The Technological Gender Gap: Evidence and Recommendations for Educators and Computer-Based Instruction Designers

Katherine Canada
Frank Brusca

Katherine Canada is at Goucher College, Towson, MD. Frank Brusca is at Westinghouse Electric Corporation, Baltimore, MD.

The term "technological gender gap" refers to the idea that males and females have different technology-related attitudes, behaviors, and skills. This article reviews the mounting evidence documenting the existence of a gender gap, which, if ignored, could render large numbers of female students unprepared to meet the technological challenges of the future. Recommendations for ameliorating the technological gender gap are presented for educators and computer-based instruction (CBI) designers who are interested in providing equitable educational opportunities for male and female students.

Equitable distribution of resources is one of the most critical issues facing the field of educational technology. Inequities tend to appear along both socioeconomic and gender lines, with male students and students from high socioeconomic status backgrounds well positioned to outpace female students and students from low socioeconomic backgrounds in terms of computer skills and knowledge (Lockard, Abrams, & Many, 1987). This article focuses on the gender-related inequities by reviewing the mounting evidence documenting the existence of a technological gender gap.

EVIDENCE OF A TECHNOLOGICAL GENDER GAP AMONG ELEMENTARY THROUGH HIGH SCHOOL STUDENTS

Research concentrating on children's and adolescents' computer-related attitudes has shown that they do not consider computers to be equally the domain of boys and girls. For example, boys and girls tend to rate computers as more masculine than feminine (e.g., Arenz & Miheon, 1990; Chen, 1985; Wilder, Mackie, & Cooper, 1985), with boys being more extreme than girls in their gender stereotyping of computers (Arenz & Miheon, 1990; Wilder et al., 1985).

Among middle school and high school students, Arenz and Miheon (1990) found that actual experience with computers interacted with gender to influence students' attitudes toward the technology. Male students who advanced beyond beginning level computer courses were most likely to report perceptions of males' superior computer abilities. In contrast, female students who advanced beyond beginning level computer courses were the least likely to report that they perceived gender differences in computer abilities. In other words, experience with computers strengthened the males' beliefs in a technological gender gap whereas it weakened females' perceptions of such a gap.

At the high school level, Chen (1985) also found that experience interacted with student gender to influence attitudes toward computers. In comparison to the female students, the male students expressed more interest in computers, more self-confidence in working with computers, less anxiety about mastering computers, a stronger belief that computer skills lead to respect from parents and peers, and a stronger belief that women cannot be as skilled with computers as men. However, when the male students' attitudes were compared with the attitudes of female students who had at least one high school course in computer programming, all but one of the attitude differences disappeared.

Although they comprised only 10% of the female sample, the females with computer programming experience expressed similar levels of computer interest, self-confidence, and beliefs in gaining respect from computer mastery as the males. However, unlike the males, the computer-literate females disagreed with the belief that women cannot be as skilled with computers as men.

These studies demonstrate the benefits of computer experience for girls; however, evidence from a variety of sources indicates that female students are not getting as much computer experience as male students. According to Chen (1985), the 1977 National Assessment of Educational Progress found that the girls in the national sample of 13–17 year olds had less access to computers as well as lower levels of computer skills than the boys. Transcript data from the National Longitudinal Study of 1980–1982 (cited in Lockheed, 1985) showed that males outnumbered females 3:2 in high school programming courses.

Gender discrepancies in students' access to and experience with computers appear as early as the elementary school years. Susan Fleig, director of the computer center at an elementary school in Washington, D.C., reported that when the facility first opened, the only students who came to the center during non-class times were boys (Kolata, 1984). Similarly, both Fetler (1985) and an Educational Testing Service study (cited in Kolata, 1984) reported that compared to girls, boys tend to spend more non-class time using school computers.

There is evidence that this gender difference also extends to home computer use. Federal statistics (U.S. Bureau of the Census, 1989, Table 231) for students in grades kindergarten through 12 showed a higher percentage of boys than girls using computers at home. There is convergence among several studies that boys are more likely than girls to report the presence of a computer in their homes (e.g., Chen, 1985; Fetler, 1985; Wilder et al., 1985). As Chen noted, it is impossible to determine from survey data whether parents are favoring boys with computers or whether boys are more persistent and successful than girls at influencing parental purchases. However, regardless of the reason, the fact that there is a difference in boys' and girls' access to home computers provides another example of a technological gender gap.

In addition to differing in the amount of time spent using computers, male and female students tend to differ in the ways they use computers. For example, Wilder et al. (1985) found that male students were more likely to have had programming courses, whereas female students were more likely to have had introductory or word processing courses. What is more, among those males and females who had exposure to more than one computer programming language, there was evidence of gender tracking. Males' second computer language was more likely to have been Fortran, which tends to be used in the sciences, whereas females' second computer language was more likely to have been Pascal, which tends to be used in business settings.

EVIDENCE OF A TECHNOLOGICAL GENDER GAP AMONG COLLEGE STUDENTS

The patterns of gender-differentiated computer attitudes and behaviors that have been identified among elementary, middle, and high school students also have been found in research focusing on college students. In their study of college students' initial encounters with computers, Sproull, Kiesler, and Zubrow (1984) found that the females were more likely than the males to report reactions of dismay and alienation.

Studies of college students' computer-related attitudes and behaviors (e.g., Arch & Cummins, 1989; Badagliacco, 1990; Wilder et al., 1985) have shown that, compared to males, females tend to perceive themselves as less equipped to deal with computers. However, a recent survey of undergraduate students (Badagliacco, 1990) found that when the variance associated with actual computer experience was controlled, the gender gap in computer-related attitudes and self-perceptions disappeared.

Although increasing female students' amount of computer time holds promise for reducing the technological gender gap, Wilder et al. (1985) speculated that the computer rooms and centers in co-educational colleges tend to be used more frequently by male students than by female students. The findings from the following study, conducted by the first author of this article, suggest that observational data would support their claim.

During the fall semester of 1989, a student research assistant visited 4 different campus computer facilities once a week for 8 weeks at randomly selected times. On each visit she recorded the location and gender of each person using the facility. On two occasions, interrater reliability was checked. Due to the lack of ambiguity in the information recorded, reliability was 100%.

Three of the computer facilities were customary, campus computer rooms, housing from 11 to 16 computers and dot matrix printers. Students tended to use these rooms mainly for word processing and occasionally for working with spreadsheet or database software. The fourth computer facility was the campus information technology center, which housed high-speed computers, laser and color printers, plotters, and desktop publishing software. In campus publications, this center has been described as housing "state-of-the-art equipment."

Chi square analyses revealed that the number of males and females using the three computer rooms was comparable to the proportion of male and female students on campus. A different pattern emerged with regard to the number of males and females using the information technology center. Compared to their numbers on campus, a disproportionate number of male students used the technology center ($\chi^2(1) = 6.62, p < .02$).

It was encouraging to find gender equity in students' use of the three campus computer rooms. However, given the history and demographics of the college, it was discouraging to have found any evidence of gender inequity or of stereotypic gender tracking with regard to the use of computers (i.e., women using word processing software and dot matrix printers and men using desktop publishing software and laser printers). Formerly the college was exclusively a women's institution. The data reported here were collected during the Fall semester of the college's third year of transition to co-education, when male students were only 17% of the entire student population. Therefore, these findings demonstrate that the technological gender gap can emerge even in a predominately female environment, and they raise questions about the extent to which student gender ratios influence the gap in males' and females' computer-related attitudes and behaviors.

RECOMMENDATIONS FOR CLOSING THE TECHNOLOGICAL GENDER GAP

The technological gender gap is created and influenced by multiple factors; therefore, single, simplistic remedies will be ineffective in closing the gap. The following broad recommendations are not presented as an exhaustive list. Rather, they are presented to educators and CBI designers as catalysts for stimulating thought, discussion, and, most importantly, action on the task of ameliorating the current gap in males' and females' technological attitudes, skills, and behaviors.

Those who consider the technological gender gap to be caused by biological factors might argue that attempts to close the gap are futile. That males and females differ biologically is indisputable; whether or not such differences have any bearing on technological attitudes, skills, and abilities is debatable. A brief review of historical trends in the computing field, as well as data from research demonstrating equally high achievement levels for males and females in technological domains, provides strong support for the argument that the technological gender gap is not biologically predetermined.

Initially, computer programming was viewed as a low-priority job and consequently was assigned to women (Kraft, 1979). The Navy assigned women to program ENIAC, which was the first operational computer (Sanders, 1981), and in 1960, when there were only 2,000 computer operators, 65% of them were women (Dicesare, 1975). Thus, women can be considered pioneers in the computer field. Dr. Grace Hopper, for example, developed programs for the world's first digital computer and created COBOL, the first compiler (Sanders, 1981).

Additional evidence that the technological gender gap is not inevitable comes from the results of previously mentioned studies (e.g., Arenz & Miheon, 1990; Badagliacco, 1990; Chen, 1985; Wilder et al., 1985) documenting the benefits of computer experience for girls. All of these studies showed that the technological gender gap narrowed when female students gained computer programming skills.

If the gap cannot be attributed solely to biological factors, other factors that can potentially hinder females' participation in and knowledge about computers must be identified. Many researchers and theorists (e.g., Badagliacco, 1990; Kiesler, Sproull, & Eccles, 1985; Lockheed, 1985; Sproull et al., 1984) have pointed to psychological, social, and cultural influences on males' and females' computer-related attitudes and behaviors. Evidence supporting these non-biological contributors to the technological gender gap is reviewed below in the context of providing recommendations to educators and CBI designers who are interested in ameliorating the gap.

Recommendation: Adopt a proactive stance. To the extent that educators ignore, deny, or view the technological gender gap as a natural state of affairs, the gap will widen. The evidence documenting the existence of the technological gender gap shows that, without intervention, males and females demonstrate different computer-related attitudes and behaviors. There is also evidence that when educators assume a proactive stance toward ensuring gender-equitable computer opportunities, the gap narrows. For example, although Fleig (Kolata, 1984) was initially distressed when boys dominated the computer room in her elementary school, she took control over the situation by designating special girls-only and "non-hacker" days in the computer center. This scheduling provided more equitable distribution of the computer resources among all of the students.

Similarly, Anderson, Klassen, Krohn, and Smith-Cunnien (cited in Chen, 1985) attributed the lack of a gender gap in Minnesota students' computer skills to the state's commitment to computer literacy, which ensured all students equal computer access and training. At the college level, Arch and Cummins (1989) found that when students were introduced to computers through structured, in-class lessons and assignments, gender differences in students' computer-related attitudes and behaviors were attenuated. However, when the computer introduction was unstructured and voluntary, the familiar gender gap appeared.

Deborah Brecher (Call, 1987) has contributed to narrowing the technological gender gap by founding the Women's Computer Literacy Program. Brecher's program is based on theories (e.g., Belenky, Clinchy, Goldberger, & Tarule, 1986; Gilligan, 1982) that men and women learn in different ways. Brecher believes that traditional methods of teaching about computers have hindered rather than facilitated women's mastery of the technology. Her techniques strive to match computer training to women's cognitive structures.

These examples stress the necessity for educators to be proactive, to exert control over the allotment of computer resources, and to create teaching strategies that will facilitate female students' learning. Without such control and planning, females tend to lag behind males in computing experience.

Recommendation: Structure the physical and social environments of computer facilities to enhance female students' learning opportunities. Commenting on the physical environment of computer rooms, one of the subjects in Sproull et al.'s (1984) study of college students' initial encounters with computers said:

> I feel like I'm in 1984, cells right next to each other. It's like Russia. . . . The walls are all white. And all they have are computer information on them. . . . All you see are computer geeks and computers and the Xerox machine and white on the walls. (p. 42)

This quote illustrates that beginning computer users notice the physical and social setting in which they learn about computers. The authors of the study concluded that beginning computer users are influenced by the social order surrounding computing and by the attitudes and behaviors of people who excel in the field. To the extent that males and females interpret social clues differently, and previous research indicates that they do (e.g., Hoffman, 1977), they will have different interpretations of and reactions to computing environments.

The physical structure of computing facilities, with their individual and segregated cells, conforms more to the masculine separation and individuation social style described by Gilligan (1982) than to her description of the feminine social style, which is characterized by personal connections and networks.

Strategies such as peer tutoring (Chen, 1985), team computer work, and computer networking to connect people (Kiesler et al., 1985) may reduce females' interpretation of computers as isolating, non-social machines and may make the culture of computing more compatible with feminine values and social styles.

Because males tend to dominate computer rooms and computer resources (Canada & Pringle, 1989; Kolata, 1984), providing females-only times in computer facilities and females-only computer classes (Call, 1987) have been effective strategies for encouraging females' computer learning and mastery. The call for single-sex learning opportunities for women may be labelled by some as segregative and thereby—based on the Supreme Court's 1954 ruling on racial segregation—unequal. However, the reality is that, with regard to computer-and-technology related learning opportunities, it is mixed-sex settings that are frequently unequal for females.

Opportunities to use computers often require potential users to compete with each other for computer time. Increasing numbers of researchers (e.g., Arch & Cummins, 1989; Kiesler et al., 1985; Swadener & Hannafin, 1987; Swadener & Jarrett, 1986) have argued that when competition is the basis for opportunity, females frequently opt not to participate. In other words, females tend to avoid spending time on computers if they have to compete to obtain it.

Some evidence for the contention that females avoid competitive situations comes from Kiesler et al.'s (1985) observational data collected in gambling establishments in Reno, Nevada. Males dominated the gaming tables, but there were equal numbers of males and females playing the video versions of the games. This finding is interesting because it contradicts research (e.g., Hanson, 1983) showing that males prefer playing games on computers rather than with other people, whereas the opposite tends to be true for females. It also provides findings contrary to what one would hypothesize on the basis of the technological gender gap.

One interpretation of the finding is that it is not necessarily computers and technology per se that females avoid, but rather the competitive, male environment that surrounds the field. Corroboration of this hypothesis about females' choices in such settings awaits further research. In the interim, findings from research (e.g., Arch & Cummins, 1989; Swadener & Hannafin, 1987; Swadener & Jarrett, 1986) demonstrating the benefits for females of removing competition as the basis for computer instruction and use should be incorporated into educational and training endeavors.

In sum, educators should ensure that the physical and social structures of computer learning environments enhance rather than impede females' opportunities for computer learning. Attempts to create such environments should be informed by research on females' social and cognitive development as well as on computer training programs that have proven successful for females.

Recommendation: Integrate computer work and programming skills across the curriculum. Sheingold, Kane, and Endreweit (1983) reported that many educational institutions acquire computer equipment without an *a priori* plan for how it will be used in the curriculum. As Hawkins (1985) explained, computers are most often integrated into mathematics and science courses because of their salient relationship to those areas. As a result of this pairing with subjects that are stereotypically male (Fennema, 1984), computers have, by association, been labelled masculine.

Computer technology, however, is not the domain of any one discipline (Lockheed, 1985). Computers have applications for all fields of study; therefore, the integration of computers into the curriculum should reflect their broad range of potential applications for every academic pursuit, regardless of the discipline's traditional gender label.

The convergence of results documenting the benefits for females of taking programming classes, coupled with the statistics showing low enrollments of females in those classes, illustrates a situation in which those who would benefit most from computer instruction are not receiving it. Attempts to mainstream components of computer programming into areas of the curriculum in which females are highly enrolled should be made in conjunction with efforts to entice female students to enroll in computer programming courses. Whether or not these mainstreaming techniques will yield the same ameliorating effect on the technological gender gap as programming classes awaits empirical investigation. In the interim, such efforts will advance efforts to demonstrate the value of computers in all disciplines.

Recommendation: Eliminate sexist stereotyping and stereotypic themes from computer software. Many researchers have noted the sex stereotyping in the themes of computer software (e.g., Hess & Miura, 1985; Kiesler et al., 1985; Kolata, 1984; Tittle, 1986). The new genre of electronic games such as Nintendo, which is played on a television monitor rather than a computer screen, continues the emphasis on male-oriented themes. A clerk at a video rental store in Baltimore, Maryland, reported to the second author of this article that the top three video game rentals for December 1989 were *Megaman II* (space and destruction theme), *Tech-Mobile* (futuristic football), and *Jordan vs. Bird* (basketball). What is more, the clerk was unable to recommend any games that would be especially appealing for young girls.

When female characters do appear in the video games, they are cast in secondary roles or are portrayed as helpless and in need of rescue from the male heroes. For example, in *Mario Brothers*, one of the cartridges that comes with The Nintendo Home Entertainment System, the goal is for the main characters, Mario and Luigi, to rescue the helpless princess. In the *Mousecapades* game, Minnie Mouse literally follows Mickey around as he combats foes and racks up points. In the course of the game, Minnie is kidnapped by a giant crow and Mickey's job is to rescue her.

So, the issue of gender stereotyping in current software and electronic games is actually a two-tiered problem. The first level of barriers to females' participation is that the topics are predominantly male oriented and therefore may not be as enticing to potential female users as they are to potential male users. For those females who do cross that first barrier and play the games, there are subtle messages about appropriate male and female behaviors. The messages are that males are active, competent, and in control, whereas females are passive, helpless, and in need of male assistance. The same messages have been documented in children's books (e.g., Saario, Jacklin, & Tittle, 1973) and in children's television shows (e.g., Sternglanz & Serbin, 1974).

Feminist writers (e.g., Sanford & Donovan, 1984) have argued that such messages undermine females' sense of efficacy and self-esteem. *Custer's Revenge*, in which the goal is to kill Indians and rape squaws, is a particularly chilling example of sexist computer software. As a joke, a male colleague introduced Mary Rowe, special assistant to the President at MIT, to the program. Rowe described hating seeing atrocities presented as a game and speculated that women who were not tough-skinned could be devastated by the experience (Kolata, 1984).

In his interview with John Seeley Brown, founder of the cognitive-science research group at the Palo Alto Research Center, Goleman (1984) provided an excellent example of the extent to which the world of computer software, and now electronic games, is developed predominantly by males for males. The research group's mandate has been to open up new areas of *man*-machine communications. Brown elaborated on this goal by describing the ultimate machine as one ". . . that acts with the subtlety of a sensitive coach. It's like a good skiing coach who watches you ski downhill, then makes one offhand remark that changes your whole performance" (p. 24).

To illustrate how such a machine would operate, Brown described a program developed to diagnose children's mathematics strengths and weaknesses. After the diagnosis, the machine would break in and remediate the child's skills. The program had a Wild West theme and was entitled, "How the West Was Won." The imagery Brown referred to—athletics, the Wild West, competition—was all stereotypically male.

Both Brown and his colleague, Tom Moran, stressed the importance of designing computer systems to match the way humans think. Moran explained that the creation of a well-designed system depended on understanding the way people's minds build mental models of the system. If the gender of the user and the possibility that males and females build different mental models are ignored, there is a very real possibility that the next generation of human-machine communication systems will serve to widen rather than close the technological gender gap.

There is information, although sparse, from research and from educational programs that can provide clues for facilitating the female-machine interface. While investigating the components of computer-based instruction that are motivating for students, Malone and Lepper (cited in Wilder et al., 1985) discovered that girls liked music in the game, but disliked the imagery of arrows popping balloons. Boys' preferences were just the opposite. Sheingold et al. (1983) found that female students were particularly responsive to computer software that allowed them to interact creatively with the computer by making pictures and choosing colors. In their attempts to incorporate computer technology into the middle school curriculum, Spoehr, Nyce, and Vaeder (1990) discovered that coupling a computer-based instruction program on American history with a role-playing exercise was particularly effective for female and minority students, who outscored white male students on subsequent tests about the material.

These findings are too sketchy to provide clear directions for increasing the appeal of computers and computer learning experiences for females, but they do highlight the necessity for respecting gender differences when designing computer-based instruction. Designers of CBI can play a vital role in narrowing the technological gender gap by increasing the appeal of entertainment software and electronic games for females, incorporating information about the female-machine interface into product design, and reducing sexist stereotyping of characters.

CONCLUSION

This review documents that male and female students in elementary school through college have different computer-related attitudes and behaviors. The differences are such that female students are at risk for missing out on the skills and knowledge that are prerequisites for success in increasingly technological educational settings. The etiology of this technological gender gap is multifaceted; therefore, it cannot be remedied with a single, simple solution. The recommendations presented here are not comprehensive, but are suggestive of the types of actions educators and CBI designers should take to begin narrowing the gap. Although not emphasized strongly in the recommendations, the implementation of intervention strategies should be guided by the results from research on females' cognitive, social, and psychological development. Where there are gaps in the research—and there are many—attempts should be made to combine ongoing research programs with flexible intervention strategies that can be modified to incorporate the emerging findings.

The need to remedy gender inequities in computer education and access is dire. Ignoring, denying, or failing to respond to the technological gender gap is likely to render large numbers of female students unprepared to meet the technological challenges of the future. □

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