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THE DIGITAL DIVIDE: THE ROLE OF GENDER IN HUMAN COMPUTER INTERACTION

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INTRODUCTION

This is the age of the computer. Whether we use a personal computer to balance our checkbook, operate a mainframe that sorts signal intercepts for our government, or work the cash register at the local Burger King, the steady hum of computer technology permeates our daily existence. Comparison shopping can now be done in seconds online with a few mouse clicks, rather than in days of real-world driving. University bookstores now compete not only with local equivalents, but also with online merchants on other continents often with favorable consequences to the wallet and purse. The cost of distributing ideas has reached an all-time low, forever altering political dialogue, and websites have brought together far-flung communities dedicated to everything from Japanese cartoons to satanic cults. According to the latest available figures from the U.S. Census, 61.8% of households in the United States have home computers and 54.7% have Internet access (U.S. Census, 2005).

This prevalence masks a persistent problem, however. While the 61.8% figure is impressive from the perspective of merely a decade ago, it is nonetheless true that the increase in computers has not been uniform across every subgroup in society nor has it affected all groups in the same way. To the contrary, the computer revolution has left some groups behind. A person with a bachelor's degree is 30% more likely to own a computer than a person with only a high-school education. A household with an income of $75,000–$99,999 has a 90% chance of owning a computer; one with an income of $25,000–$49,999 has a 67% chance. There are also racial differences in computer ownership. White and Asian Americans are over 20% more likely to own a computer than Black and Hispanic Americans (U.S. Census, 2005). Moreover, in the last decade of the 20th century, the gap in computer ownership between African Americans and Whites widened. These differences persist even when controlling for income. It has been shown that owning a computer leads to dramatic advantages on academic test scores. It is particularly interesting that, controlling for the number of computers in a particular household, wealthy Americans and White Americans gained even more of an advantage than poor and minority students (Atwell & Battle, 1999).

A divide also exists between men and women, with women not enjoying the benefits of the technological revolution on par with men (Cooper & Weaver, 2003). The difficulties women face while using computers are sweeping. They are underrepresented in their use and ownership of computers (Pinkard, 2005; Wilson, Wallin, & Reiser, 2003; Yelland & Lloyd, 2001), take fewer technology classes in high school and college (Pinkard, 2005), are far less likely to graduate college with degrees in IT fields and, most significantly, enjoy interacting with computers much less than do men (Mitra, Lenzmeir, Steffensmeir, Avon, Qu, & Hazen, 2000).

Computers are becoming central to more jobs every year. Current estimates suggested that by 2010, 25% of all new jobs in the public and private sectors will be technologically oriented (AAUW, 2000). However, even more important, computers play a role in all of the basic activities of life from banking, to shopping, to—increasingly—voting. Decades ago, computer innovation was driven by the space program, the cold war, and military technology. Now, a new car's computer technology is more than 1,000 times more powerful than what guided the Apollo moon missions (Alliance of Automobile Manufacturers, 2006). Computers are inescapable. With all of this in mind, it is a societal problem that the path to computer efficacy is more difficult for the poor, ethnic minorities, and women (Wilson, Wallin, & Reiser, 2003).

THE DIGITAL DIVIDE

Discrimination against women, at least in certain domains, has deep and complex roots. Understanding the basis of such discrimination is important and complex. The roots of the digital divide share some commonalities with discrimination that women have faced in employment and professional advancement but also have their own distinct origins. The use of computers in the home, classroom, and workplace is only a few decades old, which affords us the opportunity to gain a glimpse at the genesis of the particular problem of the gender divide in information technology.

In the late 1970s, computers began to replace television as the technological innovation in the classroom. By the 1980s they were ubiquitous in education and on their way to becoming a fixture in most households. In this context, Wilder, Mackie, and Cooper (1985) surveyed school children to assess their attitudes toward computers. They found a large difference in the degree to which boys and girls were attracted to the computer. As early as kindergarten, boys indicated more positive attitudes about computer technology than girls. These small attitudinal differences became dramatic in the fifth grade and continued to grow through the middle- and high-school years (Wilder, Mackie, & Cooper, 1985). Computer use had just begun to spread into the mainstream of public life, and numerous explanations for the difference were considered. Wilder et al. hoped that the gender differences in regards to computers were either an artifact of the particular geographic area studied in the investigation or something that would diminish as technology became more widely accessible. It was easy to hope that the problem would fix itself in those days; public education is a great equalizer.

This was not to be the case. Disturbing effects discovered in the 1980s persisted into the 1990s. The clearest data was not on the question of usage, but on anxiety. In a host of domains, both young girls and older women reported that computers are not creators of fun and amusement but rather the source of apprehension. Weil, Rosen and Sears (1987) reported that about 1 in 3 adults in the United States experienced what they called "computerphobia"—adverse anxiety reactions to the use of computers. Dembrot and her colleagues were among the first to investigate the imbalance in computer anxiety as a function of gender. They found that female college students expressed considerably more anxiety about computers than did their male counterparts (Dambrot, Watkins-Malek, Silling, Marshall, & Garver, 1985; see also Temple & Lips, 1989). This finding was replicated frequently throughout the 1990s (i.e., Colley, Gale, & Harris, 1994; Todman & Dick, 1993). In the late 1990s, these differences between males and females were as ubiquitous as they were in the 1980s, with females from elementary school grades to university graduates expressing greater anxiety and negative attitudes (Brosnan, 1998; Whitley, 1997).

Now, in the first decade of the 21st century, there are some promising signs that the gender gap in computer technology may be weakening. The U.S. Census showed marked increase in computer use by women, especially in the use of the Internet and e-mail and in the workplace. Nonetheless, despite the increased use, women continue to lag behind men in feelings of competence with the computer. They also continue to suffer greater anxiety about using information technology and have fewer positive attitudes about working and playing with the computer than do men (Colley & Comber, 2003; Schumacher & Morahan-Martin, 2001). Surveying school-age children and comparing their responses to those collected more than a decade ago, Colley and Comber (2003) found that girls' interest in computer applications improved, but that girls continue to like the computer less than boys do. When given a chance to use computers in the voluntary world outside of school, girls use the computers less frequently than do boys. Similarly, Mucherah (2003) recently reported that teenage girls feel far less involved with computers and enjoy them less than boys of comparable ages. At Princeton University, researchers asked incoming college students about their reactions to computers (Cooper & Weaver, 2003). Despite having a highly capable and academically accomplished sample, they found that the young women were far less confident of their ability with computers than were the young men. The incoming female undergraduates reported feeling significantly less comfortable with computers than the men did, even though most of them had taken computer classes in their high schools and more than 80% of them had taken higher-level mathematics, including calculus. That any differences were seen in such circumstances is very discouraging, and the effects were not small.

Those same researchers also asked incoming students to imagine that they were going to take a course in psychological statistics. They presented the following question: Suppose that you were asked to complete a statistics homework assignment on the computer. How comfortable would you feel in doing that assignment? These highly capable students again differed based on gender. Men felt that they would be comfortable completing the assignment while women felt uncomfortable (Cooper & Weaver, 2003). Therefore, the lack of confidence just noted is not merely an abstract concept. Even in the context of a specific example, women were just not as sure of their abilities as men were. We can easily imagine that the difference might have been even greater had 4 out of 5 of the women not already completed courses in calculus.

The digital divide is a worldwide problem. Much of the previous research was conducted in the United States. Other studies from Western Europe and other highly developed countries show similar effects. Data have been gathered in Great Britain (Colley, Gale, & Harris, 1994), Australia (Okebukola & Woda, 1993), Canada (Temple & Lips, 1989), and Spain (Farina, Arce, Sobral, & Carames 1991), always with the same result. In a review of this literature for the International Association for the Evaluation of Educational Achievement, Reinen and Plomp (1997) concluded that, "concern about gender equity is right. . . . Females know less about information technology, enjoy using the computer less than male students and perceive more problems with . . . activities carried out with computers in schools" (p. 65).

As interest in this issue has intensified, additional international data have led to the same conclusion. Recent data reported from Romania (Dundell & Haag, 2002), Egypt (Abdelhamid, 2002) and Italy (Favio & Antonietti, 2002), for example, continue to show the persistence of the digital divide in a wide array of educational systems around the globe. Although there are some exceptions, (i.e., Solvberg, 2002, in Norway) gender differences have been remarkably durable.

What the Digital Divide Is Not

The gender gap is less about total hours using a computer than about using a computer voluntarily for enjoyment and comfort with information technology. In schools, it is not about total number hours spent in front of the computer screen, but rather the interference of computer anxiety with the ability and excitement to learn. In the workplace, the digital divide is not about the magnitude of use, but rather about women's reactions to the technology with which they interact. It is about their comfort, attitudes, and levels of anxiety. Women use computers at their jobs more than men do. The use of the computer as typewriter and cash register, for example, necessarily requires human computer interaction (HCI) in the workplace, and with women holding far more service and administrative support jobs than men, their computer use is relatively high. In fact, in 2003, 63% of women used computers for their jobs; whereas only 51% of men did so.

Exposure in the workplace and in the school has not ended the disparity between men and women in terms of their levels of comfort using a computer, attitudes about computers, and willingness to use computers in contexts in which computer use is not required. Especially in educational settings, anxiety with using computers can not only result in a feeling of discomfort, but also can lead to less-adequate performance with the computer and the material that was supposed to be learned more enjoyably and efficaciously with computer technology.

UNDERSTANDING THE ROOTS OF THE DIGITAL DIVIDE

The digital divide is not caused by lack of use, nor is it due to differences in economic status, social class, or heredity. We also assume that differences based on biological sex play, at most, a negligible role in accounting for the differences. Rather, we see the different reactions to information technology to be rooted in the socialization of boys and girls as they learn to cope with the social constructions that form the norms, rules, and expectations for their gender. As a heuristic guide to understanding the digital divide, we propose a model that described a series of factors whose result is differential attitudes and differential comfort levels with the use of computers in contemporary society.

The model, which we will describe in more detail in the following sections, takes as its starting point the idea that there exists in our social world entrenched stereotypes of the behaviors and attitudes that are appropriate for children and adults of each gender. Boys are supposed to be more eager to play with computers than girls. The most important consequence of this stereotype is that girls will experience more anxiety when playing with, or learning from, computers; thus making it difficult for them to have pleasant and successful computer interactions. This will happen whether or not girls accept the stereotype as valid. Girls who accept the stereotype as valid will be harmed by what is referred to as the "self-fulfilling prophecy" (Merton, 1948; Rosenthal & Jacobson, 1968). Ironically, girls who do not believe that the stereotype is true will nonetheless experience anxiety with computers because of the phenomenon known as "stereotype threat" (Steele & Aronson, 1995). The mere knowledge that the stereotype exists and other members of society believe it sets in motion processes that lead to confirmation of the stereotype. As the model showed, a girl who knows that there is a stereotype predicting poor computer competency on her part will experience more computer anxiety and, in the end, poorer performance and more negative attitudes about computers. This, in turn, will lead to anxiety and a greater chance of failure.

Our model also shows that different attributional patterns for boys and girls contribute to the cycle that perpetuates the digital divide. Because of the different interpretations that boys and girls are taught with regard to success in achievement domains, the stereotype about the relation of gender to computer use may become reinforced and more resistant to change. As Fig. 38.1 suggests, the dilemma is a self-reinforcing cycle in which boys, typically to their advantage, and girls, to their disadvantage, become enveloped in the veil of the gender stereotype for computing.

In the Beginning

Undeniably, gender stereotypes abound. Like most stereotypes, they were created by society over an extended time, and even though they are now undesirable, they are reluctant to be dismantled. Regardless of whether or not they are true, stereotypes have dramatic impact on behavior. For example, in most western societies, we share common societal expectations about the toys boys and girls are supposed to play with. We do not expect to see the war characters in our favorite toy store sharing shelf space with dress-up dolls and doll strollers. To the contrary, we expect that the warriors will be near the cars, trains, and space heroes. The dolls will be near the carriages, play houses, and play schools. Boys will find their toys in the former section; girls in the latter. In reality, of course, there is gender overlap such that some boys find their favorite toy in the section with dolls and carriages. And many girls are in toy-heaven when confronted by the cars and trucks. However, in general, there is a strong effect for gender stereotyping of toys, based on and reinforced by, adult expectations of what is expected to be interesting and pleasing to boys and girls.

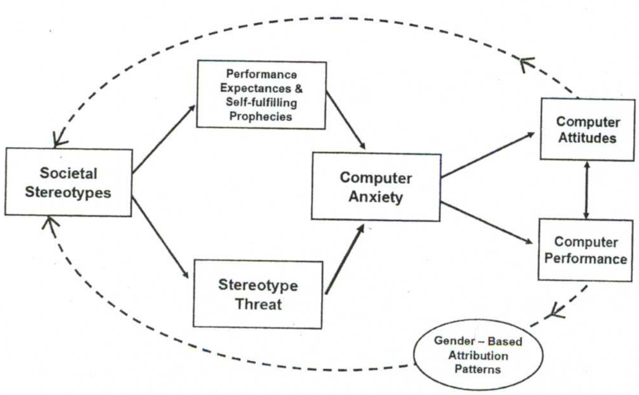

FIGURE 38.1. A logical model of digital divide.

Gender stereotypes abound in the classroom as well. Regardless of whether or not the stereotypes are true, we see mathematics, science, and technology as the province of boys more than girls. Girls write well and are interested in literature and poetry. Computers are the bedrock of information technology and, as we have seen from surveys of children and adults described above, in established democracies and developing nations, we have a similar stereotype about who enjoys and benefits from computers. It is not immediately apparent why gender stereotypes developed for computers become nearly identical to stereotypes about science and mathematics. Although the algorithms that comprise computer software are complex and mathematically sophisticated, and computers burst into our consciousness in large-scale space and science ventures, most computer users do not interact with computers at that level. A screen, keyboard and mouse pad form the basis of the interfaces that most people have with computers. Why did the use of computers become associated with gender?

The answer to that question is multidetermined and a full analysis is beyond the scope of the current chapter. However, we can isolate one of the causes of the gender stereotype in the introduction of the computer into the educational system. The classroom is a ubiquitous melting pot and its influence on children's attitudes is profound. When educators first looked to computers to supplement their normal educational methods, they made an understandable, though fundamental, error. They drew their inspiration from the world of the video game and video arcade. The best examples of popular computer games in the 1980s were not the increasingly rich variety currently available, but the far less diverse sampling of the video arcade and the early Nintendo and Sega gaming systems. While these programs drew their contexts from a multiplicity of domains, everything from medieval combat to futuristic space adventures, what most had in common was an emphasis on competitive responding. As games grew more elaborate, story lines were increasingly incorporated to keep children's interest in space adventures, sports, and battles.

Educators have always searched for ways to make learning more efficient and more enjoyable. That computers can give students an interactive experience makes them an obvious and attractive addition to the classroom. Computer-software manufacturers turned out hundreds of programs designed to assist teachers in delivering instruction in every discipline from art to zoology. They most likely contemplated how to design such programs and wondered what children wanted. One thing that was obvious at this time was that childred would rush to finish—or ignore entirely—their homework for a chance to hit the arcade. Video-game designers were posting large profits and the growth of their industry seemed to be limited only by rapidly disappearing technical issues. If children would voluntarily spend hours navigating the story line of *Kings Quest*, it seemed fair to assume that instruction delivered in the same game-like format would be popular.

What went unnoticed was predominantly boys visited arcades and spent hours playing their favorite video games. Turning classrooms into video arcades by adopting software that resembles video games might have been attractive to most young boys, but it presented a problem for girls. Every benefit that was gained among video-game players by making learning software the image of video games was a deficit to those who did not relate to or enjoy such games.

One of the earliest analyses of the issue of computer technology in the classroom was that of Lepper and Malone (1987). They asked girls and boys what they liked about computers. The responses of boys matched intuitions. Boys liked activities that were in the form of games. Story-lines featuring sports, war, and space were popular. Boys liked eye-hand coordination and competition. They preferred their feedback in the form of flashing lights, blaring sounds, and explosions. Girls were different. They disliked competitive programs, the videogame emphasis on reflexes, and the dramatic end games. What they wanted was better learning tools. Frequent and clear feedback, preferably not in the form of explosions, was also favored. Girls appreciated computers as learning tools, but found the game focus very disheartening. With computer-assisted instruction (CAI) programs like *Word Invasion, Demolition Division,* and *Slam Dunk Math*, it is clear that boys were more precisely targeted than girls. Chappel (1996) reported that in the real worlds of education and business, programs overwhelmingly favor male identification and male interests. Yet such programs have been one of the major ways in which children are introduced to computers. The grand attempt to "make learning fun" has been premised on an unfortunate, gender-biased definition of the word "fun" that is not widely applicable.

A Designer's Bias

Why is there such a strange disconnect between program designers and female users? (See Lynn, Raphael, Olefsky, & Bachen, 2003 for a discussion.) There are many possibilities. Men are more interested in computer programming than women, and one could say that male programmers are more likely to produce male-focused software, but that is both uncharitable and hard to test. Of far greater interest is the possibility that software designers implicitly assume that their users will be male and tailor their work accordingly. In everyday communication, we often adapt our tone to our audience. If we think our audience is hostile, we are likely to act in a more hostile manner ourselves (Snyder & Swann, 1978). Similarly, if a male college student believes that the female he is speaking to is attractive, he is likely to act in a friendly and inviting manner (Snyder, Tanke, & Berscheid, 1977). In HCI, a software designer is interacting with a communication partner, albeit a strange one. In the mind's eye of the programmer is an eventual user. Someone is sitting at the front end of the computer screen, answering questions, and interacting with the program. But who is that user? It is possible that the software designer uses stereotypical beliefs to portray the most likely consumer for whom he or she is preparing an educational or entertainment product. In this view, computer programmers write software as though they are communicating with boys because their automatic representation of the gender of the user is male.

Huff and Cooper (1987) investigated the possibility that the gender of the typical user influences the communication process and, accordingly, the characteristics of the software that is produced. They asked teachers in the New Jersey public schools to design software to help seventh-grade children learn the appropriate use of commas. The teachers were given one of three different instructions. One group of teachers was asked to design the software for seventh-grade boys, another for seventh-grade girls, and the third, most interestingly of all, were just told to tailor their work for seventh-grade "students." These teachers were all well versed in the likes and dislikes of seventh graders. Their designs were always fascinating and the two gender-specific conditions produced the kind of program concepts that Lepper and Malone (1987) would have expected. In describing her boy-directed idea, one teacher wrote:

> here is an opportunity to enjoy the world, do sports, and learn English grammar at the same time. Your child will enjoy shooting cannons and competing for the highest score. After playing with this program, you child will use commas in a natural and correct manner.

The group writing for girls had no difficulty in guessing the right features to include. A typical response was expressed by one teacher when she described her program as, "Two girls go on a shopping trip to a record shop to find music for a dance being given at school. They converse with each other and make decisions about what to buy. The use of commas and rules involved are taught through this trip. Reinforcement is available in worksheet form." The activity is social, not military, and lacks the boyish embellishments that girls find anxiety inducing.

The teachers recognized that they needed to write vastly different programs to motivate students of different genders. While their results appear to rely heavily on gender stereotypes, they do recognize the problem and produce programs that are appropriate to the point of caricature. Based solely on these conditions, one would expect that teachers would be able to find a happy medium when working for "students."

The "student" condition, however, is precisely where the problem arises. Teachers designing without a specified gender did *not* assume that half their users would be male and half would be female. Their answers were resoundingly like the programs that had been written for boys and nothing like the programs that had been written when girls were the focus of attention. A typical description in this condition began, "Here's a fast-paced program for your arcade-game lovers. Just what the teenager spends his quarters on! . . . . Sentences zip across the screen—some correctly punctuated with commas, some not. Correct sentences are "zapped" off the screen by your students as they try to be on the roster of top scorers."

Programs that most teachers wrote for "students" were nearly identical to programs that other teachers wrote for boys. All of the programs were coded and assessed by independent raters and then subjected to a multidimensional scaling analysis.

The results showed that the programs written for students were statistically indistinguishable from the programs written for boys on a dimension that ranged from "learning tool" to "toy." Both were markedly on the "toy" end of the dimension. Programs written when girls were the focus of attention were written as learning tools and were significantly different from both the boy and student programs (Fig. 38.2).

Greater, Anxiety, and Poorer Performance

Even though it was clear that most educational programs were designed with the boy definition of fun in mind, it still remained to be seen what effect these programs had on girls compared to more gender-neutral—though far less common—alternatives. Cooper, Hall, and Huff (1990) examined this issue using *Demolition Division,* a program intended to teach division in a stereotypically boy manner by employing war-related imagery, competition, and eye-hand coordination. Its manufacturer described it as "an opportunity to practice the division of problems [*sic*] in a war game format. Tanks move across the screen as guns from bulkheads are fired by the students as he answers the problem. Hits and misses (correct and incorrect answers) are recorded at the bottom of the screen." The researchers had middle-school boys and girls learn division with either this program or another one, *Arithmetic Classroom,* a CAI program that lacked all of the features of a stereotypically boy-focused game but taught essentially the same information. The students worked with the program for several minutes in a computer cluster in their school. Following the exercise, the children filled out a questionnaire assessing their liking for the CAI-learning program as well as their level of anxiety and stress. When they returned to the classroom, their ability to perform division problems was assessed.

The data showed that girls liked the *Demolition Division* program less often than boys did, and the girls also were considerably more anxious at the conclusion of the CAI lesson. In addition, the level of anxiety was negatively correlated with performance: the more anxious the student, the less she had learned. In *Arithmetic Classroom*, however, the results were quite different. Remember that this program had no competitive elements, no eye-hand coordination tasks, and no war-story plot line. The anxiety levels of girls using this program were not any higher than those of boys. Girls felt quite comfortable and experienced slightly less anxiety than did the boys. The results are shown in Fig. 38.3. When the computer software had the formal elements that boys enjoy, girls showed the typical pattern of the digital divide: They experienced stress and anxiety and, consequently, did not perform as well. There was no evidence for the gender divide when the program had the formal features that girls enjoy.

Nearly a decade after Cooper et al., another group of researchers found a similar effect in a more elaborate computer game. In this case, the variable of concern was not flashing lights or explosions, but identification. Littleton, Light, Joiner, Messer, and Barnes (1992) worried that many of the storyline CAI games did not include characters that girls could relate to. These researchers targeted a popular CAI game called *King and Crown*, which taught a series of spatial reasoning skills in an adventure format. The characters in the game, however, were primarily warriors and the game was aggressive. Boys learned the skills necessary for the game and fully succeeded in the adventure approximately 50% of the time. Girls were successful only 8% of the time. Littleton et al. found that the male-oriented world of *King and Crown* caused the girls to disidentify, become anxious, and withdraw. Yet, the problem was with the context, not the content. When performance was examined in another program, one that taught the same skills in a gender-neutral context, girls and boys performed equally well. Now, 50% of both genders completed the game. Taken together, the Cooper et al. (1990) and Littleton et al. studies suggested that girls are not innately inferior at learning through computer programs. The problem is in the design of the game. Programs rich in boy-favorable elements are not efficient learning tools for girls; their anxiety level increases while their interest and performance decrease. Also important is that boys do not do worse on the programs that allow girls to do better.

The problem is not one confined to young children in the lower grades. The problem may start there, but it persists into adulthood. Surveys have revealed negative attitudes and higher

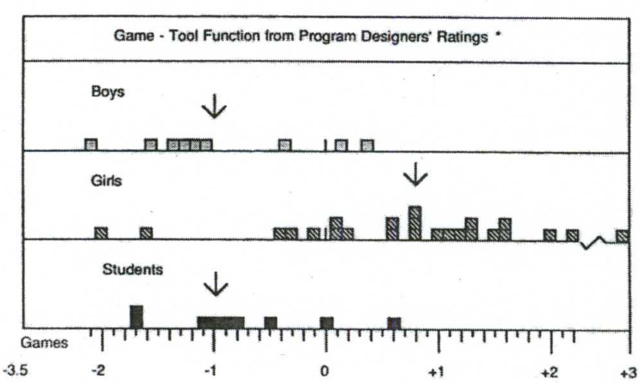

FIGURE 38.2. Level of computer anxiety after learning from a male oriented (Demolition Division) and Control (Arithmetic Classroom) Computer Assisted Learning program. (Source: Huff & Cooper).

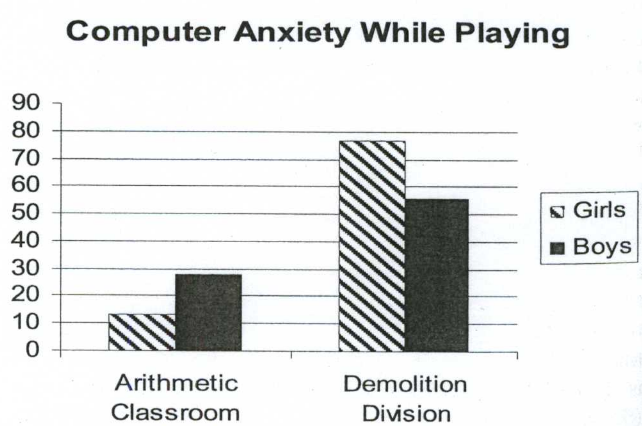

FIGURE 38.3. Results of multi-dimensional scaling depicting programs written by teachers for instructing boys, girls and students. The arrows depict the central tendency of each condition. (Source: Huff & Cooper).

computer anxiety among females in college, the workplace, and among retirees (Zhan, 2005). Experimental data collected with college students also support the negative effects of male-favored software on women's levels of computer anxiety. For example, in a study by Robinson-Staveley and Cooper (1990), men and women students at Princeton University played the game of *Zork,* in which players compete to find a buried treasure in an adventure-game format. Women reported a high degree of stress while playing the game and, in turn, performed poorly. Male students, on the other hand, performed considerably better and did not experience computer anxiety.

Another interesting finding in the Robinson-Staveley and Cooper (1990) study is that the social context of computing has a substantial effect on the experience of computer anxiety. In their research, gender differences in performance occurred only in the presence of other people. If the students were asked to solve the *Zork* adventure in complete privacy, the women did well (better than the men) and experienced only a little computer anxiety. Similarly, middle-school girls in the *Demolition Division* study did not experience more computer anxiety than boys if they worked with the CAI program without the presence of others (Cooper et al., 1990).

The social context also matters when the gender composition of learning groups is considered. Girls learning in the presence of boys suffer from increased computer anxiety and learn less. Light, Littleton, Bale, Joiner, and Messer (2000) had boys and girls work with a mildly competitive problem-solving game in which the players' task was to reach a geographical location without being captured by monsters. The children worked in groups of two, either same sex or opposite sex dyads. Light et al. (2000) found that, overall, boys performed better than girls in this game. However, in same-sex dyads, the difference in performance was small. In mixed-sex dyads, the difference was enhanced. Boys' performance was markedly improved relative to their performance in the same-sex group while girls' performance showed significant decrements.

Nicholson, Gelpi, Young, and Sulzby (1998) examined the interactions that occurred when first-grade girls and boys were asked to work together on a computer task. They found that, in mixed-gender groups, girls were likely to have their competence and/or their work criticized or laughed at compared to girls working with other girls. It is unsurprising that taking an already somewhat anxious person and putting her in a position where she may be subject to ridicule or competition worsens performance, but it is still an important consideration. While the centrality of social context in these effects relates more to usage environment than program design, these findings underscore the socially constructed nature of the gender gap. In a more friendly and accepting environment, girls can prosper.

What we have seen through the analysis of patterns in education software is just part of one path through the model we propose. Gender-stereotypes have led to the creation of programs that increase the girls' computer anxiety. This anxiety then lowers their computer performance, making them more skeptical about their computer ability and reaffirming the stereotype. However, software and peer environment are not the only means through which society can affect a woman's computer success. What are the effects of an authority figure, a parent, a teacher, a boss, holding such a stereotype?

The Hazards of Low Expectations

Reactions to stereotypes can vary. First, the stereotype can be believed. There is good reason to believe that gender-based stereotypes can have the power of the self-fulfilling prophecy, creating further evidence for the stereotype. The classic self-fulfilling prophecy study was conducted in a classroom setting by Rosenthal and Jacobson (1968). These researchers convinced teachers that a new test of intelligence could predict which of their students were likely to experience sudden improvements in their academic ability during the next school year. Some students were identified as likely to show these "spurts," but for the majority, nothing was said. When they tested the students at the end of the year, they found that students that the teachers had expected to show considerable improvement did perform much better on standardized tests than students not labeled that way, especially among younger students. The interesting part of this study was that the test Rosenthal and Jacobson administered was entirely bogus and the results were intentionally randomized. The teachers responded differently to students whom they expected to perform well. While no data shows exactly the nature of this difference, imagination provides a host of possible explanations; the teachers could have been more encouraging, more attentive, and more supportive of those they "knew" could do well. This study has long been seen as a warning to teachers to be careful in labeling their students either positively or negatively. Students are attuned to the expectations of their superiors and can be persuaded to either try harder or give up based on what is expected.

Word, Zanna, and Cooper (1974) showed that stereotypes about groups of people also impact peoples' performance. Their study made use of implicit racial stereotypes about African Americans. In the context of a job interview, Word et al. showed that the negative racial stereotypes that White job interviewers held about the traits and capabilities of Black candidates subtly and nonconsciously affected the way in which they behaved toward White and Black applicants. Although the interviewers did not consciously realize it, they behaved in subtly more negative ways toward the Black applicants than they did toward the White applicants. They spoke more quickly to African Americans, avoided eye contact, and sat at greater distances. In the end, it was clear that candidates who were treated in these ways performed objectively worse in their job interviews (Word et al., 1974).

These studies, as well as many others, should serve as a caution to parents and teachers. Believing that girls dislike computers or are not competent with them can directly lead to girls being treated differently when interacting with computers. Adult educators and parents who introduce the computer tasks to children may have negatively stereotyped beliefs (like the interviewers in the Word et al. study) and communicate these beliefs in subtle ways to their children. Self-fulfilling prophecies have the added danger of promoting resiliency in the stereotype because those parents and teachers who hold stereotypical beliefs will often see them confirmed. What they do not realize is that their lessons, their examples, and their communications may have contributed to creating the very disparity they believe they are observing (Schofield, 1995).

The self-fulfilling prophecy literature also provides examples of how expectations about *oneself* can affect one's future performance. Zanna, Sheras, Cooper, and Shaw (1975) modified Rosenthal and Jacobson's procedure by telling not only the teachers but also the students of the results of a bogus ability test. As was the case when the teachers believed certain students would excel, students who had been told that they should improve dramatically during the year drastically outperformed their peers in reading and math at year's end. In the context societal messages, a girl who comes to believe the stereotype about her gender can be expected to give up more easily and not become as competent as her peers. This link between computer attitudes and ability makes computer anxiety part of a vicious and mutually reinforcing cycle.

Boys, in believing that technology is in their domain, are likely to benefit from the self-fulfilling prophecy. Their parents, teachers, and other socializing agents act in ways that produce positive feelings about computers, and the boys may respond positively in the way they approach, think about, and perform with computers. This is also a reinforcing cycle. When trying to dismantle the negative cycle that holds back girls, one cannot neglect the positive cycle that enables boys. The message should be that technology is everyone's domain.

Mere Awareness: Stereotype Threat

People can also believe that the stereotype exists but disbelieve in the truth of the stereotype. For example, Devine's (1990) work on racial stereotypes shows that, regardless of whether White participants were prejudiced or not, they could quickly and automatically produce the list of traits that form Whites' stereotypes of Blacks. Even the most self-confident female computer scientist cannot help but be aware that most of the population considers her an anomaly. Unfortunately, even the mere knowledge of a stereotype can have harmful effects. This is another path between the gender stereotype and computer anxiety. It is called "stereotype threat."

Research on stereotype threat has shown that the mere knowledge of a negative stereotype applying to one's group can cause one to perform poorly at a particular task (Spencer, Steele, & Quinn, 1999; Steele, 1997; Steele & Aronson, 1995). Therefore, how does a girl in an introductory programming course get harmed by a stereotype she doesn't believe? She feels that girls are just as good at computers as boys. Or maybe she thinks that, even if the stereotype is true about girls in general, it is not true about her. She likes to use computers and generally does very well with them. Where is the weakness?

She could have two worries that would cause her to feel anxious. First, she may worry that others will judge her based on the stereotype. Even though she is bright and accomplished, she may worry that others still view her as a stereotypical woman. She may still have her work questioned and belittled just because of her sex (Nicholson et al., 1998; Schofield, 1995). It is a worry common to groups subject to discrimination. Such worries can distract her from the task at hand. With cognitive resources devoted to worrying about whether she is being judged according to the gender stereotype, the student may perform less well at the task.

The other worry is linked to the first. She knows there is a stereotype and she wants to disprove it. She doesn't just want to be good; she wants to overcome the deficit that people might believe exists. Task importance has been shown to be a key variable in stereotype threat research. The more something matters, the more it hurts to be reminded of the stereotype.

As in much literature about stereotypes, work on stereotype threat began with studies involving African Americans. Given the stereotype that African-American students are not as academically capable as White students, Steele and Aronson (1995) predicted that making this stereotype relevant would decrease the performance of black subjects taking a standardized test. Initially, they made the test relevant by saying that the test was a very reliable measure of academic ability. And students who thought the test was relevant performed worse than those who did not. The researchers went on to show that making the stereotype more salient also worked even if they did not tell the test-takers that the exam should accurately reflects their intelligence. Think about the two worries in the context of these experiments. Steele and Aronson's (1995) subjects were so concerned about confirming the stereotype that they did precisely that.

Spencer, Steele, and Quinn (1999) showed a similar effect using gender differences in mathematics. When women were told that the results of a test showed gender differences, they performed more poorly than when gender differences were not mentioned. Interestingly, the experimenters did not actually say that men outperformed women in the "gender-differences" conditions, but all subjects came to the appropriate conclusion.

Other research has shown that stereotype threat can affect a wide array of activities. Stone and colleagues have shown that Whites are likely to experience stereotype threat on activities that are alleged to be indicants of "natural athletic ability" when compared to Blacks (Stone, Lynch, Sjomeling, & Darley, 1991; Stone, Perry, & Darley, 1991). To revisit the math finding, Aronson and his colleagues showed that stereotype threat affected White males' performance on a mathematics test when they thought that the test was diagnostic of their performance relative to that of Asian-American males (Aronson, Lustina, Good, Keough, Steele, & Brown, 1999). Stereotype threat is a pervasive phenomenon that works by increasing anxiety and cognitive load.

The stereotype that links gender to computer performance is as well known as the others. Although there are currently no published studies to link the stereotype threat experienced by women to performance on the computer, the link between the two is clear to see. Especially when a student identifies with her gender and gender is a salient aspect of the social situation in which the student finds herself, then the same threat that dealt a blow to women's performance on mathematics tests. White males' performance on an athletic task should occur to women using the computer. Simply through knowledge of the existence of the stereotype, the woman is more likely than the man to succumb to that stereotype demonstrating greater anxiety and poorer performance.

Compounding the Problem: Gender Differences in Attribution

One of the more ubiquitous assumptions in the behavioral sciences is that people strive to understand the causes of their behavior in the social world. This axiom has given rise to a field of study known as "attribution" (Heider, 1958; Jones & Davis, 1965;

Kelley 1967; Weiner, 1979). In the wake of witnessing behavior, people are motivated to make attributions for the causes of the act, whether it is their own act or the behavior of another. If an athlete catches a football on the gridiron, was it because he was a good athlete (an internal attribution) or because it was an easy pass to catch (an external attribution) or simply because he was lucky, opening his arms at the right moment with the ball floating into his hands at just the right moment? Similarly, if I answer a question correctly on a standardized test, I wonder if it was because I am smart, because the test question was easy, or because I luckily picked the correct answer from a set of equally obscure alternatives.

In achievement domains that are stereotypically male, a pattern of attributions occurs that is protective for boys but damaging for girls. Boys come to feel that any success they achieve at a stereotypically male task is a function of their ability, whereas any failure is due to lack of trying, bad luck, or an unduly difficult task. This is a protective pattern because success serves to bolster boys' opinions of how good they are. It enables them to complete even more difficult tasks with a strong belief in their own ability to succeed. If they don't succeed, they can rely on the notion that they only need to try harder, pay more attention, or be more judicious in their choice of tasks. Lack of success, in short, does not translate into a belief in lack of ability.

Girls, on the other hand, make a very different pattern of attribution. Success is attributed moreso because of external factors such as luck, effort, or an unduly easy task; whereas failure is taken personally as confirmation of a lack of ability. This potentially damaging attributional pattern causes girls to believe that the primary route to success in a stereotypically male domain like math, science, or computer technology is through luck or effort. By continuously working hard, a girl may feel that she can achieve success, but it is not because of her ability or intelligence at the task. Failure, by contrast, can be devastating because it can provide evidence for what she already believed: That she is not a capable performer in the world that has, according to stereotypes, been the province of boys (Diener & Dweck, 1978; Licht & Dweck, 1984; Nicholls, 1975).

Parsons and colleagues examined attributional differences in the field of mathematics (Parsons, Meece, Adler, & Kaczula, 1982). Children were asked to rate their own ability at mathematics, as well the difficulty level of the courses they were taking. The children's parents were also asked to rate their children's math ability and course difficulty. Parents of girls believed that their children had less mathematical ability than did parents of boys. Moreover, the girls' view of their own ability was related to their parents' view, but not to their actual performance in math classes. Objective school records showed neither overall difference in the children's performance nor any difference in the difficulty of the courses. Nonetheless, parents unintentionally socialized their children into thinking that the girls were less gifted in math than their male counterparts.

More recently, Tiedermann (2000) surveyed several hundred elementary-school students and their parents concerning the children's ability in mathematics. As in the Parsons et al. (1982) study, there were no objective differences between boys and girls as measured by their school records. Tiedermann found that both mothers and fathers thought that boys were more skilled in mathematics than girls. And the more strongly parents believed in the gender stereotype about math, the more they attributed greater mathematics ability to their sons, but not to their daughters.

The consensus of studies that have been conducted in the attribution tradition shows that boys and girls do make different attributions for success and failure in stereotypically male domains and that the impact on girls' confidence in their own ability is damaging. Nelson and Cooper (1997) adopted these insights and applied them to the field of information technology. Ten-year-old boys and girls were asked to unscramble anagrams on a computer. After a few trials, half of the boys and half of the girls began to see error messages appear on the screen. The error messages increased in frequency and severity until they finally stated that the computer was shutting down and the drive was about to be destroyed. The other half of the children received no such error messages and, in the end, reported that no computer errors had been detected.

Nelson and Cooper (1997) then asked the children to indicate what they thought their ability level was at computer tasks. Following a successful performance (i.e., without error messages), girls thought that their ability was about average compared with other 10-year old girls, In the failure message condition, however, they thought their ability was significantly inferior to the average 10-year old. Boys thought their computer ability was higher than the average 10-year old, and failure messages did not affect their confidence in their ability. In addition, when the boys and girls in the error-message (failure) condition were asked to describe the reason for their failure to complete the task, girls were three times more likely to attribute the failure to their lack of ability than were boys. In the success condition, boys were much more likely than girls to attribute their smooth and errorless performance to their own ability, while girls were more likely to evenly distribute their attributions to good luck, persistent effort, or an easy task.

Working with college students in Germany, Dickhauser, and Stiensmeyer-Pelster (2002) also asked students to make attributions for success and failure at a computer task. Like the young children in the Nelson and Cooper (1997) study, university males were much more likely to attribute failure to a defective computer; whereas females were more likely to attribute failure to their own ability, causing females to feel greater shame about their performance and lowered expectation about future interactions with the computer.

The conclusion of these studies points to the fact that children are taught by their parents about how to make attributions for success and failure. At least in the academic areas that are stereotypically seen as male domains, parents teach their children that success for boys is due to ability, but success for girls is due to more ephemeral factors that do not rely on girls' internal capabilities. In contrast, girls' failure is an indictment of their capability at the task but boys need only work harder or have better luck in order to achieve in the future. These attributions have consequences. Boys are encouraged to keep trying, because they have the basic ability to succeed. Girls, on the other hand, are not stimulated by success because success is not a reflection of their ability. Failure is. Therefore, it is not surprising that, in the last step of the Nelson and Cooper (1997) study, children were asked if they would like to try another task either on the computer or by traditional paper and pencil. Following failure at the anagrams task, girls were much less likely than boys to want to interact with a computer for the future task.

DISMANTLING THE DIVIDE

The digital divide has made it difficult for women to participate fully in the technological age. As we have seen, women now use computers frequently but continue to feel greater anxiety, more negative attitudes, and lower personal efficacy in their interactions with computer technology. The cycle is continuous. Beginning with the shared knowledge, or stereotype, that computers are the province of men and boys, women and girls either succumb to that stereotype or fight against it. Either way, the mere knowledge that the stereotype exists causes girls and women to experience anxiety. They need not believe the stereotype is true; nor do they need to believe that the stereotype applies to them. This computer anxiety often leads to negative attitudes and lowered performance, which is then interpreted via attributional processes to reflect the accuracy of the stereotype. Parents and educators inadvertently teach girls to attribute any success they may have with computer technology to luck or effort, which limits the ameliorative role that positive performance can have on a girl's estimation of her capability to succeed at computer tasks. The attributional patterns that boys develop allow them to benefit from successful performance and shield them from being dissuaded or discouraged by the occasional occurrence of errors and failures.

Software Design Can Limit the Gender Stereotype

How then can the cycle be disrupted? One place to begin is with the stereotype itself. It cannot be willed out of existence overnight. However, its pervasiveness can be disrupted in a number of ways. Educators and software designers were partially insightful when they saw the opportunity to use technology to make learning fun. With the power of digital technology to accommodate children's varied interests and fantasies, learning can be placed in a context that children find meaningful. What the designers did not see clearly was that their collective decision to model educational software on the image of the video arcade set in motion a series of psychological and sociological factors that helped to reify the image of computers as being the province of boys—i.e., the people who are fascinated by the video arcade.

The design of educational software needs to change. This has already begun to happen, with far more of a variety of educational programs available in the current decade than existed in the past two decades. Nonetheless, the pace of educational software that appeals equally to both genders needs to quicken. The software, along with the various peripheral interfaces, is a significant communicator of the computer stereotype. As we have seen, the educational and entertainment software packages available at the end of the 20th century were communication packages directed at boys. They were written as though educators were speaking directly to boys, encouraging them to learn by having fun, and simultaneously leaving girls out of the conversation.

One means to change the communication pattern of computer technology is to change the metaphor that characterizes the fantasy elements of the game. A war metaphor is a strong communication that that the learning technology is for boys; a sports metaphor is a less potent, but probably similar, communication. Learning a lesson for the purpose of hitting a home run, making a goal, or scoring a touchdown are less likely to pique the interests of most girls; nor would such metaphors serve to weaken the stereotype that educational computing has been designed for boys.

Learning what girls like, and ultimately designing information technology software that appeals to girls, is an empirical question. We need to study girls' interactions with computer technology and design software that addresses their interests and preferences. Lepper and Malone (1987) led the way by showing that girls prefer educational communication to be in the form of a learning tool. If it is to be preferred over other communications, then it much teach what needs to be learned in a direct and efficient way (Lynn et al., 2003). Moreover, the software attracts the interest of girls to the extent that it is interactive, and involves communication and sharing (Light et al., 2000; Littleton et al., 1992).

Other forms of human computer interaction (HCI) issues are also important. What kinds of peripheral devices should be used? How will the student ask for help? Will the screen be used to keep score? Will there be a score? Will lights flash and objects explode in order to increase attention, curiosity, and interest? These are not trivial considerations. When girls come to feel that the computer is not a tool intended for them, part of their belief may be through the human factors assumptions made about their interactions with the machine. Passig and Levin (1999) worked with kindergarten children to assess what they liked about computer interfaces. They found that boys, compared to the girls, preferred to use navigational buttons to discover how a game should be played. Girls preferred that writing be part of the game and preferred a way to ask for help directly rather than use computer interfaces such as buttons. Passig and Levin (1999) found that the children's satisfaction with the games, and their time-on-task for learning at the computer, were direct functions of whether the human-factor decisions were consistent with their gender preferences.

The creation of software programs that speak to both genders is a first step. A second step is to encourage parents, school boards, and educators to purchase such programs. This is a business and educational issue with obvious payoffs to society as well as the corporate bottom line. Recent, successful commercial experience with such programs as *Barbie Fashion Designer* (Subrahmanyarn & Greenfield, 1998) and *Purple Moon* attests to the financial viability of such enterprises. Whether it is more appropriate to utilize current gender stereotypes in order to be certain that there are computer programs accessible to each gender, or whether it is best to design programs that have elements that both genders enjoy is a complex issue that goes beyond the scope of the current chapter. However, the conscious and deliberate focus that ascertains that programs educators put in schools and that parents bring to the home is a necessary step to weaken the stereotype that forms the crux of the digital divide.

Decisions about software design can also be informed by examining data collected from adults. Men and women across a broad age range have logged into Massive Online Role Playing Games (MMORPGs). Men vastly outnumber women in the game (Yee, 2006a), but it is still informative to illustrate the kinds of activities and parameters within the MMORPGs that interest women. Players can choose a character, or avatar, to represent them in the game. In one data set, 48% of the males chose to be represented by a female character; whereas only 23% of the female players chose a male avatar. This suggests the importance of having female protagonists in computer activities. Those activities, such as learning tools for school-aged children, that require an identification between player and a character on the screen, will most likely cause a female player to feel uncomfortable if she is not represented by a female protagonist. Women also are more likely then men to view their avatar as an idealized representation of themselves and to see their in-game behavior as similar to their real-life behavior (Yee, 2007).

Women are also more likely then men to use the MMORPG environment to build supportive social networks. According to (Yee, 2006b), women form stronger friendships in the game than do men and shun playing for achievement, dominance and advancement. On a percentage basis, women are more likely than men to join the game with friends and are much more likely to join with a romantic partner. They are also more likely to share contact information. Men play for power, dominance, and points. Women play to enjoy the communication, social contact, and social interaction. Games that are multifaceted such as the MMORPG environment allow for players to find elements, activities, and goals that appeal to both genders. Careful scrutiny of what appeals to women in these multifaceted games can highlight the features that would make games for young and adult females more interesting and more acceptable.

Disrupting the digital divide at the level of software stereotyping is the most important step in reducing its deleterious impact on women. The self-fulfilling nature of the stereotype and the existence of stereotype threat will cease to be issues that support the divide if the stereotypes are diminished. Software designers need to orient their software to appeal to all groups of users. This is particularly true of programs used in education because, for many children, school represents their first exposure to the computer. It is here that they learn whether computer technology is competitive, like the games in video arcades or is a medium of communication that is equally accessible to girls and boys.

Adjusting the Social Context

The social context of computing can also help to weaken the digital divide. In line with the research of Robinson-Staveley and Cooper (1990) and Cooper et al. (1990), female college students and middle-school students performed better and experienced less anxiety when computing in private than when computing in public. One suggestion from these studies is that girls should be afforded more private space when working with computer technology. Discomfort about competitive interactions, worry about ridicule (Nicholson et al., 1998), and stress about the stereotype held by others (Steele & Aronson, 1995) can exacerbate the anxiety that perpetuates the digital divide. Where possible, structuring the work and school environments to allow private computer interactions may be quite helpful.

Another strategy for diminishing the gender divide in computing is to consider an educational structure in which girls have an opportunity to engage in computer instruction with other girls rather than boys. This can be accomplished by single-sex schools or by classes within a traditional school that are for girls only. Research with young children (Light et al., 2000) showed that girls performed significantly better in same-sex dyads. Jackson and Smith (2000) applied the single-gender concept to 11–13-year-old girls in their math classes. They found evidence for increased performance and lower stress when the girls took their class in the single-gender format.

Changing the Conclusions

Parents and educators are prone to succumb to the same stereotype as the rest of society: If computer technology is an area that boys do well in, then it must be true that girls' success is a lucky break or a matter of sheer determined effort. In our roles as parents and educators, we must be vigilant about the two elements of that trap. First, it is only a stereotype that supports the first premise: Girls are not intrinsically worse at interacting with computers than boys. Second, girls and boys must be allowed to use the outcomes of their behavior to make judgments about how good they are at computer tasks. If a child does well at computer tasks, it should be taken as evidence for his or her ability. However, research has shown that girls are not given the opportunity to benefit from their success. By unwittingly communicating attributional patterns that differ by gender, parents and educators have systematically deprived girls of benefiting from their success and deprived all children of learning from their mistakes. As Fig. 38.1 depicts, the effects of successful and unsuccessful computer performance pass through an attributional filter that undermines the beneficial effects of success and exacerbates the digital divide.

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