free-time exploratory use. Of these, games and free-time exploratory use are most frequently cited as the primary causes of boys' greater computer experience. Computer course-taking in high school in the U.S. was roughly equal until 1994; however, the latest data (for 2001) show that it is more unequal now, favoring boys, than at any time since such data were collected in 1982. (Snyder, Tan & Hoffman, 2004, Table 137)

A few studies, however, have not found greater male computer experience. In 1992 Liu and colleagues found that girls had more prior computer experience than boys. (Liu, Min & Phillips, 1992) Other studies found negligible or no differences in experience. (Freeman, 2004; Whitley, 1997) Robin Kay, in a review of 38 studies, found that males had more experience in 30 studies, females in four, and no difference in four. (Kay, 1992) In the United States, student computer use (as opposed to course-taking) is now for the most part equal (Snyder, Tan & Hoffman, 2004), with the following exceptions: use of the Internet for educational purposes is equal until college, at which point females use it more than males (Table 426); non-Internet computer use for school purposes is equal until college, at which point males use it more (Table 429). A recent study in Scotland found that college women were less likely to own a computer than their male counterparts. (Gunn, 2003) This may be due to unequal financial resources.

Beyond overall experience patterns, several studies have had particularly interesting, although inconsistent, results. When first-year college students were randomly assigned to a writing course with required or optional (optional meaning computers and instruction were readily available) computer use, females' computer use levels by the end of the course were higher in the computer-required condition than for females in the optional condition or for males in either condition, suggesting that requiring the use of computers may be beneficial. (Arch & Cummins, 1989) A large number of children in grades 4 to 10 were surveyed annually for three years. The more experienced the students became with computers, the less confidence they had in their computer skills, and this was particularly true for girls. The authors conclude that experience alone will not close the computer gender gap. (Krendl, Broihier & Fleetwood, 1989) In most studies dealing with experience and attitudes, though, greater experience tended to result in improved attitudes. When children ages 10 to 15 were surveyed about their computer experience, girls indicated about the same number of hours per week as boys when they completed the questionnaire in same-sex groups but significantly less time when in mixed-sex groups. (Cooper & Stone, 1996)

In a well known effort to increase women's CS enrollment at Carnegie Mellon University, it was observed that foreign women tended to have less computer experience than American women — sometimes none at all — but nevertheless persisted because of economic and pragmatic realities. (Margolis & Fisher, 2002; Margolis, Fisher & Miller, n.d.-b) Gurer and Camp have pointed out that when instructors in prerequisite courses for ICT majors in college discover that women have not had extensive computer experience, they erroneously infer the women's lack of ability or interest which presumably leads to differential treatment in class. (Gurer & Camp, 2002)

<u>Attitudes</u>. There has been more research on attitudes about computers, by far, than about any other topic, and perhaps more confusion as well. Published studies number literally in the hundreds, using dozens of home-grown as well as validated instruments. Definitions are not reliably consistent; even the term "computer" means different things to preschoolers than graduate students. Volman and Eck have pointed out that gender differences in computer attitudes are both a cause and a consequence of gender differences in ICT participation and performance. (Volman & Eck, 2001) Within these constraints, I will summarize the highlights here.

Liking and Interest. With some exceptions, many studies and in many countries find that boys have more positive feelings about the computer than girls — boys tend to like computers more and are more interested in them. Again with some exceptions, many studies find that the level of computer experience correlates with liking and interest. Typically, studies find that computer liking and interest decrease with age for both girls and boys but more strongly for girls. (Gurer & Camp, 2002; Lage, 1991; Shashaani, 1993; Whitley, 1997) Krendl found that while girls' attitudes decrease with age, their sense of computers' value and usefulness increases. (Krendl, Broihier & Fleetwood, 1989) In a 1999 meta-analysis of 106 studies, Liao found that males had slightly more positive computer attitudes (Liao, 1999), while another study established that girls' and boys' computer attitudes were equal when the factors of experience and gender stereotyping were removed (Colley, Gale & Harris, 1994). Computer attitudes were seen to correlate with math attitudes (Shashaani, 1995), and were affected by socio-economic status in a study linking lower-SES girls with high computer liking. (Miura, 1987) Margolis and her colleagues have explored computer interest in several studies, finally concluding that in the "nexus of confidence and interest" (Margolis, Fisher & Miller, 2000, p. 7), a female's loss of confidence in her computer abilities precedes a drop in her interest in computers. (Margolis & Fisher, 2000) In many studies boys invariably saw computers and computer skills as male-associated; females differed, seeing them as male or neutral or, in a few cases, female.

Comfort and Confidence. By and large, studies find that females' comfort level with computers increases (and anxiety decreases) with experience. I found several studies that examined the relationship of computer confidence with masculinity or femininity as measured by the Bem Sex Role Inventory, and all five agreed that positive computer attitudes correlated with high masculinity for both males and females, not with maleness *per se*. (Brosnan, 1998a, 1998b; Charlton, 1999; Colley, Gale, & Harris, 1994; Ogletree & Williams, 1990) Another determined that girls scoring high-feminine were drawn to Web sites by their appearance, while high-masculine girls were drawn by their content. (Agosto, 2004)

Some studies found that males' and females' confidence in their computer ability was equal (DeRemer, 1990; Dyck & Smither, 1994; Houle, 1996; Jennings & Onwuegbuzie, 2001), but most found females' confidence level significantly lower than that of males even when females were more successful than the males in the class. (Gurer & Camp, 1998; Selby, 1997; Shashaani, 1997) Girls with lower confidence are likelier to drop out of computer programs (Kekelis, Ancheta, et al., 2004). Parental encouragement correlates with confidence for both girls and boys, but boys receive more of it. (Shashaani, 1994; Shashaani & Khalili, 2001) Girls had lower confidence in their computer skills in studies conducted in Hong Kong (Lee, 2003), Australia (Lee, 1997; Ring, 1991), New Zealand (Selby, 1997), and in a 20-nation study (Reinen & Plomp, 1993). In the United States in a huge annual survey of incoming college freshmen, the gender gap in computer confidence was wider than it had ever been in the 35 years of the survey, with males twice as likely as females to view their computer skills as above average. (Sax, Astin, et al., 2001) A recent approach to boosting females' computer confidence, however, is "pair programming," discussed in Section 4, In the Classroom.

Anxiety. There is also a healthy literature on computer anxiety, although it seems to have wound down a bit. Most studies have found computer anxiety higher in females than in males, at all ages and in many countries. One study found that females who dropped out of computer courses had higher computer anxiety than those who stayed, but that males who dropped out had *lower* anxiety than those who stayed. (Nelson, Weise & Cooper,1991) Another, following students for three years, found girls more anxious than boys in grade 7, equal in grade 9 and lower in grade ll. (King, Bond & Blandford, 2002) Examining survey results of incoming college freshmen from 1992 to 1998, it was found that over the years the males became less computer-anxious while the females became more so. (Todman, 2000) Whitley determined that prior experience did not mediate gender differences in anxiety, but that anxiety mediated gender differences in computer behavior. (Whitley, 1996)

Self-Efficacy. The final computer attitude to be examined here is the self-efficacy, competence, skill, and aptitude cluster. The overall conclusion from the research is that females consistently under-estimate their technology skills regardless of what their skills really are. Betty Collis memorably referred to girls' tendency to deprecate their own skills but assert confidence in females' skills in general as the "I can't, but we can" paradox. (Collis, 1985a) This theme was heard again in Japan (Makrakis, 1993) and in the U.S. nearly 20 years later. (Shashaani, 1993) Several authors consider that males who denigrate females' computer skills are a source of females' low self-confidence. (MIT Computer Science Female Graduate Students and Research Staff, 1983; Temple & Lips, 1989; Wasburn & Miller, 2005) Any discussion of females' computer competence must be filtered through Henwood's astute perception about the minority of women in university-level computing programs who see themselves, and are seen by men, as exceptional "and therefore, by implication, different from the majority of women, who are thereby rendered incompetent and outsiders in technological culture. … [T]he task of changing the outcomes of women's education in computer technologies is more complicated than simply teaching them how to use computers. … It is also necessary to change how the women (and the men around them) understand and talk about the presence and competence of women." (Henwood, 1999, p. 24 and 25)

Nearly a decade of surveys in the UK of university students from the mid-80s to the mid-90's revealed that women continued to believe they had deficient computer skills, despite an increase in everyone's computer skills. (Durndell & Thomson, 1997) In South Africa, female university ICT students predicted they would receive lower grades for the course than males; in reality they received quite similar grades. (Galpin, Sanders, et al., 2003) A review of 32 studies on gender and computer aptitude, skills and abilities found that males performed better than females in 14, equally in 13, and less well in five. (Kay, 1992) In a university where all students have their own laptops, students used them similarly but females still rated their skill levels lower than males. (McCoy & Heafner, 2004) Young found that middle-school boys had more confidence in their computer skills despite their teachers' deliberate encouragement of girls, despite the girls' disbelief that computers were for boys, and despite the boys' feeling that teachers did not take their interest in computer careers seriously. (Young, 1999)

To end this discussion of attitudes, Brosnan in a 1994 research review of "computerphobia" concluded that there is no agreement among researchers about the relative strength of attitude, experience, and related factors to account for females' and males' computer behavior. (Brosnan, 1994) More than ten years later, I would concur but would go further: there isn't even agreement about the meaning of the terms and concepts involved.

Computer Use Patterns. The first programmers were eighty women (their job title was "computers") who calculated ballistics trajectories on the ENIAC computer during World War II at the University of Pennsylvania. (Women in Technology International, 1997) Since then, however, *programming* has become a male enclave with high school, college, and graduate programming enrollments primarily male. As early as 1983 this was noted with concern. (Anderson, Welch & Harris, 1983; Bakon, Nielsen & McKenzie, 1983) One barrier to female programming enrollment is the negative stereotype of the geeky computer nerd, discussed at the beginning of this chapter. Another is that many females erroneously believe that computer science is nothing but programming, an unpleasant prospect to them. (Fisher, 1997; Margolis & Fisher, 2002) Female under-representation in programming is still a cause for concern because there is a correlation between taking programming in high school and persistence in CS in college. (Nelson, Weise & Cooper, 1991) Programming experience was found to be four times more predictive of CS success in college for women than it is for men (Taylor & Mounfield, 1994), and that knowledge of applications alone without programming had no predictive value. Despite females' programming under-enrollment, two empirical studies have found female superiority in programming tasks. (Ayersman & Reed, 1995; Mandinach & Linn, 1987) In one study, all the girls taking a high school programming course had male relatives in technical jobs. (Goode, Estrella & Margolis, 2005)

Advanced Placement Courses. The Advanced Placement (AP) program in the United States gives college credit to students who pass advanced courses taken in high school. Female participation in the computer science AP exams on programming languages (e.g., Pascal, C++, and now Java) has decreased substantially since their start in 1984. (Stumpf & Stanley, 1997) Recently it was shown that girls who achieved highly in mathematics were less likely than boys with similar scores to enroll in AP computer science courses and received lower scores on the AP exams. (Sanders & Nelson, 2004)

Games. As the focus of this book is education I will not cover computer games in any detail other than to say that dozens of studies have established boys' overwhelming primacy in this area. (Cassell & Jenkins, 1998; Goodfellow, 1996) Boys tend to play games starting at young ages and for long periods of time, and persist in game-playing as they get older; girls tend not to follow these patterns. Many observers have speculated that this early male advantage at games produces confidence with the medium and eventually translates into male primacy in ICT as adults, but there has been no research support for this as yet.

Telecommunications. The Internet presents quite a different picture. In the United States, use of the Internet in 2001 (the most recent data available) was roughly equal by students of all ages in school, with a slight male advantage at younger ages and a slight female advantage beginning in high school. (Snyder, Tan & Hoffman, 2004, Table 426) At home, Internet usage remained roughly equal until graduate school, when females had an advantage. (Snyder, Tan & Hoffman, 2004, Table 428). One disturbing note is that 82 percent of applicants to higher education institutions who applied online were male, while the proportion by sex was more equal with paper applications. (Hirt, Murray & McBee, 2000)

Distance Learning. Evidence here is contradictory, with some showing positive and some negative results for women in distance learning. Two studies indicated that females do better in electronic learning environments, or at least prefer them, than in face-to-face classrooms (Hsi & Hoadley, 1997; Leong & Hawamdeh, 1999) One study found that online academic discussions equalized female and male contributions. (Linn, 2005) In New Zealand, women performed better online than in a classroom environment in a Web design course. (Gunn, 2003) More women posted more frequently than males in an online chemistry course, significant in part because frequency of posting correlated positively with course performance, especially for women. (Kimbrough, 1999) Others found nonexistent or tiny gender differences in online behavior. (Atan, Sulaiman, et al., 2002; Atan, Azli, et al., 2002; Davidson-Shivers, Morris & Sriwongkol, 2003; Ory, Bullock & Burnaska, 1997)

Some evidence shows negative results for distance learning. Roy and colleagues found that females preferred classroom learning to the electronic version. (Roy, Taylor & Chi, 2003) Males' unpleasant online behavior discouraged female participation. (Herring, 1992, 1999, 2000). Researchers in the U.S., the UK, and Australia found gender-role stereotypes, sometimes including outright hostility, reproduced in an online environment. (Barrett & Lally, 1999; Cook, Leathwood & Oriogon, 2001; Myers, Bennett & Lysaght, 2004 respectively) In the Australian study the instructor declined to deal with male online hostility despite repeated requests from female students. Family considerations entered in when women did their online coursework later at night than men and when women reported they had less access to computers than men because of the need to share it with others in the family; grades, however, were equal. (Gunn, 2003) There is a recognition that online instructional designers need to understand the pedagogical needs of many women. (Campbell, 2000; Knupfer, 1997)

Software. The very existence of software "for girls" confirms that software is indeed for boys. Early on it was clearly seen that software was designed by males for males. (Kiesler, Sproull & Eccles, 1983) Software developed for girls has been based on common gender stereotypes: "shopping, makeup, fashion, dating," (Rubin, Murray, et al., 1997, p. 1) and described as "saccharine, boring, and stereotyped." (Manes, 1997). Software titles for girls "perpetuate sexism and serve only to enrich the companies that produce them." (Linn, 1999, p. 16) Sexism in software occurs in characters, content, reward systems, and structure. (Bhargava, Kirova-Petrovna & McNair, 2002) In an empirical study, Cooper and Hall showed that middle-school girls who used violent math software had more anxiety and lower math performance than girls who used verbally based math software, and more than boys using either type. (Cooper & Hall, 1986)

Math software has repeatedly been shown to feature male characters, but this line of research peaked about ten years ago. (Chappell, 1996; Hodes, 1995) According to Joiner, however, the sex of the main character made no difference to children (Joiner, Messer, et al.,1996), and Littleton and colleagues found the intrinsic interest of the software more influential with children than the sex of the main character. (Littleton, Light, et al., 1998) Teacher intervention has been shown to be effective in correcting children's frequent assumption that ambiguous software characters are male. (Bradshaw, Clegg & Trayhurn,1995)

Teachers, females and males alike, play a helping role in stereotyped software. When asked to evaluate educational software, teachers identified gender bias only when specifically asked to look for it and even then only sporadically. (Rosenthal & Demetrulius, 1988) When teachers from grade 1 through college were asked to design software for girls, boys or students, they designed tool software for girls and game software featuring violence and competitiveness for boys and students. (Huff & Cooper, 1987) Fifteen years later the repeated experiment obtained exactly the same result: "[w]e conclude that it is not the computer, or even the software, that is at the root of the sex bias in software, but the expectations and stereotypes of the designers of the software." (Huff, 2002, p. 519)

There has been little recent research on gender and software. It is not clear if this is because current educational software makes a gender analysis irrelevant or if the topic has merely dropped out of fashion.

4. In the Classroom

Peers. Several empirical studies revealed substantial gender stereotyping among students, which influences their peers. When British college students rated written descriptions of "Stephen's" and "Susan's" identical programming experience for their skill level, both sexes rated "Stephen's" programming ability higher than "Susan's." (Colley, Hill, et al., 1995) Especially interesting are several experiments with university students by Clifford Nass. When computers "spoke" about male- or female-stereotypical topics in synthetic low- (male) or high-pitched (female) voices, college students of both sexes rated the "female" computer more knowledgeable about feminine topics and the "male" computer more knowledgeable about male topics. Students of both sexes found evaluation from the "male" computer more credible. Nevertheless, students denied harboring stereotypes or being influenced by the gender of the computer voices. (Nass & Brave, 2005; Nass, Moon, & Green, 1997) Consistently, girls and boys believed males to be better at computing than females; just as consistently, boys were more likely to hold stronger stereotypes in this regard than girls. (Durndell, Glissov & Siann, 1995; Eastman & Krendl, 1987; Levin & Gordon, 1989; Shashaani, 1993) However, women who took technological career paths credited male peers and siblings for encouraging them. (Smith, 2000)

Public/Private Context and Stereotype Threat. The social context of computing makes a difference. Several studies have found that both sexes performed a computer task worse in public than in private when they expected it to be difficult. (Cooper, Hall; & Huff, 1990; Robinson-Staveley & Cooper, 1990; Tsai, 2002) Another found that only girls performed worse in public. (Cooper & Hall, 1986). When girls used software designed by teachers for boys, they experienced more "situational stress" in a public setting than in a private one. (Huff, 2002) A study of college students found that the presence of another person resulted in lower performance on a computer task among women with little previous computer experience than when alone, while for men another person's presence had the opposite effect. Males and females with extensive computer experience were unaffected. (Robinson-Staveley & Cooper, 1990)

The sex of the observer apparently matters. Girls performed a computer task better when alone or in the presence of female observers than male observers. (Corston & Colman, 1996) Ten- to15-year-old girls in the presence of boys related to the computer in more gender-stereotyped ways than in the presence of girls: "This suggests that gender differences in computer use may be a function of the classroom context." (Cooper & Stone, 1996)

This research clearly raises the issue of stereotype threat, the anxiety felt in evaluative contexts (e.g., tests, public speaking, etc.) by people who identify with groups about which a negative stereotype exists because they are concerned they might confirm the stereotype about their group or themselves. The anxiety itself seems to decrease performance, which appears to confirm the stereotype. (Aronson, 2002, 2004; Steele, 1997) There have been several studies confirming the stereotype threat effect for females in math, in which females performed worse when their female identity was emphasized, (Inzlicht & Ben-Zeev, 2000; Shih, Pittinsky & Ambady, 1999; Spencer, Steele & Quinn, 1999) and even one on knowledge of politics and civics (McGlone & Aronson, in press), but none as yet in technology. I would expect the outcome to be similar.

Pedagogy. Hundreds of papers and articles deal with pedagogical issues in gender and technology, but most of them simply describe programs without evaluating (or for some even presenting) outcomes, or they repeat commonly accepted notions rather than contributing new knowledge. The assertion of a technique, no matter how frequent, or even a finding that girls like it still leaves open the question of whether it is in fact better for their learning or persistence in technology.

Collaboration. Very few studies escaped the assertion trap here. When students could freely choose, girls chose to work collaboratively on the computer while boys chose to work individually. (Ching, Kafait & Marshall, 2002) Girls describe their ideal computer use as one that permits collaboration and sharing, while boys fantasized about computers giving them power and speed. (Brunner, 1992) Sixth- to 12th-grade girls preferred software that required them to collaborate rather than compete. (Miller, Chaika & Groppe, 1996)

Single- vs. Mixed-Sex Environments. Much of the research on this topic is problematic. Girls (or girls' parents) who voluntarily choose single-sex schools or classes may well have other characteristics, such as academic orientation, that might account more strongly for any differences found. Randomization would control for this but no studies have as yet done so. Many do not specify the basis for condition assignment, thus limiting their value. In addition, many studies that contrast single-sex with coed settings have different and non-comparable teachers, curriculum, or other circumstances, further limiting their value. (Campbell & Sanders, 2002) In the United States, for example, most if not all of the single-sex projects that are funded have optional participation. In a study of over 400 projects on females in science, technology, engineering, and mathematics, 57 percent were for females only and did not have coed control groups. (American Association of University Women Educational Foundation Commission on Technology, Gender, and Teacher Education, 2004) One researcher warns that some single-sex programs risk appealing to girls on the basis of gender stereotypes, much as we have seen software do. (Volman, 1990)

Some ICT-oriented research found positive results. In England, female university students who took a computer course as non-majors had more computer confidence if they had attended a single-sex school than a coed school. (Carter & Jenkins, 2001) Also in England, instructions were given to children in single-sex and mixed-sex groups to collaborate on a computer task. Mixed-sex groups refused or were unable to collaborate; female groups did so regardless of the instructions; and male groups collaborated more than previously. (Underwood & Jindal, 1994) Middle-school age girls in South African single-sex schools had higher computer self-efficacy measures than girls from coed schools. (Galpin, Sanders, et al., 2003) In Northern Ireland, girls at coed schools were likelier to agree that boys were better at computers. (Gardner, McEwen & Curry, 1986) First grade girls in the U.S. who composed stories on the computer in mixed-sex groups were laughed at and criticized by the boys, while all-female groups worked well and smoothly. (Nicholson, Gelpi & Young, 1998)

Others have come up with different results. Two different studies of single-sex and co-ed schools in Australia found that girls had more computer experience and more positive computer in the single-sex schools; however when experience was held constant there was no effect for educational setting on attitudes. (Craig, Fisher, et al., 1998; Jones & Clarke, 1995) Unexpectedly, Hughes et al. found that all-female groups performed computer tasks worse than mixed-sex groups because of females' lower confidence levels, and that girls who had been part of female pairs subsequently did worse than girls who had been part of mixed-sex pairs. (Hughes, Brackenridge, et al., 1988) One study, however, found that males and females performed equally well in single-sex pairs and better than in coed pairs. (Underwood, McCaffrey & Underwood, 1990) Oberman found that high school girls preferred to work individually, not in groups of any composition. (Oberman, 2000)

Some researchers have found overwhelming resistance to single-sex approaches. A program in Australia was disbanded due to hostility from staff and students of both sexes. (Clayton & Lynch, 2002) A Canadian program in which female teachers and students were selected for the first computer training in the school so that they could teach others met with active resistance from faculty and parents. (Jenson, de Castell & Bryson, 2003) In a paper on computer equity efforts in five European countries, it was observed that some single-sex courses were resisted by females as "self-consciousness training." (Sorenson et al., 2003, p. 16) Cohoon has observed that women's resistance to single-sex activities is related to their wish to evade stereotype threat situations. (Cohoon, 2005)

Perhaps the most interesting recent research on the single-sex approach is pair programming. Werner and her colleagues have found that both female and male pairs of university students, but especially women, were more likely to complete their computer course and major in computer science than mixed-sex pairs or students working solo. There is no information as yet on the pair selection procedures but this may be a promising avenue of research. (Werner, Hanks, et al., 2005; Werner, McDowell & Hanks, 2004)

In short, the hotly debated topic of single-sex education shows no signs of being clarified any time soon, the identical conclusion drawn by Sutton back in 1991. (Sutton, 1991)

Critical Mass. A closely related issue is critical mass. The classic work is Rosabeth Moss Kanter's analysis of the social dynamics of majorities and minorities. (Kanter, 1977; Kanter & Stein, 1993) Sanders discovered that it is not the presence of boys at the computers that discourages girls' participation, but rather the absence of the girls' girlfriends. (Sanders, 1985) Probably the best recent study is by Cohoon, who found that a critical mass of other women correlated more strongly than any other factor with women's retention in computer science majors in Virginia (USA) universities. (Cohoon, 2001) One of the factors credited for raising the female presence in Carnegie Mellon University's (CMU) School of Computer Science was the critical mass provided by increasing numbers of women. (Blum, 2001a) According to several theorists, when computer enrollment becomes more equalized by sex, the culture changes in ways that are positive for both men and women. (Blum & Frieze, 2005; Etzkowitz, Kemelgor, et al., 1992) The computer science department at the Massachusetts Institute of Technology lowered test score admission requirements and admitted more women, who then raised academic standards overall once their numbers increased. (Linn, 2005) In a related area, however, Sanders found that when teachers worked with colleagues from their own schools (in a critical mass effect) on gender equity projects for girls they were not more successful than teachers working alone. (Sanders, 1996)

Support groups are an attempt to create a critical mass. I found nothing on the effectiveness of support groups for women's learning or persistence in ICT, although they are often mentioned as desirable. One source described an unsuccessful support group in college women in CS that never got off the ground, perhaps because of the lack of a critical mass of female students. (Margolis & Fisher, 2002) Several papers, however, described successful support group approaches in detail. (Blum, 2001a, 2001b; Frieze & Blum, 2002)

Mentors and Role Models. Many studies (and students) confuse these two related concepts. A mentor is a trusted and known guide and adviser; a role model is a person looked upon as an example to follow, who may not be personally known. There are a few good studies on faculty as mentors. Cohoon determined that the time that computer science faculty of either sex spent mentoring female students correlated with the students' retention in CS. (Cohoon, 2001) She also found that computer science faculty spent less time mentoring female students than biology faculty did; there is of course a higher percentage of female enrollment in biology. (Cohoon, 2002) In a study of college freshmen at SUNY-Binghamton in New York State, there was a correlation between female retention in math, science, and technology and the number of these courses taught by women. The correlation did not hold for women's retention in other courses nor for men. (Robst, Russo & Keil, 1996)

High school students in three U.S. states said that a lack of role models was the main reason why girls are less likely to pursue technology careers. (Jepson & Perl, 2002) A similar finding occurred in Scotland. (Durndell, Siann & Glissov, 1990) Twelve women in technology careers credited role models in part for their career choice. (Smith, 2000) Women faculty and graduate students in CS in two American universities believed that the lack of viable role models contributed to the greater female attrition rate. (Etzkowitz, Kemelgor, et al., 1992) In another study, however, girls rejected the notion that the number of female role models bore any relation to the number of girls taking computer courses. (Kwan, Trauth & Dreihaus, 1985) Reinen and Plomp have noted that primarily male computer teachers do not provide role models for girls, but they may be confusing role models with mentors. (Reinen & Plomp, 1993, 1997)

Unlike mentoring, which has real evidence in its favor, I was not able to find any studies that documented a positive relationship between female enrollment and/or retention in technology with a role-model intervention.

Classroom Interactions. Female CS students at Purdue reported in a survey their observation that professors did not treat male and female students equally. (Wasburn & Miller, 2005). Several authors point out that it is the subtle, often unintentional, and individually trivial incidents of gender bias that are cumulatively powerful and have the effect of discouraging female participation in technology. (Gatta, 2001; Sanders & McGinnis, 1993; Valian, 1998) The latter speaks of the different expectations we all have about both males and females as "gender schemas" that create the differences in our treatment of them.

<u>Curriculum</u>. Criticism of the standard computer curriculum includes its exclusive focus on programming (Schofield, 1995), its emphasis on basic skills as opposed to problem-solving (Goode, Estrella & Margolis, 2005), and the fact that complex and more interesting projects are often reserved for advanced courses that come too late for most women (Linn, 2005). However, much of the research presumes female homogeneity, manifestly not the case, and does not establish a correlation between curriculum variations and persistence in technology. Most work here falls into the assertion trap.

Two themes run through most of the work on curriculum improvement for girls or women in technology. First and most frequent, make curriculum relevant to real-world concerns, partly by making it cross-disciplinary. Male-oriented and abstract curriculum devoid of social relevance has been of particular concern. (Margolis & Fisher, 2002; Schoenberg, 2001; Schofield, 1995) Margolis and Fisher call for "computing with a purpose" and suggest curriculum "within human and social contexts." (Margolis & Fisher, 2002, p. 52; also Brunner & Bennett, 1997; Burger, 2002) A paper called for curriculum that appeals to females' social and ethical interests (McCormick & McCormick, 1991), while a book of strategies called for "usefulness." (Sanders, 1994) As a remedy, undergraduates created software for local community social service agencies and this course attracted a higher proportion of females than other CS courses. (Jessup & Sumner, 2005) A redesigned university course offered projects that were personally relevant and focused on helping people. (Holzberg, 1997) Infusing technology across the curriculum, especially below the college level, is seen as one way to make curriculum relevant. (Burstyn, 1993; Dain, 1991; Starr, 2000). Several researchers have pointed out girls' and women's preference for contextualized curriculum in which computing and technology in general are seen as tools for solving humanity's problems and enriching humanity's experiences. (Dain, 1991; J. F. Margolis, Fisher & Miller, n.d.-a; Tillberg, 2005) Blum, however, warms that curriculum changes based on commonly accepted gender differences can perpetuate stereotypes, and indeed the risk is obvious. (Blum & Frieze, 2005)

Second, use different curricular approaches and teaching methods to appeal to diverse learning styles. In the UK a "taster" course was created for to attract more girls. (Dain, 1991) Starr emphasizes the importance of having a flexible curriculum to accommodate people's diverse paths to technology. (Starr, 2000; Margolis & Fisher, 2002.) There is little clear evidence of the effectiveness of either theme.

<u>Teachers and Faculty</u>. Several studies have documented teachers' sexist beliefs about their female students' computer abilities. In Canada, teachers explained gender differences in computing with stereotypes but denied that gender was a consideration in their explanations. (Bryson & de Castell, 1998). A large sample of American high school students of both sexes agreed that teachers, counselors, and parents all believed that computers were more appropriate for males than females. (Shashaani, 1993) Cole and colleagues reported

that teachers saw less need for technology in the future of their female students. (Cole, Conlon, et al., 1994) Teachers stereotype computing as a male domain. (Huber & Schofield, 1998). In Japan and Costa Rica, teachers were seen to encourage males more than females. (Huber & Scaglion, 1995; Makrakis, 1993) Middle-school girls did everything their teachers asked of them and did good work, but they were still assessed by teachers has having less of a flair for computing. (Culley, 1988) UK teachers and counselors recognized the existence of gender stereotypes in computing and expressed a commitment to equal opportunity, but saw the source of stereotypes as occurring exclusively outside of school in parents, peers, and the media. (Culley, 1998) The same teacher belief was reported in the U.S. by Opie. (Opie, 1998) These studies matter, of course, because teachers' expectations become self-fulfilling prophecies, work that originated with Rosenthal in 1968 with his *Pygmalion in the Classroom*. (Rosenthal & Jacobson, 1968; Cooper & Weaver, 2003; Rhem, 1999)

Several researchers have observed that foreign-born computer science instructors at the postsecondary level have cultural biases against females. (Bohonak, 1995; Breene, 1992). In a survey of teachers in 20 countries, Reinen and Plomp found that most computer teachers were male and that most female computer teachers had less confidence in their own skills and knowledge. (Reinen & Plomp, 1993) Cohoon reported that females' retention in CS is positively related to their professors' positive attitudes toward women students and negatively related to their professors' belief that female students are not well suited to their major. (Cohoon, 2001, 2002)

What seems to work to improve teachers' gender-related behavior, although not with all teachers, are staff development that emphasizes no personal blame for universally learned gender stereotypes, attention to the WIIFM Rule (What's In It For Me?), praise for progress whenever possible, and the need for teachers to be explicit with students about gender bias because merely modeling exemplary behavior is often not sufficient to counteract the students' sexist notions. (Sanders, 1996, 2005) Much more research is needed here, however.

5. Special Efforts

Interventions. The literature is full of publications on interventions at all educational levels, far too many to present here. Some describe programs; others merely list recommended interventions. A number of interventions have been discussed above. The National Science Foundation published the most comprehensive source of information on interventions from 250 funded projects; it has an excellent index. (McNees, 2003) When the AAUW Educational Foundation analyzed a decade of funded projects in the U.S. they found that the majority of technology projects were for girls only, were extracurricular, and focused on attitudes rather than academics. (American Association of University Women Educational Foundation Commission on Technology, Gender, and Teacher Education, 2004) Extracurricular projects were typically after-school, weekend, and summer programs with limited and voluntary participation, by definition not involving all girls or all teachers.

There are several common failings of research on interventions. First, virtually none of them present evaluation data; two exceptions are the Computer Mania Day program for middle-school girls, which found improved attitudes (Morrell, Cotten, et al., 2004), and a summer institute program in which high school girls said they were more likely to be involved with technology in the future. (Volk & Holsey, 1997) Second, evaluation of most of these programs would be problematic due to multiple simultaneous interventions. Third, none of them were conducted longitudinally, leaving their ultimate effectiveness unknown.

Teacher Education. Nearly everything on teacher education with respect to gender and technology concerns in-service education with classroom teachers. Wasburn and Miller described workshops for technology faculty and graduate student instructors at Purdue University (Wasburn & Miller, 2005), but all the others deal with K-12 teachers and those concern voluntary participation by teachers. Variations run from short-term teacher training (Chabot Space and Science Center, 2004; Morrell, Cotten, et al., 2004) to training over one to two years (Sanders & Nelson, 2004). Margolis and Fisher described weeklong workshops for high school AP computer teachers at Carnegie Mellon (Margolis & Fisher, 2002), but Sanders presented evaluation data for that project that became available after the book went to press. She found disappointing results in that girls' enrollment increases were likely due to factors other than the gender equity intervention and that girls' enrollment levels were unrelated to the number of intervention strategies carried out by participating teachers. (Sanders, 2002)

Research on gender and technology in pre-service teacher education is nearly non-existent. The AAUW report, *Tech Savvy*, concluded that many teacher education students, most of whom are female, tend to be computer-anxious and have little computer experience. (American Association of University Women Educational Foundation Commission on Technology, Gender, and Teacher Education, 2000) Sanders has pointed out the general lack of attention to the issue and the need for its systemic inclusion in pre-service teacher education. (Sanders, 1997, 2000; Sanders & Campbell, 2001) There is a web-based course on gender and technology for pre- and in-service teachers at the postsecondary and secondary levels (Sanders & Tescione, 2004), but this does not escape the problem of focusing on supplying gender equity materials for teachers while paying no attention to demand, which may be far lower. (Sanders, 1995).

<u>Departmental Change</u>. Reinen and Plomp point out the importance of establishing gender equity policy at the departmental level in elementary, middle and high schools to counteract girls' often lesser access to computers at home. (Reinen & Plomp, 1997) Most papers on this topic, however, concern the postsecondary (tertiary) level. One calls for computer science departments to accommodate the contradiction for women between the tenure clock and the biological clock (Etzkowitz, Kemelgor, et al., 1992). At Carnegie Mellon, changes that occurred included the creation of new entry courses in the School of Computer Science to allow for differential initial knowledge levels, new cross-disciplinary courses, and accepting students with less prior computer experience than previously. (Margolis & Fisher, 2002) In the web course mentioned above, suggested departmental changes include a climate survey among students, a recommendation that the best instructors teach the introductory courses, gender equity education for faculty, and a new-student orientation that includes attention to gender equity issues. (Sanders & Tescione, 2004.)

6. Conclusions

<u>What We Need to Know</u>. This review of the research has raised in my mind some questions about gender and technology to which answers are needed. Consider this a source of dissertation topic ideas.

- We know that parental influence on daughters' technology interests and behavior varies by SES and educational level, but does it vary by racial/ethnic group?
- There is a great deal of research on attitudes and on behavior, but what is the causative direction? Does it vary by student characteristics? If so, which characteristics are relevant?
- Does computer game-playing in childhood lead to technology competence and careers as adults?
- Is stereotype threat a factor in females' computer technology behavior and performance?
- What is the relationship, if any, between role models and females' academic achievement and persistence in technology? Does this vary by race/ethnicity or other characteristics?
- What is the relationship, if any, between support groups and females' academic achievement and persistence in technology? Does this vary by race/ethnicity or other characteristics?
- What is the relationship, if any, between collaborative learning and females' academic achievement and persistence in technology? Does this vary by race/ethnicity or other characteristics?
- What is the relationship, if any, between single-sex learning environments and females' academic achievement and persistence in technology? Does this vary by race/ethnicity or other characteristics?
- Are there curricular approaches that correlate with persistence in technology? What curricular approaches are better for different groups of learners, and which characteristics are relevant in light of females' (and males') multiple learning styles?

- What approaches to staff development are most effective with different groups of teachers, and which teacher characteristics are relevant?

What We Need to Do. One rather glaring hole in this review is research on teachers from their point of view. What is it that makes teachers want to help close the computer gender gap? Could that motivation or skill set be more widely shared with their colleagues? I bring this up because most developmental work originates in activists' belief in their ability to produce programs and materials that teachers will value and that will be effective in increasing female participation in technology. In other words, we concentrate on supply, not on demand. As this chapter should make clear, while we certainly don't know all the answers we have enough of them to know that the lack of progress is not due to total ignorance. Good ideas, good practices, and good materials exist, and even in easily accessible forms. What does not exist nearly as much is educators' desire to make use of them. It is time for gender equity researchers and advocates to focus on demand.

A great deal of the research on gender and technology represents wasted opportunities. By this I mean that for all the effort that has gone in to providing compensatory programs for girls and women in technology, we would know a great deal more than we do had the programs been conceptualized to permit effective evaluation. Having read nearly 600 articles and papers for this chapter, I am left with the feeling that program developers and researchers don't talk to each other often enough. Closer cooperation between the two groups would help immensely since each truly does need the other for optimal effectiveness. Equally helpful would be an understanding from governmental and private funding sources that short-term answers do not serve our long-term needs well. Longitudinal research is expensive but it is necessary, and funders must recognize that reality.

Reflecting the origins of technology, most research has focused on female deficits: their lower experience levels, less positive attitudes, and failure to persist and perform well in educational programs, as compared with males. Research on gender and mathematics, science and engineering, further along than technology, repeatedly points to the value of including 'different" people — women, people of color, people with disabilities, and others —to expand the scope of the questions asked and paths followed. How do the technological disciplines change if they are approached from different points of view, with different desired outcomes, indeed, with different understandings of the disciplines themselves? We need to re-imagine technology, to shift it from what it can do to what it can serve, and in so doing to free ourselves from the conceptual constraints posed by business as usual according to the male model.

Finally, because women are performing at a high level in technology careers, there is no question about women's capability in the field. The issue for education is therefore to remove the barriers that are interfering with girls' and women's access to technology and success in it. This review of the research identifies many ways that barriers have been removed, usually on a small scale, and suggests ways they might be removed on a wider scale in the future.

There are many activists and researchers all over the world who are concerned with gender in technology. Working in non-profit organizations, advocacy groups, universities, government, and research and development organizations, we have limited influence over what happens in the education establishment — in elementary and secondary schools, in departments of computer science at the postsecondary (tertiary) level, in colleges of education that prepare new teachers, in the professional associations that serve them all, and in governmental agencies that set and fund education policy. As long as gender equity in technology depends on the voluntary efforts of activists and researchers trying to influence the education establishment, progress for women will remain slow or nonexistent, or might even regress further than it has already. With more aspects of life invested in technology with each passing year, the senseless waste of so much talent delays solutions for humanity's ills.

As Myra Sadker, the late gender equity advocate, used to say, "If the cure for cancer is in the mind of a girl, we might never find it." Myra died of cancer when she was only 54. The person who finds a cure will need a solid background in technology. What can we do, each and every one of us, to make it possible for that girl to find the cure some day?

References

An annotated and searchable bibliography on gender and technology on about 580 sources, including keywords, can be found at www.umbc.edu/cwit/itgenderbib/

Please note that one keyword is "research review."

Agosto, Denise E. (2004). Using gender schema theory to examine gender equity in computing: A preliminary study. *Journal of Women and Minorities in Science and Engineering, 10*(1), 37-53.

American Association of University Women Educational Foundation Commission on Technology, Gender, and Teacher Education. (2000). *Tech-Savvy: Educating Girls in the New Computer Age*: Author.

American Association of University Women Educational Foundation Commission on Technology, Gender, and Teacher Education. (2004). *Under the microscope: A decade of gender equity projects in the sciences*. Washington D.C.: Author.

Anderson, Ronald E.; Welch, Wayne W.; & Harris, Linda J. (1983). *Computer inequities in opportunities for computer literacy*. Unpublished manuscript, Minneapolis: University of Minnesota.

Arch, Elizabeth C. & Cummins, David E. (1989). Structured and unstructured exposure to computers: Sex differences in attitude and use among college students. *Sex Roles: A Journal of Research, 20*(5/6), 245-254.

Aronson, Joshua. (2002). Stereotype threat: Contending and coping with unnerving expectations. In J. Aronson (Ed.), *Improving Academic Achievement: Impact of Psychological Factors on Education* (pp. 281-301). San Diego: Academic Press.

Aronson, Joshua. (2004). The threat of stereotype. *Educational Leadership, 62*(4), 14-19.

Atan, H.; Sulaiman, F.; Rahman, Z.A.; & Idrus, R.M. (2002). Gender differences in availability, internet access and rate of usage of computers among distance education learners. *Educational Media International, 39*(3-4), 205-210.

Atan, Hanafi; Azli, Nazirah A.; Rahman, Zuraidah A. & Idrus, Rozman M. (2002). Computers in distance education: Gender differences in self-perceived computer competencies. *Journal of Educational Media, 27*(3), 123-135.

Attewell, Paul & Battle, Juan. (1999). Home computers and school performance. *The Information Society, 15*(1), 1-10.

Ayersman, David J. & Reed, W. Michael. (1995). Effects of learning styles, programming, and gender on computer anxiety. *Journal of Research on Computing in Education, 28*, 148-161.

Bakon, Cynthia; Nielsen, Antonia; & McKenzie, Jamieson. (1983). Computer fear. *Educational Leadership,* 27 (September).

Bannert, Maria & Arbinger, Paul Roland. (1996). Gender-related differences in exposure to and use of computers: Results of a survey of secondary school students. *European Journal of Psychology of Education, 11*(3), 269-282.

Barrett, E. & Lally, V. (1999). Gender differences in an online learning environment. *Journal of Computer Assisted Learning, 15*(1), 48-60.

Beeson, Betty Spillers & Williams, R. Ann. (1985). The effects of gender and age on preschool children's choice of the computer as a child-selected activity. Journal of the *American Society for Information Science*, *36*(5), 339-341.

Bernhard, Judith K. (1992). Gender-related attitudes and the development of computer skills: A preschool intervention. *Alberta Journal of Educational Research, 38*(3), 177-188.

Bhargava, Ambika; Kirova-Petrovna, Anna; & McNair, Shannan. (2002). Gender bias in computer software programs: A checklist for teachers. *Information Technology in Childhood Education Annual, 2002*(1), 205-218.

Blum, Lenore. (2001a). Transforming the culture of computing at Carnegie Mellon. *Computing Research News, 13*(5), 2-9.

Blum, Lenore. (2001b). Women in computer science: The Carnegie Mellon experience. In *The Future of the University: The University of the Future*. Unpublished manuscript.

Blum, Lenore & Frieze, Carol. (2005). The evolving culture of computing: Similarity is the difference. *Frontiers: A Journal of Women Studies, 26*(1).

Bohonak, Noni McCullough. (1995). Attracting and retaining women in graduate programs in computer science. In Sue V. Rosser (Ed.), *Teaching the Majority: Breaking the Gender Barrier in Science, Mathematics, and Engineering* (pp. 169-180). New York: Teachers College Press.

Bradshaw, Jackie; Clegg, Sue; & Trayhurn, Deborah. (1995). An investigtion into gender bias in educational software used in English primary schools. *Gender and Education, 7*(2), 167-174.

Breene, L. Anne. (1992). Women and computer science. *Initiatives, 55*(2), 39-44.

Brosnan, Mark J. (1994). Computerphobia: Is it a particularly female phenomenon? *The Psychologist, 7*, 73-78.

Brosnan, Mark J. (1998a). The impact of psychological gender, gender-related perceptions, significant others, and the introducer of technology upon computer anxiety in students. *Journal of Educational Computing Research, 18*(1), 63-78.

Brosnan, Mark J. (1998b). The role of psychological gender in the computer-related attainments of primary school children (aged 6-11). *Computers and Education, 30*(3-4), 203-208.

Brunner, Cornelia. (1992). *Gender and distance learning* (Technical Report #19). New York: Bank Street College of Education.

Brunner, Cornelia & Bennett, Dorothy. (1997). Technology and gender: Differences in masculine and feminine views. *NASSP Bulletin, 81*, 46-51.

Bryson, Mary & de Castell, Suzanne. (1998). New technologies and the cultural ecology of primary schooling: Imagining teachers as Luddites in/deed. *Educational Policy, 12*(5), 542-567.

Buckley, Jeanne. (1988). *Hard disc, RAM-drive, cold boot and score ... or why Sally won't compute.* Unpublished Research review, Teachers College, Columbia University, New York.

Burger, Carol J. (2002). Helping girls take a byte out of technology. *Principal, 81*(3), 42-43.

Burstyn, Joan. (1993). "Who benefits and who suffers": Gender and education at the dawn of the age of information technology. In Sari Knopp Biklen & Diane Pollard (Eds.), *Gender in Education* (pp. 107-125). Chicago: National Society for the Study of Education.

Calvert, Sandra L.; Watson, J. Allen; Brinkley, Vickie M. & Bordeaux, Barbara. (1989). Computer presentational features for young children's preferential selection and recall of information. *Journal of Educational Computing Research, 5*(1), 35-49.

Camp, Tracy. (1997a). A decade in the university pipeline. *Computing Research News*. May issue.

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

Camp, Tracy. (2000). The incredible shrinking pipeline unlikely to reverse. Unpublished manuscript.

Campbell, Katy. (2000). Gender and educational technologies: Relational frameworks for learning design. *Journal of Educational Multimedia and Hypermedia, 9*(2), 131-149.

Campbell, Patricia B. (2004). Personal communication.

Campbell, Patricia B. & Gulardo, Sonia. (1984). Computers in education: A question of access. *Computers in the Schools, 1*(1), 57-65.

Campbell, Patricia B. & Sanders, Jo. (2002). Challenging the system: Assumptions and data behind the push for single-sex schooling. In Amanda Datnow and Lea Hubbard (Eds.), *Gender in Policy and Practice: Perspectives on Single-Sex and Coeducational Schooling* (pp. 31-46). New York: Routledge Falmer.

Canada, Katherine & Brusca, Frank. (1991). The technological gender gap: Evidence and recommendations for educators and computer-based instruction designers. *Educational Technology Research and Development, 39*(2), 43-51.

Carter, Janet & Jenkins, Tony. (2001). *What they think: Students' preconceptions of computing.* Paper presented at the International Conference on Engineering Education, Oslo, Norway.

Cassell, Justine & Jenkins, Henry (eds.). (1998). *From Barbie to Mortal Kombat: Gender and computer games*. Cambridge, MA: The MIT Press.

Chabot Space and Science Center. (2004). *Techbridge: Encouraging girls in technology*, from http://www.chabotspace.org/visit/programs/techbridge.asp, retrieved December 1, 2004

Chambers, S.M. & Clarke, V.A. (1987). Is inequity cumulative? The relationship between disadvantaged group membership and students' computing experience, knowledge, attitudes, and intentions. *Journal of Educational Computing Research, 3*(4), 495-518.

Chan, Vania; Stafford, Katie; Klawe, Maria; & Chen, Grace. (2000). *Gender differences in Vancouver secondary students' interests related to information technology careers.* Paper presented at the Canadian Coalition of Women in Engineering, Science, Trades, and Technology.

Chappell, Kelly K. (1996). Mathematics computer software characteristics with possible gender-specific impact: A content analysis. *Journal of Educational Computing Research, 15*(1), 25-35.

Charles, Maria, & Bradley, Karen. (2005). A matter of degrees: Female underrepresentation in computer science programs cross-nationally. In J.McGrath Cohoon & William C. Aspray (Eds.), *Women and Information Technology: Research on the Reasons for Underrepresentation*.

Charlton, John P. (1999). Biological sex, sex-role identity, and the spectrum of computing orientations: A re-appraisal at the end of the 90s. *Journal of Educational Computing Research, 21*(4), 393-412.

Ching, Cynthia Carter; Kafai, Yasmin B. & Marshall, Sue K. (2002). "I always get stuck with the books": Creating space for girls to access technology in a software design project. In Nicola Yelland & Andee Rubin (Eds.), *Ghosts in the Machine: Women's Voices in Research with Technology* (pp. 167-189). New York: Peter Lang Publishing, Inc.

Clarke, Valerie A. & Teague, Joy. (1996). Characterizations of computing careers: Students and professionals disagree. *Computers in Education, 26*(4), 241-246.

Clayton, Debbie & Lynch, Teresa. (2002). Ten years of strategies to increase participation of women in computing programs: The Central Queensland University experience, 1999-2001. *SIGCSE Bulletin, 34*(2), 89-93.

Cohoon, J. McGrath. (2001). Toward improving female retention in the computer science major. *Communications of the ACM, 44*(5), 108-114.

Cohoon, J. McGrath. (2002). *Women in CS and biology.* Paper presented at the SIGCSE Technical Symposium on Computer Science Education, Northern Kentucky University.

Cohoon, J. McGrath. (2005). Personal communication, February 14, 2005.

Cole, Anne; Conlon, Tom; Jackson, Sylvia & Welch, Dorothy. (1994). Information technology and gender: Problems and proposals. *Gender and Education, 6*(1), 77-85.

College Entrance Examination Board. (2004). *2004 College-bound seniors: A profile of SAT program test-takers*. New York: author.

Colley, Ann M; Gale, Matthew T. & Harris, Teri A. (1994). Effects of gender role identity and experience on computer attitude components. *Journal of Educational Computing Research, 10*(2), 129-137.

Colley, Ann; Hill, Fiona; Hill, Justin; & Jones, Anna. (1995). Gender effects in the stereotyping of those with different kinds of computing experience. *Journal of Educational Computing Research, 12*(1), 19-27.

Collis, Betty. (1985a). Psychosocial implications of sex differences in attitudes towards computers: Results of a survey. *International Journal of Women's Studies, 8*(3), 207-213.

Collis, Betty. (1985b). Sex-related differences in attitudes toward computers: Implications for counselors. *The School Counselor, 32*(2), 120-130.

Collis, Betty A. & Williams, Richard L. (1987). Cross-cultural comparison of gender differences in adolescents' attitudes toward computers and selected school subjects. *Journal of Educational Research, 81*(1), 17-27.

Cook, John; Leathwood, Carole & Oriogun, Peter. (2001). *Online conferencing with multimedia students: Monitoring gender participation and promoting critical debate.* Paper presented at the Higher Education Academy, Center for Information and Computer Sciences, London.

Cooper, Joel & Hall, Joan. (1986). *Use with caution: The consequences of sex-biased software*.Unpublished manuscript, Princeton University, Princeton, NJ.

Cooper, Joel & Stone, Jeff. (1996). Gender, computer-assisted learning, and anxiety: With a little help from a friend. *Journal of Educational Computing Research, 15*(1), 67-91.

Cooper, Joel & Weaver, Kimberlee D. (2003). *Gender and computers: Understanding the Digital Divide*. Mahwah, N.J.: Lawrence Erlbaum Associates, Inc.

Cooper, Joel; Hall, Joan; & Huff, Charles W. (1990). Situational stress as a consequence of sex stereotyped software. *Personality and Social Psychology Bulletin, 16*, 419-429.

Corston, Rod & Colman, Andrew M. (1996). Gender and social facilitation effects on computer competence and attitudes toward computers. *Journal of Educational Computing Research, 14*(2), 171-183.

Craig, Annemieke; Fisher, Julie; Scollary, Angela & Singh, Mohini. (1998). Closing the gap: Women education and information technology courses in Australia. *Journal of Systems Software, 40*(1), 7-15.

Crowley, Kevin. (2000). Parent differences during museum visits: Gender differences in how children hear informal science. *Visitor Studies Today, 3*(3), 21-28.

Culley, Lorraine. (1988). Girls, boys and computers. *Educational Studies, 14*(1), 3-8.

Culley, Lorraine. (1998). Option choice and careers guidance: Gender and computing in secondary schools. *British Journal of Guidance and Counseling, 16*(1), 73-82.

Currell, Wendy. (1990). *Sex differences in preschool children's computer play.* Paper presented at the Fifth World Conference on Computers in Education, Sydney, Australia.

Dain, Julia. (1991). Women and computing: Some responses to falling numbers in higher education. *Women's Studies International Forum, 14*(3), 217-225.

Dambrot, Faye H.; Watkins-Malek, Michelle A.; Silling, S. Marc; Marshall, Rodney S. & Garver, Jo Ann. (1985). Correlates of sex differences in attitudes toward and involvement with computers. *Journal of Vocational Behavior, 27*, 71-86.

Davidson-Shivers, G. et al. (2003). Gender differences: Are they diminished in online discussions? *International Journal on E-Learning, 2*(1), 29-36.

Davies, A.R.;Klawe, M.; Ng, M.; Nyhus, C. & Sullivan, H. (2000, May 2000). *Gender issues in computer science education.* Paper presented at the Fifth Annual NISE Forum, Detroit.

DeRemer, Mary. (1990). The computer gender gap in elementary school. *Computers in the Schools, 6*(3/4), 39-49.

Dryburgh, Heather. (2000). Underrepresentation of girls and women in computer science: Classification of 1990s research. *Journal of Educational Computing Research, 23*(2), 181-202.

Durndell, A. & Thomson, K. (1997). Gender and computing: A decade of change? *Computers and Education, 28*(1), 1-9.

Durndell, A.; Cameron, C.; Knox, A. & Stocks, R. (1997). Gender and computing: West and East Europe. *Computers in Human Behavior, 13*(2), 269-280.

Durndell, Alan. (1990). Why do female students tend to avoid computer studies? *Research in Science & Technological Education, 8*(2), 163-170.

Durndell, Alan; Glissov, Peter; & Siann, Gerda. (1995). Gender and computing: persisting differences. *Educational Research, 37*(3), 219-227.

Durndell, Alan; Siann, Gerda & Glissov, Peter. (1990). Gender differences and computing in course choice at entry into higher education. *British Educational Research Journal, 16*(2), 149-162.

Dyck, Jennifer L. & Smither, Janan Al-Awar. (1994). Age differences in computer anxiety: The role of computer experience, gender and education. *Journal of Educational Computing Research, 10*(3), 239-248.

Eastman, Caroline M. (1995). Accomodating diversity in computer science education. In Sue V. Rosser (Ed.), *Teaching the Majority: Breaking the Gender Barrier in Science, Mathematics and Engineering* (pp. 160-168). New York: Teachers College Press.

Eastman, Susan Tyler & Krendl, Kathy. (1987). Computers and gender: differential effects of electronic search on students' achievement and attitudes. *Journal of Research and Development in Education, 20*(3), 41-

48.
Edwards, Carol. (1992). Implications of the computer culture for women of color. In C. Dianne Martin & Eric Murchie-Beyma (Eds.), *In search of gender-free paradigms for computer science education* (pp. 57-68). Eugene, OR: International Society for Technology in Education.
Elkjaer, Bente. (1992). Girls and information technology in Denmark: An account of a socially constructed problem. *Gender and Education, 4*(1/2), 25-40.
ENWISE. (2004). *Enwise Report*. http://europa.eu.int/comm/research/science-society/women/enwise/index, retrieved October 11, 2004.
Etzkowitz, Henry; Kemelgor, Carol; Neuschatz, Michael; & Uzzi, Brian. (1992). Restructurturing Departments for Equity. In C. Dianne Martin & Eric Murchie-Beyma (Eds.) *In Search of Gender Free paradigms for Computer Science Education*. Eugene, OR: International Society for Technology in Education.
Fisher, Allan; Margolis, Jane; & Miller, Faye. (1997). *Undergraduate women in computer science: Experience, motivation and culture.* Paper presented at the SIGCSE Technical Symposium, San Jose CA.
Fletcher-Flinn, Claire M. & Suddendorf, Thomas. (1996). Computer attitudes, gender and exploratory behavior: A developmental study. *Journal of Educational Computing Research, 15*(4), 369-392.
Freeman, Catherine E. (2004). *Trends in educational equity of girls & women: 2004* (NCES 2005-016). Washington DC: National Center of Education Statistics, U.S. Department of Education.
Frieze, Carol & Blum, Lenore. (2002). Building an effective computer science student organization: The Carnegie Mellon *Women@SCS* Action Plan. *SIGCSE Bulletin, 34*(2), 74-78.
Galpin, Vashti. (2002). Women in computing around the world. *SIGCSE Bulletin, 34*(2), 94-100.
Galpin, Vashti; Sanders, Ian; Turner, Heather & Venter, Bernadine. (2003). *Computer self-efficacy, gender, and educational background in South Africa*. Unpublished manuscript.
Gardner, J.R.; McEwen, A. & Curry, C.A. (1986). A sample survey of attitudes to computer studies. *Computers and Education, 10*(2), 293-298.
Gatta, Mary. (2001). *Women and work: Prospects for parity in the new economy*. New Brunswick, NJ: Center for Women and Work, Rutgers University.
Goode, Joanna; Estrella, Rachel & Margolis, Jane. (2005). Lost in translation: Gender and high school computer science. In William C. Aspray & J. McGrath Cohoon (Eds.), *Women and Information Technology: Research on the Reasons for Under-Representation*.
Goodfellow, Kris. (1996). The games people play. *New York Times*. July 22.
Grant, W. Vance & Snyder, Thomas D. (1986). *Digest of Education Statistics, 1985-86*. Washington DC: U.S. Department of Education, Center for Statistics.
Gressard, Clarice P. & Loyd, Brenda H. (1987). An investigation of the effects of math anxiety and sex on computer attitude. *School Science and Mathematics, 87*(2), 125-135.
Gunn, Cathy. (2003). Dominant or different? Gender issues in computer supported learning. *Journal of Asynchronous Learning Networks, 7*(1), 14-30.
Gurer, Denise & Camp, Tracy. (1998). *Investigating the incredible shrinking pipeline for women in computer science* (Final report of NSF Grant 98-12016).
Gurer, Denise & Camp, Tracy. (2002). An ACM-W literature review on women in computing. *ACM SIGCSE Bulletin, 34*(2), 121-127.
Hattie, John & Fitzgerald, Donald. (1987). Sex differences in attitudes, achievement, and use of computers. *Australian Journal of Education, 31*(1), 3-26.
Henwood, Flis. (1999). Exceptional women? Gender and technology in U.K. higher education. *IEEE Technology and Society Magazine, 18*(7), 21-27.
Herring, Susan C. (1992). *Gender and participation in computer-mediated linguistic discourse*. ERIC #ED 345 552.
Herring, Susan C. (1999). *The rhetorical dynamics of gender harassment on-line*. ERIC #EJ 599 669.
Herring, Susan C. (2000). Gender differences in CMC: Findings and implications. *The CPSR Newsletter (Computer Professionals for Social Responsibility), 18*(1).
Hess, Robert D. & Miura, Irene T. (1985). Gender differences in enrollment in computer camps and classes. *Sex*

Roles: A Journal of Research, 13, 193-203.
Hickling-Hudson, Anne. (1992). Rich schools, poor schools, boys and girls: Computer education in Australian secondary schools. *Journal of Educational Policy, 7*(1), 1-21.
Hirt, Joan B.; Murray, James H. & McBee, Janice K. (2000). Technology and diversity: An impending collision on the information superhighway? *NASPA Journal, 38*(1), 1-17.
Hodes, Carol L. (1995). Gender representations in mathematics software. *Journal of Educational Technology Systems, 24*(1), 67-73.
Holzberg, Carol S. (1997). Computer technology: It's a girl thing. *Technology and Learning*. May/June, 42-48.
Houle, Philip. (1996). Toward understanding student differences in a computer skills course. *Journal of Educational Computing Research, 14*(1), 25-48.
Hoyles, Celia. (1988). Review of the literature. In Celia Hoyles (Ed.), *Girls and Computers* (Bedford Way Papers 34). London: Institute of Education, University of London.
Hsi, Sherry & Hoadley, Christopher M. (1997). Productive discussion in science; Gender equity through electronic discourse. *Journal of Science Education and Technology, 6*(1), 23-36.
Huber, Brad R. & Scaglion, Richard. (1995). Gender differences in computer education: A Costa Rican case study. *Journal of Educational Computing Research, 13*(3), 271-304.
Huber, Brad R. & Schofield, Janet Ward. (1998). "I like computers, but many girls don't": Gender and the sociocultural context of computing. In Hank Bromley & Michael W. Apple (Eds.), *Education/Technology/Power: Educational Computing as a Social Practice* (pp. 103-131). Albany: State University of New York Press.
Huff, Charles & Cooper, Joel. (1987). Sex bias in educational software: The effect of designers' stereotypes on the software they design. *Journal of Applied Social Psychology, 17*(6), 519-532.
Huff, Chuck. (2002). Gender, software design, and occupational equity. *SIGCSE Bulletin, 34*(2), 112-115.
Hughes, Martin; Brackenridge, Ann; Bibby, Alan & Greenhough, Pam. (1988). Girls, boys and turtles: Gender effects in young children learning with Logo. In Celia Hoyles (Ed.), *Girls and Computers* (Bedford Way Papers 34). London: Institute of Education, University of London.
Huyer, Sophia. (2003). *Gender, ICT, and Education*. Unpublished manuscript.
Information Technology Association of America. (2003). *Report of the ITAA Blue Ribbon Panel on IT Diversity*. Arlington, VA.
Inzlicht, Michael & Ben-Zeev, Talia. (2000). A threatening intellectual environment: Why females are susceptible to experiencing problem-solving deficits in the presence of males. *Psychological Science, 11*(5), 365-371.
Jennings, Susan Evans & Onwuegbuzie, Anthony J. (2001). Computer attitudes as a function of age, gender, math attitude, and developmental status. *Journal of Educational Computing Research, 25*(4), 367-384.
Jenson, Jennifer; de Castell, Suzanne; & Bryson, Mary. (2003). "Girl talk": Gender, equity, and identity discourses in a school-based computer culture. *Women's Studies International Forum, 26*(6), 561-573.
Jepson, Andrea & Perl, Teri. (2002). Priming the pipeline. *SIGCSE Bulletin, 34*(2), 36-39.
Jessup, Elizabeth R. & Sumner, Tamara. (2005). Design-based learning and women's participation in IT. *Frontiers: A Journal of Women Studies, 26*(1).
Johnson, James P. (1982). Can computers close the educational equity gap? *Civil Rights Quarterly Perspectives, 14*(3), 20-25.
Johnson, Robert T.; Johnson, David W.; & Stanne, Mary Beth. (1985). Effects of cooperative, competitive, and individualistic goal structures on computer-assisted instruction. *Journal of Educational Psychology, 77*(6), 668-677.
Joiner, Richard; Messer, David; Littleton, Karen; & Light, Paul. (1996). Gender, computer experience and computer-based problem solving. *Computers and Education, 26*(1-3), 179-197.
Jones, Trudi & Clarke, Valerie A. (1995). Diversity as a determinant of attitudes: A possible explanation of the apparent advantage of single-sex settings. *Journal of Educational Computing Research, 21*(1), 51-64.
Kanter, Rosabeth Moss. (1977). *Men and Women of the Corporation*. New York: Basic Books.
Kanter, Rosabeth Moss & Stein, Barry A. (1993). A tale of "O": On being different. Melrose, MA:

Goodmeasure, Inc.
Kay, Robin. (1992). An analysis of methods used to examine gender differences in computer-related behavior. *Journal of Educational Computing Research, 8*(3), 277-290.
Kay, Robin H. (1992). Understanding gender differences in computer attitudes, aptitude, and use: An invitation to build theory. *Journal of Research on Computing in Education, 25*(2), 159-171.
Kekelis, Linda S.; Ancheta, Rebecca Wepsic; & Heber, Etta. (2005). Hurdles in the pipeline: Girls and technology careers. *Frontiers: A Journal of Women Studies, 26*(1).
Kekelis, Linda S.; Ancheta, Rebecca Wepsic; Heber, Etta; & Countryman, Jeri. (2004). *Bridging differences: How social relationships and racial diversity matter in a girls' technology program*. Unpublished manuscript.
Kiesler, Sara; Sproull, Lee; & Eccles, Jacquelynne S. (1983). Second class citizens? *Psychology Today*. March, 41-48.
Kimbrough, Doris R. (1999). On-line "chat room" tutorials: An unusual gender bias in computer use. *Journal of Science Education and Technology, 8*(3), 227-234.
King, John; Bond, Trevor; & Blandford, Sonya. (2002). An investigation of computer anxiety by gender and grade. *Computers in Human Behavior, 18*(1), 69-84.
Kirkman, C. (1993). Computer experience and attitudes of 12-year-old students: Implications for the UK National Curriculum. *Journal of Computer Assisted Learning, 9*, 51-62.
Kirkpatrick, Heather & Cuban, Larry. (1998). Should be we worried? What the research says about gender differences in access, use, attitudes, and achievement with computers. *Education and Computing, 38*(4), 56-61.
Klawe, Maria & Leveson, Nancy. (2001). Refreshing the nerds. *Communications of the ACM, 44*(7), 67 ff.
Knupfer, Nancy Nelson. (1998). Gender divisions across technology advertisements and the WWW: Implications for educational equity. *Theory into Practice, 37*(1), 54-63.
Knupfer, Nancy Nelson; Kramer, Kevin M.; & Pryor, Debra. (1997). *Gender equity on-line: Messages portrayed with and about the new technologies.* Paper presented at the International Visual Literacy Association, Cheyenne, WY.
Knupfer, Nancy Nelson; Rust, William J.; & Mahoney, Judy E. (1997). *Out of the picture, out of the club: Technology, mass media, society, and gender.* Paper presented at the International Visual Literacy Association, Cheyenne, WY.
Koohang, Alex A. (1986). Effects of age, gender, college status, and computer experience on attitudes toward library computer systems (LCS). *Library and Information Science Research, 8*, 349-355.
Krendl, Kathy A; Broihier, Mary C. & Fleetwood, Cynthia. (1989). Children and computers: Do sex-related differences persist? *Journal of Communication, 39*(3), 85-93.
Kwan, Steven K.; Trauth, Eileen M. & Driehaus, Kathleen C. (1985). Gender differences and computing: Students' assessment of societal influences. *Education and Computing, 1*, 187-194.
Lage, Elisabeth. (1991). Boys, girls, and microcomputing. *European Journal of Psychology of Women, 6*(1), 29-44.
Lee, A.C.K. (2003). Undergraduate students' gender differences in IT skills and attitudes. *Journal of Computer Assisted Learning, 19*(4), 488 ff.
Lee, Kar-Tin. (1997). Impediments to good computing practice: Some gender issues. *Computers and Education, 28*(4), 251-259.
Leong, Siew Chee & Hawamdeh, Suliman. (1999). Gender and learning attitudes in using web-based science lessons. *Information Research, 5*(1). http://informationr.netir/5-1/paper66.html, retrieved December 26, 2004.
Leveson, Nancy G. (1990). *Educational pipeline issues for women.* Paper presented at the Computing Research Association, Snowbird.
Levin, Tamar & Gordon, Claire. (1989). Effect of gender and computer experience on attitudes toward computers. *Journal of Educational Computing Research, 5*(1), 69-88.
Liao, Yuen-kuang Cliff. (1999). *Gender differences on attitudes toward computers: A meta-analysis.* Paper

presented at the Society for Information Technology and Teacher Education International Conference, San Antonio Texas.

Linn, Eleanor. (1999). Gender equity and computer technology. *Equity Coalition, 5*, 14-17.

Linn, Marcia C. (2005). Technology and gender equity: What works? In Nancy Felipe Russo, Connie Chan, Mary Beth Kenkel, Cheryl B. Travis, & Melba Vasquez (Eds.), *Women in Science and Technology*. New York: American Psychological Association.

Littleton, Karen & Hoyles, Celia. (2002). The gendering of information technology. In Nicola Yelland & Andee Rubin (Eds.), *Ghosts in the Machine: Women's Voices in Research with Technology* (pp. 3-32). New York: Peter Lang Publishing, Inc.

Littleton, Karen; Light, Paul; Joiner, Richard; Messer, David; & Barnes, Peter. (1998). Gender, task scenarios and children's computer-based problem solving. *Educational Psychology, 18*(3), 327-340.

Liu, Min; Reed, W. Michael; & Phillips, Perry D. (1992). Teacher education students and computers: Gender, major, prior computer experience, occurrence, and anxiety. *Journal of Research on Computing in Education, 24*(4), 457-467.

Makrakis, Vasilios. (1992). Cross-cultural comparison of gender differences toward computers in Japan and Sweden. *Scandinavian Journal of Educational Research, 36*(4), 275-287.

Makrakis, Vasilios. (1993). Gender and computing in schools in Japan: The "we can, I can't" paradox. *Computers and Education, 20*(2), 191-198.

Mandinach, Ellen B. & Linn, Marcia C. (1987). Cognitive consequences of programming: Achievements of experienced and talented programmers. *Journal of Educational Computing Research, 3*(1), 53-72.

Manes, Stephen. (1997, October 7). Alice's adventures in boredomland. *New York Times*.

Margolis, Jane & Fisher, Allan. (2000). *Women in computer science: Closing the gender gap in higher education*. Final Report to the Sloan Foundation.

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

Margolis, Jane; Fisher, Allan; & Miller, Faye. (2000). The anatomy of interest: Women in undergraduate computer science. *Women's Studies Quarterly, 28*(1/2), 104-127.

Margolis, Jane; Fisher, Allan; & Miller, Faye. (n.d.-a). *Computing for a purpose: Gender and attachment to computer science*. Unpublished manuscript. http://www-2.cs.cmu.edu/~gendergap/purpose.html, retrieved November 8, 2004.

Margolis, Jane; Fisher, Allan; & Miller, Faye. (n.d.-b). *Failure is not an option: International women in computer science*. Unpublished manuscript. http://www-2.cs.cmu.edu/~gendergap/intwomen.html, retrieved November 8, 2004.

Markoff, John. (1989). Computing in America: A masculine mystique. *New York Times,* p. 1A.

Maxwell, D. Jackson. (2000). Technology and inequality with the United States school systems. *Journal of Educational Thought, 34*(1), 43-57.

McCormick, Naomi & McCormick, John. (1991). Not for men only: Why so few women major in computer science. *College Student Journal, 25*, 345-350.

McCoy, Leah P. & Heafner, Tina L. (2004). Effect of gender on computer use and attitudes of college seniors. *Journal of Women and Minorities in Science and Engineering, 10*(1), 55-66.

McGlone, Matthew S. & Aronson, Joshua. (In press). Stereotype threat and the gender gap in political knowledge. *Public Opinion Quarterly*.

McNees, Pat. (2003). *New Formulas for America's Workforce: Girls in Science and Engineering*. Arlington, VA: National Science Foundation, pub. # NSF 03-207.

Miller, Leslie; Chaika, Melissa; & Groppe, Laura. (1996). Girls' preferences in software design: Insights from a focus group. *Interpersonal Computing and Technology, 4*(2), 27-36.

MIT Computer Science Female Graduate Students and Research Staff. (1983). *Barriers to equality in academia: Women in computer science at MIT*. Cambridge, MA: Laboratory for Computer Science, MIT.

MIT Department of Electrical Engineering & Computer Science. (1995). *Women undergraduate enrollment in*

electrical engineering and computer science at MIT. Cambridge, Massachusetts: MIT.
Miura, Irene T. (1987). Gender and socioeconomic status differences in middle-school computer interest and use. *Journal of Early Adolescence, 7*(2), 243-254.
Morrell, Claudia; Cotten, Shelia; Sparks, Alisha; & Spurgas, Alyson. (2004). *Computer Mania Day: An effective intervention for increasing youth's interest in technology*: Center for Women & Information Technology, University of Maryland/Baltimore County.
Morse, Frances K. & Daiute, Colette. (1992). *I LIKE computers versus I LIKERT computers: Rethinking methods for assessing the gender gap in computing.* Paper presented at the American Educational Research Association, San Francisco.
Munger, Gail F. & Loyd, Brenda H. (1989). Gender and attitudes toward computers and calculators: their relationship to math performance. *Journal of Educational Computing Research, 5*(2), 167-177.
Myers, Wendy; Bennett, Sue & Lysaght, Pauline. (2004). *Asynchronous communication: Strategies for equitable e-learning.* Paper presented at the Australian Society for Computers in Learning in Tertiary Education, Perth.
Nass, Clifford & Brave, Scott. (2005). Gender stereotyping of voices: Sex is everywhere. In Clifford Nass (Ed.), *Wired for Speech: How Voice Activates and Advances the Human-Computer Relationship* (Chapter 3). Cambridge: MIT Press.
Nass, Clifford; Moon, Youngme; & Green, Nancy. (1997). Are computers gender-neutral? Gender stereotypic responses to computers. *Journal of Applied Social Psychology, 27*(10), 864-876.
Nelson, Lori J.; Weise, Gina M. & Cooper, Joel. (1991). Getting started with computers: Experience, anxiety, and relational style. *Computers in Human Behavior, 7*, 185-202.
Nicholson, Julie; Gelpi, Adrienne; & Young, Shannon. (1998). Influences of gender and open-ended software on first graders' collaborative composing activities on computers. *Journal of Computing in Childhood Education, 9*(1), 3-42.
Oberman, Paul S. (2000). *Academic help seeking and peer interactions of high school girls in computer science classes.* Paper presented at the American Educational Research Association, New Orleans.
Ogletree, Shirley M. & Williams, Sue W. (1990). Sex and sex-typing effects on computer attitudes and aptitude. *Sex Roles: A Journal of Research, 23*(11/12), 703-712.
Opie, Clive. (1998). Whose turn next? Gender issues in information technology. In Ann Clark & Elaine Millard (Eds.), *Gender in the Secondary Curriculum: Balancing the Books* (pp. 80-95). London: Routledge.
Ory, John C.; Bullock, Cheryl; & Burnaska, Kristine. (1997). Gender similarity in the use of and attitudes about ALN [asynchronous learning networks] in a university setting. *Journal of Asynchronous Learning Networks, 1*(1), 39-51.
Palmer, Carolyn. (1989). New users in jeopardy on campus: What can we do? *Brown Online, 2*, 14-17.
Pearl, Amy; Pollack, Martha E.; Riskin, Eve; Thomas, Becky; Wolf, Elizabeth; & Wu, Alice. (1990). Becoming a computer scientist: A report by the ACM Committe on the Status of Women in Computer Science. *Communications of the ACM, 33*(11), 47-57.
Reece, Carol Carter. (1986). *Gender and microcomputers: Implications for the school curriculum.* Paper presented at the Mid-South Educational Research Association, Memphis Tennessee.
Reinen, Ingeborg Janssen & Plomp, Tjeerd. (1993). Some gender issues in educational computer use: Results of an international comparative survey. *Computers and Education, 20*(4), 353-365.
Reinen, Ingeborg Janssen & Plomp, Tjeerd. (1997). Information technology and gender equality: A contradiction in terminis? *Computers and Education, 28*(2), 65-78.
Rhem, James. (1999). Pygmalion in the classroom. *National Teaching and Learning Forum, 8*(2). http://www.ntlf.com/html/pi/9902/pygm_1.htm, retrieved March 29, 2005.
Ring, Geoff. (1991). Student reactions to courseware: Gender differences. *British Journal of Educational Technology, 22*(3), 210-215.
Robinson-Staveley, Kris & Cooper, Joel. (1990). Mere presence, gender, and reactions to computers: Studying human-computer interaction in the social context. *Journal of Experimental Social Psychology, 26*, 168-183.

Robst, John; Russo, Dean & Keil, Jack. (1996). *Female role models: The effect of of gender composition of faculty on student retention.* Paper presented at the Association for Institutional Research, Albuquerque New Mexico.

Rosenthal, Nina Ribak & Demetrulias, Diana Mayer. (1988). Assessing gender bias in computer software. *Computers in the Schools, 5*(1/2), 153-163.

Rosenthal, R. & Jacobson, L. (1968). *Pygmalion in the Classroom*. New York: Holt, Rinehart & Winston.

Roy, Marguerite; Taylor, Roger & Chi, Michelene T.H. (2003). Searching for information on-line and off-line: Gender differences among middle school students. *Journal of Educational Computing Research, 29*(2), 229-252.

Rubin, Andee; Murray, Megan; O'Neil, Kim & Ashley, Juania. (1997). *What kind of educational computer games would girls like?* Paper presented at the American Educational Research Association, Chicago.

Sanders, Jo. (1994). *Lifting the Barriers: 600 Strategies that Really Work to Increase Girls' Participation in Science, Mathematics, and Computers*. Seattle: Jo Sanders Publications.

Sanders, Jo. (1995). *How do we get educators to teach gender equity?* Paper presented at Is There a Pedagogy for Girls?, London, England.

Sanders, Jo. (1996). *What works to create change on an individual basis?* Paper presented at the American Educational Research Association, New York City.

Sanders, Jo. (1997). Teacher education and gender equity. *ERIC Digest, 96*(3).

Sanders, Jo. (1998). The molehill and the mountain. *TIES: The Magazine of Design and Technology Education*, 1. September.

Sanders, Jo. (2000). *Women in science and technology, and the role of public policy.* Paper presented at the Association for Public Policy Analysis and Management, Seattle Washington.

Sanders, Jo. (2002). *Snatching defeat from the jaws of victory: When good projects go bad. Girls and computer science.* Paper presented at the American Educational Research Association, New Orleans.

Sanders, Jo. (2005). *Teaching teachers about gender equity in computing.* Paper presented at Crossing Cultures, Changing Lives: Integrating Research on Girls' Choices of IT Careers, Oxford, England.

Sanders, Jo & Campbell, Patricia B. (2001). Making it happen: The role of teacher education in ensuring gender equity. *AACTE Policy Perspectives, 2*(4), 1-5.

Sanders, Jo & Lubetkin, Rebecca. (1991). Preparing female students for technician careers: Dealing with our own elitist biases. *Peabody Journal of Education, 66*(2), 113-126.

Sanders, Jo & McGinnis, Mary. (1993). What we can learn from girls' computer avoidance. *NCSEE News (National Coalition for Sex Equity in Education)*. Spring.

Sanders, Jo & Nelson, Sarah Cotton. (2004). Closing gender gaps in science. *Educational Leadership, 62*(3), 74-77.

Sanders, Jo & Tescione, Susan T. (2004). *Equity in the IT Classroom*, http://www.josanders.com/portal/index.htm

Sanders, Jo Shuchat. (1984). The computer: Male, female or androgynous? *The Computing Teacher*, 31-34. April.

Sanders, Jo Shuchat. (1985). Here's how you can help girls take greater advantage of school computers. *American School Board Journal*, 37-38.

Sanders, Jo Shuchat. (1985). Making the computer neuter. *The Computing Teacher*, 23-27.

Sax, Linda J.; Astin, Alexander W.; Korn, William S.; & Mahoney, Kathryn M. (2001). *The American freshman: National Norms for Fall 2000*: UCLA.

Schoenberg, Judy. (2001). *The girl difference: Short-circuiting the myth of the technophobic girl*. New York City: Girls Scouts of the United States of America.

Schofield, Janet Ward. (1995). *Computers and Classroom Culture*. New York: Cambridge University Press.

Selby, Linda. (1997). *Increasing the participation of women in tertiary level computing courses: What works and why.* Paper presented at the Australian Society for Computers in Learning in Tertiary Education, Perth.

Seymour, Elaine & Hewitt, Nancy M. (1997). Issues of gender. In *Talking about Leaving: Why Undergraduates*

Leave the Sciences. Boulder, CO: Westview Press. Chapter 5, 231-318.
Shashaani, Lily. (1993). Gender-based differences in attitudes toward computers. *Computers and Education, 20*(2), 169-181.
Shashaani, Lily. (1994). Socioeconomic status, parents' sex-role stereotypes, and the gender gap in computing. *Journal of Research on Computing in Education, 26*(4), 433-451.
Shashaani, Lily. (1995). Gender differences in mathematics experience and attitude and their relation to computer attitude. *Educational Technology, 35*(3), 32-38.
Shashaani, Lily. (1997). Gender differences in computer attitudes and use among college students. *Journal of Educational Computing Research, 16*(1), 37-51.
Shashaani, Lily & Khalili, Ashmad. (2001). Gender and computers: Similarities and differences in Iranian college students' attitudes toward computers. *Computers and Education, 37*(3-4), 363-375.
Shih, Margaret; Pittinsky, Todd L. & Ambady, Nalini. (1999). Stereotype susceptibility: Identity saleince and shifts in quantitative performance. *Psychology of Women Quarterly, 10*(1), 80-83.
Smith, Lola B. (2000). The socialization of females with regard to a technology-related career: recommendations for change. *Meridian: A Middle School Computer Technologies Journal, 3*(2).
Snyder, Thomas D.; Tan, Alexandra G. & Hoffman, Charlene M. (2004). *Digest of Education Statistics 2003*. Washington DC: U.S. Department of Education, Institute of Education Sciences.
Sorenson, Knut et al. (2003). *Case studies of public efforts to include women in ICT* (IST-2000-26329 SIGIS, Deliverable Number D03, Volume 1): Information Society Technologies.
Spencer, Steven J.; Steele, Claude M. & Quinn, Diane M. (1999). Stereotype threat and women's math performance. *Journal of Experimental Social Psychology, 35*(1), 4-28.
Spertus, Ellen. (1991). *Why Are There So Few Female Computer Scientists?* Cambridge, MA: MIT Artificial Intelligence Laboratory.
Sproull, Lee; Zubrow, David & Kiesler, Sara. (1986). Cultural socialization to computing in college. *Computers in Human Behavior, 2*, 257-275.
Starr, Linda. (2000). *An Education World e-interview with Sherry Turkle: Is technology just for boys?* http://www.education-world.com/a_curr/curr228.shtml, retrieved October 11, 2001.
Steele, Claude M. (1997). A threat in the air: How stereotypes shape intellectual identity and performance. *American Psychologist, 52*(6), 613-629.
Stumpf, Heinrich & Stanley, Julian C. (1997). The gender gap in Advanced Placement computer science: Participation and performance, 1984-1996. *College Board Review*(181), 22-27.
Sutton, Rosemary E. (1991). Equity and computers in the schools: A decade of research. *Review of Educational Research, 61*(4), 475-503.
Taylor, Harriet G. & Mounfield, Luegina. (1991). An analysis of success factors in college computer science: High school methodology is a key element. *Journal of Research on Computing in Education, 24*(2), 240-245.
Taylor, Harriet G. & Mounfield, Luegina. (1994). Exploration of the relationship between prior computing experience and gender on success in college computer science. *Journal of Educational Computing Research, 11*(4), 291-306.
Temple, Linda & Lips, Hilary M. (1989). Gender differences and similarities in attitudes toward computers. *Computers in Human Behavior, 5*, 215-226.
Tillberg, Heather K. & Cohoon, J. McGrath. (2005). Attracting women to the CS major. *Frontiers: A Journal of Women Studies, 26*(1).
Todman, John. (2000). Gender differences in computer anxiety among university entrants since 1992. *Computers and Education, 34*(1), 27-35.
Tsai, Meng-Jung. (2002). Do male students often perform better than female students when learning computers? A study of Taiwanese eight graders' computer education through strategic and cooperative learning. *Journal of Educational Computing Research, 26*(1), 67-85.
Turner, Sandra V.; Bernt, Phyllis W. & Pecora, Norma. (2002). *Why women choose information technology careers: Educational, social, and familial influences.* Paper presented at the American Educational

Research Association, New Orleans.

Underwood, Geoffrey & Jindal, Nishchint. (1994). Gender differences and effects of co-operation in a computer-based language task. *Educational Research 36*(1), 63-74.

Underwood, Geoffrey; McCaffrey, Michelle & Underwood, Jean. (1990). Gender differences in a cooperative computer-based language task. *Educational Research, 32*(1), 44-49.

Valian, Virginia. (1998). *Why So Slow? The Advancement of Women*. Cambridge, MA: MIT Press.

Vegso, Jay. (2005). Interest in CS as a major drops among incoming freshmen. *Computing Research News*, *17*(3). http://www.cra.org/CRN/articles/may05/vegso.

Volk, Ken & Holsey, Lilla. (1997). TAP: A gender equity program in high technology. *The Technology Teacher*, December/January, 10-13.

Volman, Monique. (1990). *Computer education as a gender relationship: Deconstructing the dilemma of girl-friendly education.* Paper presented at the Fourth Interdisciplinary Congress on Women, New York.

Volman, Monique & Eck, Edith van. (2001). Gender equity and information technology in education: The second decade. *Review of Educational Research, 71*(4), 613-634.

Ware, Mary Catherine & Stuck, Mary Frances. (1985). Sex-role messages vis-a-vis microcomputer use: A look at the pictures. *Sex Roles: A Journal of Research, 13*(3/4), 205-214.

Wasburn, Mara H. & Miller, Susan G. (2005). Still a chilly climate for women students in technology: A case study. In Sue V. Rosser & Mary Frank Fox (Eds.), *Women, Gender and Technology*. Urbana-Champaign: University of Illinois Press.

Werner, Linda L; Hanks, Brian; McDowell, Harlie; Bullock, Heather; & Fernald, Julian. (2005). Want to increase retention of your female students? *Computing Research News, 17*(2).

Werner, Linda; McDowell, Charlie & Hanks, Brian. (2004). *Female computer science students who pair persist*. Unpublished manuscript.

Whitley, Bernard E., Jr. (1996). Gender differences in computer-related attitudes: It depends on what you ask. *Computers in Human Behavior, 12*(2), 275-289.

Whitley, Bernard E., Jr. (1997). Gender differences in computer-related attitudes and behavior: A meta-analysis. *Computers in Human Behavior, 13*(1), 1-22.

Williams, Sue Winkle & Ogletree, Shirley Matile. (1992). Preschool children's computer interest and competence: Effects of sex and gender role. *Early Childhood Research Quarterly, 7*, 135-143.

Women and Minorities in Information Technology Forum. (1999). *Causes and solutions for increasing the numbers in the workforce pipeline.* Paper presented at the Women and Minorities in Information Technology Forum, Old Dominion University, Hampton Virginia.

Women in Technology International. (1997). *The ENIAC programmers*. http://www.witi.com/center/witimuseum/halloffame/1997/eniac.php, retrieved March 18, 2005.

Young, Betty J. (1999). Gender differences in student attitude toward computers. *Journal of Research on Computing in Education, 33*(2), 204-216.

About the Author

Jo Sanders has provided consulting services of the highest quality to education and employment institutions and programs for three decades. Her work has been featured in *the Dallas Morning News, Seattle Times, USA Today, Boston Globe, San Francisco Chronicle, Washington Post*, and the *New York Times*, among many others. She has appeared on Good Morning, America and many radio stations. She has published articles on gender equity in *Education Leadership, Education Digest, Phi Delta Kappan, ERIC Digest, WEEA Diges*t, and many other periodicals, in addition to ten books and many book chapters.

Areas of Gender Equity Expertise

- Gender equity in education - all levels
- Gender equity in technology
- Gender equity in teacher education
- Gender equity in mathematics and science
- Nontraditional occupations for women
- Gender equity in vocational education
- Gender equity in occupational preparation
- Single-sex vs. coed education
- Gender equity issues for males

Recent Clients

- Dallas Women's Foundation for Dallas high schools
- Seattle Girls' School
- Denver Public Schools
- Kent (WA) Public Schools
- Washington State School Directors Association
- Texas Instruments, Inc.
- Montgomery County (MD) Commission on Women
- Northwest Girls Coalition
- Northern Kentucky University
- Center for American Women and Politics
- University of Wisconsin at Stout

Gender Equity Consulting Available

- Training and staff development
- Writing, from brochures to books
- Program development
- Policy analysis
- Keynote speeches
- Evaluation
- Technical assistance