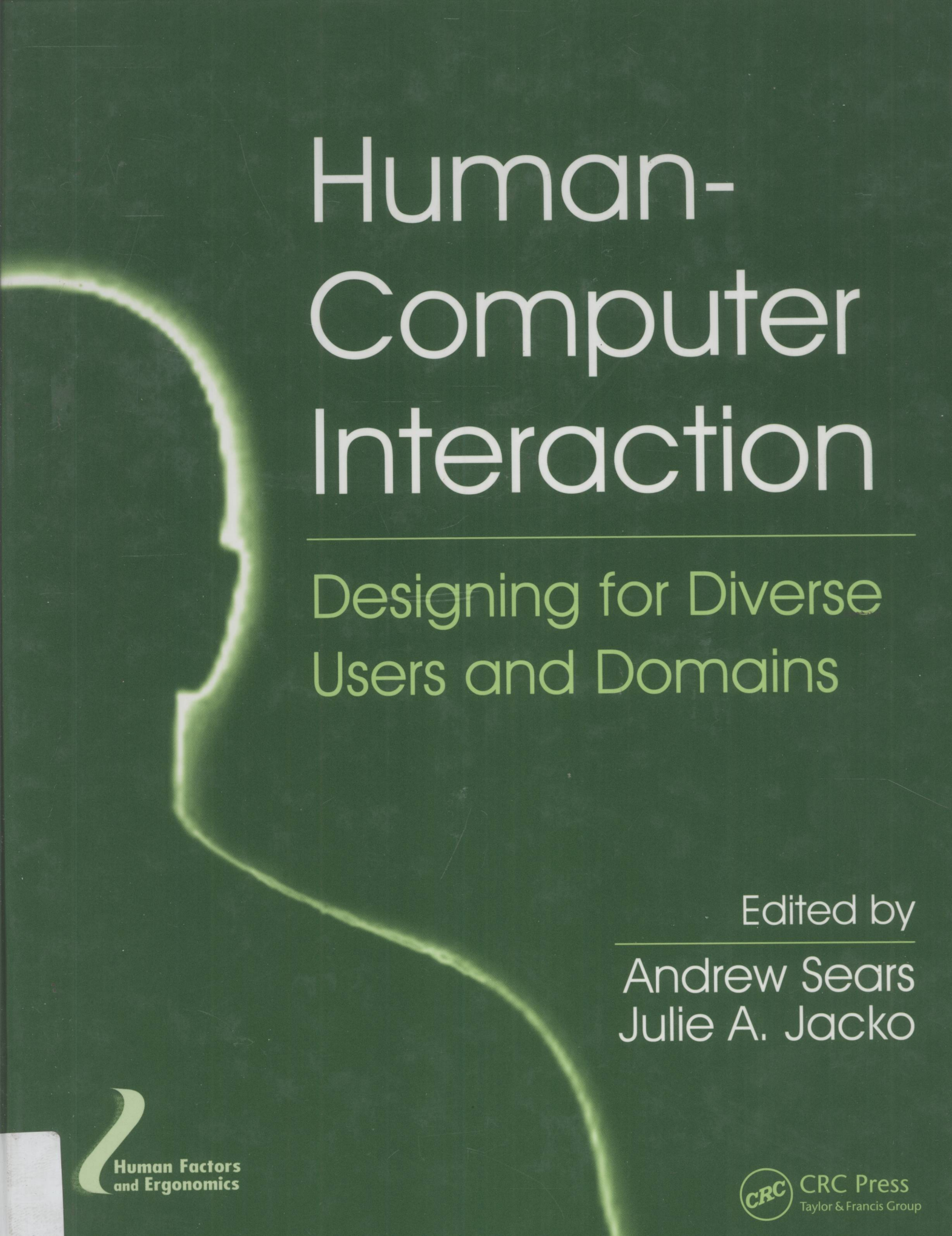

Human-Computer Interaction

Designing for Diverse Users and Domains

Edited by

Andrew Sears
Julie A. Jacko

Human Factors and Ergonomics

CRC Press
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PREFACE

We are pleased to offer access to a select set of chapters from the second edition of *The Human–Computer Interaction Handbook*. Each of the four books in the set comprises select chapters that focus on specific issues including fundamentals which serve as the foundation for human–computer interactions, design issues, issues involved in designing solutions for diverse users, and the development process.

While human–computer interaction (HCI) may have emerged from within computing, significant contributions have come from a variety of fields including industrial engineering, psychology, education, and graphic design. The resulting interdisciplinary research has produced important outcomes including an improved understanding of the relationship between people and technology as well as more effective processes for utilizing this knowledge in the design and development of solutions that can increase productivity, quality of life, and competitiveness. HCI now has a home in every application, environment, and device, and is routinely used as a tool for inclusion. HCI is no longer just an area of specialization within more traditional academic disciplines, but has developed such that both undergraduate and graduate degrees are available that focus explicitly on the subject.

The HCI Handbook provides practitioners, researchers, students, and academicians with access to 67 chapters and nearly 2000 pages covering a vast array of issues that are important to the HCI community. Through four smaller books, readers can access select chapters from the Handbook. The first book, *Human–Computer Interaction: Fundamentals,* comprises 16 chapters that discuss fundamental issues about the technology involved in human–computer interactions as well as the users themselves. Examples include human information processing, motivation, emotion in HCI, sensor-based input solutions, and wearable computing. The second book, *Human–Computer Interaction: Design Issues,* also includes 16 chapters that address a variety of issues involved when designing the interactions between users and computing technologies. Example topics include adaptive interfaces, tangible interfaces, information visualization, designing for the web, and computer-supported cooperative work. The third book, *Human–Computer Interaction: Designing for Diverse Users and Domains,* includes eight chapters that address issues involved in designing solutions for diverse users including children, older adults, and individuals with physical, cognitive, visual, or hearing impairments. Five additional chapters discuss HCI in the context of specific domains including health care, games, and the aerospace industry. The final book, *Human–Computer Interaction: The Development Process,* includes fifteen chapters that address requirements specification, design and development, and testing and evaluation activities. Sample chapters address task analysis, contextual design, personas, scenario-based design, participatory design, and a variety of evaluation techniques including usability testing, inspection-based techniques, and survey design.

Andrew Sears and Julie A. Jacko

March 2008

ABOUT THE EDITORS

Andrew Sears is a Professor of Information Systems and the Chair of the Information Systems Department at UMBC. He is also the director of UMBC's Interactive Systems Research Center. Dr. Sears' research explores issues related to human-centered computing with an emphasis on accessibility. His current projects focus on accessibility, broadly defined, including the needs of individuals with physical disabilities and older users of information technologies as well as mobile computing, speech recognition, and the difficulties information technology users experience as a result of the environment in which they are working or the tasks in which they are engaged. His research projects have been supported by numerous corporations (e.g., IBM Corporation, Intel Corporation, Microsoft Corporation, Motorola), foundations (e.g., the Verizon Foundation), and government agencies (e.g., NASA, the National Institute on Disability and Rehabilitation Research, the National Science Foundation, and the State of Maryland). Dr. Sears is the author or co-author of numerous research publications including journal articles, books, book chapters, and conference proceedings. He is the Founding Co-Editor-in-Chief of the *ACM Transactions on Accessible Computing,* and serves on the editorial boards of the *International Journal of Human–Computer Studies*, the *International Journal of Human–Computer Interaction,* the *International Journal of Mobil Human–Computer Interaction,* and *Universal Access in the Information Society*, and the advisory board of the upcoming *Universal Access Handbook.* He has served on a variety of conference committees including as Conference and Technical Program Co-Chair of the Association for Computing Machinery's Conference on Human Factors in Computing Systems (CHI 2001), Conference Chair of the ACM Conference on Accessible Computing (Assets 2005), and Program Chair for Asset 2004. He is currently Vice Chair of the ACM Special Interest Group on Accessible Computing. He earned his BS in Computer Science from Rensselaer Polytechnic Institute and his Ph.D. in Computer Science with an emphasis on Human–Computer Interaction from the University of Maryland—College Park.

Julie A. Jacko is Director of the Institute for Health Informatics at the University of Minnesota as well as a Professor in the School of Public Health and the School of Nursing. She is the author or co-author of over 120 research publications including journal articles, books, book chapters, and conference proceedings. Dr. Jacko's research activities focus on human–computer interaction, human aspects of computing, universal access to electronic information technologies, and health informatics. Her externally funded research has been supported by the Intel Corporation, Microsoft Corporation, the National Science Foundation, NASA, the Agency for Health Care Research and Quality (AHRQ), and the National Institute on Disability and Rehabilitation Research. Dr. Jacko received a National Science Foundation CAREER Award for her research titled, "Universal Access to the Graphical User Interface: Design For The Partially Sighted," and the National Science Foundation's Presidential Early Career Award for Scientists and Engineers, which is the highest honor bestowed on young scientists and engineers by the US government. She is Editor-in-Chief of the *International Journal of Human–Computer Interaction* and she is Associate Editor for the *International Journal of Human Computer Studies*. In 2001 she served as Conference and Technical Program Co-Chair for the ACM Conference on Human Factors in Computing Systems (CHI 2001). She also served as Program Chair for the Fifth ACM SIGCAPH Conference on Assistive Technologies (ASSETS 2002), and as General Conference Chair of ASSETS 2004. In 2006, Dr. Jacko was elected to serve a three-year term as President of SIGCHI. Dr. Jacko routinely provides expert consultancy for organizations and corporations on systems usability and accessibility, emphasizing human aspects of interactive systems design. She earned her Ph.D. in Industrial Engineering from Purdue University.

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Part

I

DESIGNING FOR DIVERSITY

1

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

Joel Cooper and Matthew B. Kugler
Princeton University

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, Lenzmeier, Steffensmeier, 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 cannot 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 exist 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. 1.1 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.

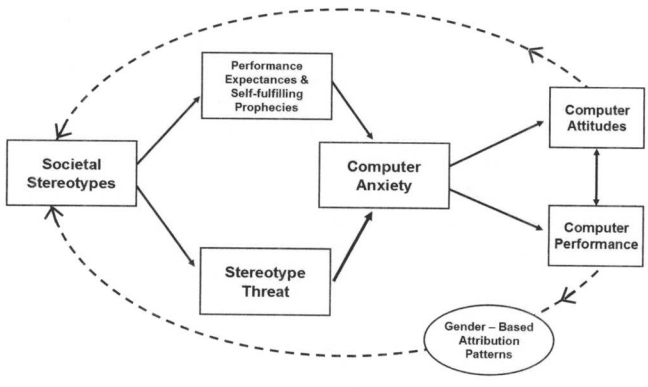

FIGURE 1.1. A logical model of digital divide.

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