The digital divide: the special case of gender

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Abstract This paper examines the evidence for the digital divide based on gender. An overview of research published in the last 20 years draws to the conclusion that females are at a disadvantage relative to men when learning about computers or learning other material with the aid of computer-assisted software. The evidence shows that the digital divide affects people of all ages and across international boundaries. We suggest that the digital divide is fundamentally a problem of computer anxiety whose roots are deep in socialization patterns of boys and girls and that interact with the stereotype of computers as toys for boys. A model of the digital divide is presented that examines gender stereotypes, attribution patterns, and stereotype threat as antecedents of computer anxiety. Computer anxiety in turn leads to differences in computer attitudes and computer performance. A number of suggestions are offered to reduce the impact of the digital divide.

Keywords computers, digital divide, gender, stereotype threat.

Introduction

Technology is arguably the lynchpin of our modern society. It is hard to conceive of many aspects of our lives that do not rely on technology in general and computers in particular. The clerk at the fast food restaurant no longer performs addition to calculate your bill nor subtraction to provide correct change. Few secretaries lament the passing of the typewriter keyboard and carriage return and few consumers desire to run from store to store without at least doing some comparison shopping on the Internet. And few classrooms in western society would consider education complete if they did not teach at least some of their lessons through the medium of modern computer programmes. Yet, there is a pernicious and often overlooked wedge that divides modern society. Everyday, we risk losing the talents of women as contributors to science, technology, and the arts because the advantages that technology provide are being conveyed disproportionately to men in modern society. Women are being disadvantaged in the process.

The ubiquity of computer use is in our everyday world grows exponentially. Not too long ago, computers were used solely for higher order calculations, almost exclusively dedicated to the accumulation and analysis of large sets of data. Nowadays, citizens from university professors to kindergarten children, cashiers to nuclear scientists, must be at least somewhat conversant with computers. The role played by technology in the workplace will continue to grow, with current estimates suggesting that by 2010, 25% of all new jobs in the public and private sectors will be technologically oriented (American Association of University Women Educational Foundation Commission on Technology, Gender and Teacher Education 2000). It is society's dilemma that the path to computer efficacy is more difficult for the poor, for ethnic minorities and for women (Wilson *et al*. 2003). According to a report of the National Science Foundation, nearly half of all White families in the United States own a home computer, but fewer than one quarter of African-American families own one.

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Moreover, in the last decade of the 20th century, the gap in computer ownership between African Americans and Whites widened. Income, of course, is directly related to the ability to own a computer. But, even controlling for income, the difference between African-American ownership and White ownership persisted. Owning a computer has been shown to lead 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).

The disparity between groups of people is equally invidious when gender is considered. There is a dramatic digital divide for gender such that women are not reaping the benefits of the technological revolution on a par with men (Cooper & Weaver 2003). The manifestations of the gender divide are clear for all to see: women are underrepresented in their use and ownership of computers (Yelland & Lloyd 2001; Wilson *et al*. 2003; Pinkard 2005), women take fewer technology classes in high school (Pinkard 2005), in college women are far less likely to graduate with degrees in IT fields and, quite frankly, enjoy interacting with computers less than men do (Mitra *et al*. 2001). This is not to say that it is unabashedly wonderful to own and be interested in computers nor that lack of interest is a deficiency (Littleton & Hoyles 2002). However, with economic and academic success depending more and more on a facility with information technology, any disparity in interest or proficiency that differs systematically with gender is a problem for society.

When Gita Wilder, Diane Mackie, and I surveyed school children in the early 1980s, we found a large difference in the degree to which boys and girls were attracted to the computer. Beginning in kindergarten, boys indicated more positive attitudes about computer technology than did girls. These small attitudinal differences became dramatic in the fifth grade and continued to grow through the middle- and high-school years (Wilder *et al*. 1985). At that time, we expressed the hope that the differences were either local (i.e. confined to the narrow geographical area in which the study was conducted) or, if not, would at least be temporary, reducing markedly in scope as computer technology became more accessible to all. We were sorely disappointed on both counts.

Persistence of computer anxiety over time and across international borders

Across a broad spectrum of activities, girls and women report that computers are not the source of fun and amusement but rather the source of anxiety. Nearly 20 years ago, Weil *et al*. (1987) reported that about one in three adults in the United States experienced what they called computerphobia – adverse anxiety reactions to the use of computers. It is not clear whether that proportion has remained constant over the decades. What is clear, however, is that computer anxiety has disproportionately affected females in the past, and continues to do so into the 21st century. In the 1980s Dembrot and her colleagues found that female college students expressed considerably more anxiety about computers than did their male counterparts (Dambrot *et al*. 1985; see also Temple & Lips 1989). Many studies in the 1990s showed continued disparities between males and females, with females from the elementary school grades to university graduates expressing greater anxiety and negative attitudes than males (Todman & Dick 1993; Colley *et al*. 1994; Whitley 1997; Brosnan 1998).

Recent research has shown only modest improvements in the gender gap. For example, Colley and Comber (2003) found that girls' interest in computer applications has improved, but girls continue to like the computer less than boys do, and still use them less outside of school. Similarly, Mucherah (2003) found that, relative to the reactions of adolescent boys, teenage girls felt far less involved with computers and enjoyed them less. At Princeton University, Kim Weaver and I (Cooper & Weaver 2003) asked incoming college students about their reactions to computers. The young women were far more unsure of their ability with computers than the young men. They 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. Nonetheless, they felt considerable discomfort with the idea of using technology.

We also asked the students to imagine that they were going to take a course in psychological statistics. We queried them with the following dilemma: suppose that you were asked to complete a statistics homework assignment on the computer. How comfortable would you feel in doing that assignment? Again, the students' comfort with the computer-based assignment differed significantly by gender. Men felt that they would be comfortable completing the assignment, while women expressed considerable discomfort (Cooper & Weaver 2003). The discomfort with technology that women entering the university experienced thus generalized to their discomfort within the domain of a specific course that relied on that technology, which is all the more perplexing considering that four out of five of the women had already completed courses in calculus.

The digital divide is a worldwide problem. Although much of the research has been conducted in the United States, data from other nations show a similar phenomenon. Research in Great Britain (Colley *et al*. 1994), Australia (Okebukola & Woda 1993), Canada (Temple & Lips 1989), and Spain (Farina *et al*. 1991) all converge on the same conclusion. In surveying the existing 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).

Since the time of Reinen and Plomp's assessment, data have continued to accumulate on the international nature of the digital divide. Data reported from Romania (Dundell & Haag 2002), Egypt (Abdelhamid 2002), and Italy (Fabio & Antonietti 2002) consistently show the persistence of the digital divide in a wide array of educational systems around the globe. Although there have been some reports showing null findings (e.g. Solvberg 2002, in a Norwegian sample), the weight of the evidence strongly suggests a digital divide that has persisted across time and international boundaries.

Accounting for the digital divide

The digital divide is multiply determined. Its roots are embedded in social developmental differences between boys and girls, societal stereotypes of what is appropriate for the two genders and gender-specific attributional patterns. These factors are intertwined to create the expectation that computers are the province of boys and men, not girls and women. Such expectations are reinforced by others in the social environment and exacerbated by the social context in which computing is typically learned and performed. The confluence of these factors reinforces the social stereotype that links technology to gender and creates the atmosphere that permits the digital divide to continue. We will examine the factors that facilitate the digital divide and, in turn, offer some tentative suggestions for change based on the extant evidence.

Are we having fun yet? Understanding girls' reluctance to use computers

Most children begin their interaction with computers through the video game. Children either learn to play video games themselves, watch others play them or are aware that their older siblings, neighbours, or friends are playing with them. For small children, computer games come in any number of shapes and sizes. They may be ostensibly geared towards teaching children an educational lesson or have a licensing relationship with a set of television characters. What most programmes have in common, however, is a game-like nature and competitive responding. As children grow, their interaction with computers centres even more fully on the competitive nature of the video game, with story lines to keep children's interest that involve adventures in space, sports, and battles. Most frequently, the computer keeps players' scores, with the express purpose of allowing them to compete with others who may be playing the game simultaneously, to compete with others who have recently played the game, to compete with others who soon will play the game and/or to compete with themselves for obtaining higher scores.

The prototypical locale for such games is the video arcade. The conventional arcade is geared towards a slightly older clientele. However, the popularity of a restaurant chain that serves pizza in one-tenth of its floor space and provides video arcade games for young children in the remainder of the space attests to the role of computer games in the lives of even pre-school and early school-aged children.

In schools, educators have always searched for ways to make learning more efficient and more enjoyable. The marriage between the schools and computer technology was a natural. Computer software manufacturers turned out hundreds of programmes designed to assist teachers in delivering instruction in every discipline from art to zoology. And what better way to do it than to adopt the structure of the video arcade and the video game? After all, children voluntarily spend hours navigating the story lines of the video games. How much fun it will be, they reasoned, if they could deliver instruction in the same game-like format.

The problem that went unnoticed for too long was that it is predominantly boys who visit video arcades and it is predominantly boys who spend hours with their favourite games. Turning classrooms into video arcades by adopting software that resembles video games may be attractive to most of the boys and some of the girls. But it disenfranchises the girls whose predilection is to avoid such games.

The work of Lepper and Malone (1987) is informative. They asked girls and boys what they liked about computers. Boys were quick to point out that they liked activities that were in the form of games. They liked the story lines to be about sports, war, and space. They liked eye-hand coordination and competition. No wonder that boys would love to learn their arithmetic with CAI programmes called *Demolition Division* and *Slam Dunk Math*. Girls, on the other hand, liked very little of what the boys liked. They disliked programmes that featured sports and war, competition and coordination. Girls liked colourful arrays, but their most ardent preference was for programmes that *taught them something*. That is, girls appreciated computers as learning tools but not as games. Would they have fun learning to divide fractions with *Demolition Division?* Clearly not. Yet, all too often, girls have been introduced to computers with well-intentioned but misguided attempts to make learning fun. As it turns out, the fun has been in a male frame of reference. For girls, the result has been lowered interest, negative attitudes, lowered performance, and computer anxiety.

Evidence for the deleterious effect of boy-toy computers

Joan Hall, Chuck Huff, and I set out to examine the impact of learning division with computer software that was designed in a way that was consistent with what I will call the boy-toy – i.e. software that was based on a sports-, war-, or space-oriented story featuring competition and eye–hand coordination. *Demolition Division* was a prototypical boy-toy, described by its manufacturer as follows: ‘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’. Cooper *et al*. (1990) had middle-school boys and girls learn division with this programme. The students worked with the programme 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 programme 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 programme less than boys did, and the girls had considerably more anxiety at the conclusion of the CAI lesson. In addition, the level of anxiety was negatively correlated with performance: the higher the anxiety, the less the children seem to have learned. On the other hand, when boys and girls from the same school learned the same division facts from a CAI programme that was devoid of all of the formal features that comprise the boy-toy, the anxiety levels of girls were not any higher than that of boys. In a programme called *Arithmetic Classroom* in which there is no competition, eye–hand coordination or war story, girls felt quite comfortable and experienced slightly less anxiety than did the boys. The results are shown in Fig 1.

In a similar vein, Littleton *et al*. (1998) reasoned that one of the difficulties that girls have with learning from CAI programmes is that the characters in the typical stories that underlie the games are not appealing to them. In a popular CAI game called *King and Crown*, children are taught a series of spatial reasoning skills as they attempt to navigate a computer-generated adventure. However, the adventure consists of identifying with characters in the form of warriors while working towards a solution to the adventure. In Littleton *et al*.’s (1998) research, boys learned the skills necessary for the game and fully succeeded in the adventure approximately 50% of the time. Girls, however, were successful only 8% of the

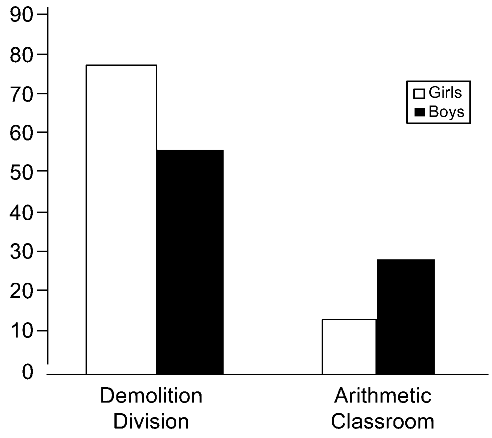

Fig 1 Level of computer anxiety after learning from a male-oriented (*Demolition Division*) and control (*Arithmetic Classroom*) Computer-Assisted Learning programme.

time. By cleverly manipulating the game such that the same skills were embedded in a more gender-neutral context, the deficit that the girls had shown on the original version of the task completely disappeared. Apparently, the boy-toy nature of *King and Crown* caused a blend of anxiety, disidentification and withdrawal of effort by the girls. However, when Littleton *et al*. (1998) converted the software to one that taught the same skills in a non-aggressive format that did not rely on warriors and adventure to make the learning fun, the girls and the boys performed equally well, with 50% of both genders achieving the maximum solution. Taken together, the Cooper *et al*. (1990) and Littleton *et al*. (1998) studies suggest that girls are more than capable of using the computer to learn the skills that are the focus of a CAI lesson. But when faced with learning on boy-toys, the learning experience for most of the girls is far from fun. Their anxiety level increases while their interest and performance decrease.

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 computer anxiety among females in college, the workplace and among retirees (Karavidas 2004). Experimental data collected with college students also support the deleterious effect of boy-toy 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 at the game. Male students, on the other hand, performed considerably better and did not experience computer anxiety.

A caveat: the context matters

Another relevant finding in the Robinson-Stavely and Cooper (1990) study is that the social context of computing had a substantial effect on the experience of computer anxiety. The disparity in performance on Zork only occurred 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 slight 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 programme without the presence of others (Cooper *et al*. 1990). The social context matters.

The social context also matters when the gender composition of learning groups is considered. If other children are present, does it matter if they are of the same gender or opposite gender? The answer seems to be that, for the girls, having boys present has the effect of increasing computer anxiety and decreasing learning. Light *et al*. (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 *et al*. (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 with girls working with other girls. It is hardly a wonder that the public nature of computing in this mixed gender context would make girls particularly uneasy and uncomfortable.

Learning software talks to boys

The data we have been examining suggest the possibility that the differences between males and females in academic computing can be ameliorated by software that is either gender-neutral or by software written for girls that accommodates what girls enjoy in computer learning – namely, that the software be directed primarily as a learning tool. Unfortunately, the preponderance of software developed for education contains at least some of the formal features that bring joy to the hearts of boys but anxiety to the hearts of women and girls.

Why should this be so? One possibility is that most of the people who write computer software are male and thus write programmes that would be entertaining and motivating to them. This notion is not without merit, but an additional intriguing possibility is that everyone who writes software, regardless of gender, communicates in a way that matches their assumption of who the recipient is. We do this frequently in spoken and written communication, adjusting our words to adapt to the audience. We may speak in an aggressive tone if we think we are speaking to a hostile listener (Snyder *et al*. 1977) or in a condescending way if racial prejudice is invoked (Word *et al*. 1974). It should not be surprising, then, that authors of computer-assisted software write programmes that match their expectation of who the audience is at that is seated across from the computer screen.

This was the hypothesis examined in a study by Huff and Cooper (1987). We asked teachers in the New Jersey public schools to design software to help seventh-grade children learn the appropriate use of commas. One group of teachers was asked to design the software for seventh-grade boys. Their designs were always interesting, but more to the current point, they persistently showed the features that boys typically like. After designing the software, the teachers were asked to write a description for a CD jacket that would describe the software for potential purchasers. One teacher's response extolled, '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'.

Another group of teachers was asked to design the software for seventh–grade girls. Interestingly, they had no difficulty in intuiting that the motivational embellishments should be different when writing for girls. A typical response was expressed by one teacher when she described her programme 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'.

So, when thinking about the gender of the recipient of the software designed to teach commas, teachers recognized that they needed to write vastly different programmes to motivate the students. Did they overrely on gender stereotypes? Perhaps. But what is clear is that motivational embellishments for the boys were effected through aggressive weaponry and sports, whereas the embellishments for the girls focused on shopping, conversing and a strong emphasis on viewing the computer programme as a learning tool rather than a toy.

What do teachers assume when the gender of the students is not specified? We asked a third group of teachers to design software to teach commas to seventh-grade *students*. Their answers were resoundingly like the programmes that had been written for boys and nothing like the programmes that had been written when girls were the focus of attention. A typical teacher described the advertisement for her CD jacket by saying, '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'.

Programmes written for students were nearly carbon copies of the programmes that other teachers wrote when they had boys in mind. All of the programmes were coded and assessed by independent raters and then subjected to a multi-dimensional scaling analysis. The results showed that the programmes written for students were statistically indistinguishable from the programmes written for boys on a dimension that

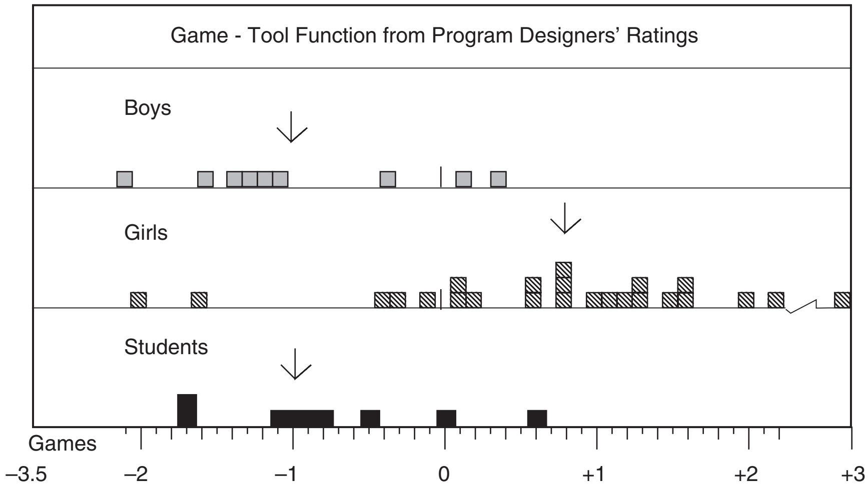

Fig 2 Results of multi-dimensional scaling depicting programmes written by teachers for instructing boys, girls, and students. The arrows depict the central tendency of each condition.

ranged from 'learning tool' to 'toy'. Both were markedly on the 'toy' end of the dimension. Programmes written when girls were the focus of attention were written as learning tools and were significantly different from both the boy and student programme. Figure 2 shows the results of the multi-dimensional scaling.

One root cause of the digital divide has emerged from this analysis. The attempt to introduce computers into education with the same motivational embellishments that bring boys to the video arcade begins a cascade of expectations associating computers with the male gender. Girls learn quickly that computers are an educational medium designed with boys in mind. The games that attempt to make learning fun are not fun for most girls. To the contrary, interacting with the computer medium creates stress and anxiety, leading ultimately to negative attitudes, and withdrawal from computer activities. And, as we have seen, even well-intentioned adult educators who are instructed to design CAI lessons for children seem automatically to succumb to the expectation that they are teaching boys rather than girls (Huff & Cooper 1987).

It would be misleading to imply that all computer software is designed on the video arcade model and that no software designers consider girls' interests when designing software. Computer games based on interests traditionally associated with girls are on the rise. Various skills have been addressed by programmes that focus, for example, on Barbie and her friends as well as programmes based on stereotypically feminine interests such as cooking and sewing. Such programmes have been commercially successful. Whether they have also been successful in allaying some of the issues generated by the more prevalent arcade-type games is difficult to discern because their number is still small. Also difficult to discern is the impact of such software on reifying socially problematic gender stereotypes, an important issue that is beyond the scope of the present analysis.

Interpreting success and failure: the power of attribution

Whenever people succeed or fail at a task, they are confronted with making an attribution for the cause of that success or failure (Weiner 1979). An array of important factors line up to help boys feel that any success they achieve in technology is a function of their ability whereas any failure is a product of bad luck or lack of trying. For girls, success at technology is attributed less to their ability and more to effort or luck. Failure, on the other hand, must be due to their low level of ability. The pattern of attribution is protective for boys and damaging to girls.

If a teacher presents a computer task in the classroom, and a boy succeeds, he assumes that he is good at computers and, by extension, whatever the computer task was assisting him to learn. Should he fail, he merely needs to try harder, pay more attention, or feel that he was unlucky enough to be given a poorly constructed programme for his computer. A girl who does not succeed finds it likely that she is not good at computers and, perhaps by extension, not competent at the skill she was trying to learn. And girls who succeed attribute their success to having worked hard, luck, or the simple programme that they were provided for the task.

First, let us examine some evidence that shows this to be true. Then, we will consider some of the reasons for these different patterns of attribution. Nelson and Cooper (1997) had 10-year-old boys and girls unscramble anagrams on a computer. After some initial trials in which the children successfully unscrambled some fairly simple anagrams, for half of the children, the computer began to report error messages. When the error messages started, the computer indicated errors contiguous with the children's key strokes. Soon the computer messages instructed the students that the computer was shutting down and that drive was about to be destroyed. For the other half of the children, the computer programme simply processed their answers to the anagrams and at the end reported that no computer errors had been detected.

In all conditions, we administered a questionnaire deigned to assess how the children attributed their success or failure with the computer. In the success condition, boys attributed the smooth and errorless computer performance to their ability far more than the girls did. On the other hand, girls thought that their success on the CAI anagrams programme was a product of their hard work, or their luck, or the easy nature of the task. In the failure condition, only a small proportion of the boys regarded the failure as a sign of their inability to use computers. Girls were three times more likely than boys to attribute the failure to their ability. Following the anagrams task, the girls and boys were asked to rate their ability with computers relative to the average 10-year old. Following success, girls thought that their ability was about average, but following failure they thought that their ability was significantly less. Boys thought that their computer ability was higher than the average 10-year old, and they persisted in this belief regardless of whether they believed they had succeeded or failed at the computerized anagrams task. The attributions for success and failure also took its toll on children's eagerness to use a computer for a subsequent task. Those who had made stable attributions for success (mostly the boys) chose to use a computer for a subsequent learning task. Those who had made an ability attribution for their failure (mostly the girls) rejected using the computer for subsequent learning, choosing a paper, and pencil task instead.

It is not surprising that making a stable attribution for failure would make children anxious and stressed at the thought of using a computer. Why should such attributions be made by girls more than boys? Similarly, why do girls refrain from using the evidence of their success to feel that they are genuinely good at the task? There may be a general tendency for girls and boys to differ in their attributional patterns, regardless of whether the task pertains to technology or not (Nicholls 1975; Diener & Dweck 1978; Licht & Dweck 1984). In addition, success and failure in arenas that are viewed as stereotypically male exacerbate these basic patterns. Consider an academic cousin of computer skills, namely mathematical skills. This is an area of skill that is also associated with gender and has caused similar anxiety and negative attitudes among girls and women as computer skills. In a study by Tiedermann (2000), several hundred elementary school students and their parents were surveyed about their children's performance in mathematics. Tiedermann found that both mothers and fathers thought that boys were more skilled in mathematics than girls. And the more the parents believed in the gender stereotype about math, the more they attributed greater mathematics ability to their sons, and not to their daughters. In truth, there was no objective difference in performance between the boys and girls in Tiedermann's study, but it did not stop parents who believed in gender stereotypes from thinking that their girls were not as skilled in mathematics as their boys.

Parsons *et al*. (1982) asked children to rate their own math ability, their perceptions of the effort needed to do well in math and the difficulty of their current math courses. Parents were asked to rate their children on the same dimensions. As in Tiederman's study, an examination of school records showed that there were no objective differences between boys and girls in the grades they achieved nor the difficulty level of the courses they were taking. Nonetheless, parents of girls generally believed that their children were not as able and, if they did well in their courses, it was a function of how much effort they had put into studying. Parents of boys believed that their sons did well because of their ability. Parsons *et al*. refer to parents as the 'expectancy socializers'. That is, the attributions that parents make about their children's performance is communicated to children who take on those attributions as their own. In fact, Parsons *et al*. found that girls' self-concept about their mathematics ability was more highly related to their parents' attitudes than it was to their own performance. There is every reason to believe that parents are attribution socializers when it comes to information technology as well. When gender stereotypes implicate a domain as being within the realm of boys' ability and interest, parents communicate their beliefs to their sons and daughters that success for boys is a tribute to their ability, whereas success for girls is a tribute to non-ability factors such as effort or luck.

Boys and girls react to gender stereotypes: the self-fulfilling prophecy

There can be little question that there exists a stereotype that links the use of computers to gender (Cooper & Weaver 2003). Men and women, regardless of their age, background, or competence with technology, know that the general public believes that men and boys are more interested in, and are more competent at, the use of computers.

Reactions to stereotypes can vary. People can believe that the stereotype exists but disbelieve in the truth of the stereotype. For example, Devine's (1989) 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. Non-prejudiced people do not believe that the stereotype is true. Nonetheless, the existence and content of the stereotype is known by everyone.

In the case of the gender stereotype for computers, belief in the stereotype can have some dramatic consequences. 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 example of the self-fulfilling prophecy occurred in a classroom setting created by Rosenthal and Jacobson (1968). In their well-known study, Rosenthal and Jacobson led teachers to believe that a fancy (although actually bogus) test of intelligence had identified some of their students as children who were almost certainly going to show 'spurts' in their academic development during the coming school year, whereas no information was given about the rest of the children in the class. At the end of the school year, Rosenthal and Jacobson found that, especially in the lower grades, the children whose teachers expected them to spurt actually performed better on standardized tests than children for whom there were no expectations. As the test was bogus, Rosenthal and Jacobson actually designated 'spurters' at random. Nonetheless, the expectation that the children would do well caused something dramatic to occur in the interaction between student and teacher to cause the difference in performance.

What the Rosenthal and Jacobson study shows us is that the expectation of the teacher about the likely performance of the students can determine the experience of the educational interaction and affect the behavioural outcomes of the students. Rosenthal and Jacobson's study was based on erroneous information that was provided to teachers about individual students. Word *et al*. (1974) showed that stereotypes about groups of people can also impact peoples' performance. 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 non-consciously affected the way in which they behaved towards White and Black applicants. In the end, these differences led to poorer performance in the job interviews, thus reinforcing the original racial stereotype. The job interviewers acted in ways that ultimately supported and re-affirmed the racial stereotypes – i.e. that White candidates were better suited to be selected for the job than Black candidates.

Taken together, these studies show that people can unwittingly produce behaviour in others that is consistent with the beliefs they hold about them. This self-fulfilling prophecy occurs regardless of whether it is based on individuating information or stereotyped beliefs. Teachers who believe that girls dislike computers or are not competent with them can direct their attention to the boys in the room, introduce activities and examples that the boys like and then discover that, just as they had thought, boys are more interested in computers than are the girls. What they do not realize is that their lessons, their examples and their communications may have contributed to causing the very same differences that they expected to see (Schofield 1995).

Self-fulfilling prophecies also affect students directly. In Rosenthal and Jacobson's and Word *et al*.'s studies, the source of the self-fulfilling prophecy resided in the teachers and job interviewers, who then produced that behaviour in the targets. Zanna *et al*. (1975) showed that the self-fulfilling prophecy also affects the target directly. A student who believes she is not going to do well may alter her own behaviour to conform to her expectation. A student who believes she will do well may behave in ways that produce that result. In a manner similar to the procedure of Rosenthal and Jacobson, Zanna *et al*. had students take a test that would indicate whether they were likely to show spurts in their academic progress. However, the expectancy was transmitted directly to the students rather than the teachers. The teaching staff was not given any expectation about their students. The results showed that when the teachers had no particular expectations about the students, performance varied as a function of the manipulated student expectation. At the end of the academic programme, students who had been randomly selected to be given the success manipulation outperformed their peers in reading and mathematics. Thus, students' beliefs about how they were expected to perform dramatically changed their academic achievements in the class.

Knowing but not believing: stereotype threat and performance

The targets of stereotypes do not necessarily believe the content of the stereotype that is held by the community. When they *do* believe it, and the content is positive, it can have productive consequences. Boys, for example, 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. However, when they believe the stereotype and it is a negative one, then the self-fulfilling prophecy may work the other way, causing negative feelings, avoidance, and poor performance.

What happens when the target of a negative stereotype does not believe the content of the stereotype? A girl sitting in an introductory computer course in high school may not believe that the stereotype is true. Girls, she feels, are just as good at computers as boys. Alternatively, she may feel that even if the stereotype is true about girls in general, it is not true about her. That is, even if the average girl is not interested in computers, even if the average girl experiences computer anxiety, even if the average girl does not perform well with computers, she knows she is different. She is not intimidated by computers, likes to use them and believes she can perform just as well as the boys. Recent research shows that this confident and able girl is still at risk of succumbing to the negative consequence of the stereotype.

Research on *stereotype threat* has shown that the mere knowledge of a negative stereotype applying to a person's group can cause that person to perform poorly at a particular task (Steele & Aronson 1995; Steele 1997; Spencer *et al*. 1999). There are at least two possible mechanisms that can lead to this result. A girl who is about to work with a computer in her classroom knows that there is a stereotype that suggests she is not going to do well. One can imagine a scenario in which the boys in her class have made it clear that they are the ones who are supposed to be at the computer. They may interrupt her, belittle her work (Schofield 1995; Nicholson *et al*. 1998) or she may just imagine what they are thinking. She knows that any mistake, any mis-step, any admission of error may be taken as evidence for the stereotypical belief that she is not good at computers. Her dilemma is that she would like to succeed and prove the stereotype wrong but the pressure this places on her can do precisely the opposite. It makes it more likely that she will make a mistake, and the mistake, she fears, will lead others to believe that the stereotype is correct.

In a set of intriguing studies, Steele and his colleagues have shown that African-American students can succumb to negative stereotypes in academic performance. Given the stereotype that African-American students are not as academically capable as White students, Steele and Aronson (1995) predicted that the pressure caused by that stereotype would manifest itself in poorer performance by Black students on tests of academic ability. Indeed, their study showed that Black students performed significantly worse on a test of intellectual ability if they believed that the test was highly diagnostic of ability. When the same test was presented as a measure whose validity was uncertain, then Black and White students performed equally well.

Similarly, Spencer *et al*. (1999) showed that, compared with men, women performed worse in a test of mathematics when they thought the test was diagnostic of possible gender differences. Other research has shown that stereotype threat can affect a wide array of activities, as long as there exists a culturally shared negative stereotype that predicts that a group member should perform poorly. Stone and his colleagues have shown that Whites, relative to Blacks, are more likely to experience stereotype threat on activities that are alleged to be indicants of 'natural athletic ability' (Stone *et al*. 1997, 1999). Aronson *et al*. (1999) 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 the performance of Asian American males. Thus, the impact of stereotype threat is far-reaching. It occurs when people feel identified with a group, when they feel that their performance will be diagnostic and when there exists a negative stereotype about how likely it is that group members will do well at a particular task.

Stereotype threat and the computer performance: an experimental study

Although the stereotype that links gender to computer performance is well known, there have been no reports of behavioural studies that examined the effect of stereotype threat on girls' performance with computers. Data recently collected in our laboratory begin to shed address this omission. Adapting a procedure that successfully found evidence for the deleterious consequences of stereotype threat for women in the field of mathematics (Shih *et al*. 1999), we examined how high-school girls responded to stereotype threat in computer education.

All of us have multiple group identities. We may identify with our race, our gender, our political affiliation, our country and many more. We reasoned that to the extent that the students in our sample thought of themselves primarily as girls, then they would suffer the consequences of stereotype threat when learning a skill on the computer. However, if they thought of themselves in terms of a different group identity – e.g. as students at an excellent high school – then they should experience much less stereotype threat and would learn their computer skill much more easily.

Priming gender in the laboratory

For half of the students in our study, we primed their *gender identity* by asking them to write a paragraph describing social life at their high school. We asked them to describe, in general, such issues as dating and partying at the high school. With this procedure, we expected to make cognitions associated with being female more accessible in memory. The other half of the subjects were primed for their *student identity*. We asked these students to write a paragraph describing the courses and curriculum at their high school. In this way, the student-primed participants had thoughts of themselves as classroom students made more accessible as they finished the first part of the experiment.

All students were then given a computer task to perform. We used a task that required the use of the computer for its completion but, more pertinent to the stereotype of women and computer, where success was intimately connected to information technology. The task was to learn, manipulate, and create presentations in Power Point. Participants read the instructions for how to put together a graphic interface in Power Point for the presentation of various data tables. They then had to work with tables of data to create graphic presentations and to complete as many as possible within a specified period of time.

And the data show...

The performance results, depicting the mean number of items performed correctly, are presented in Fig 3. The figure shows that high-school females primed with their student identity performed considerably better at the computer-graphing task than the students primed with their female identity. When primed with their student identity, the mean number of steps correctly completed was 72, whereas the mean number of steps correctly performed by girls whose gender identity was primed was 58. Not only was perfor-

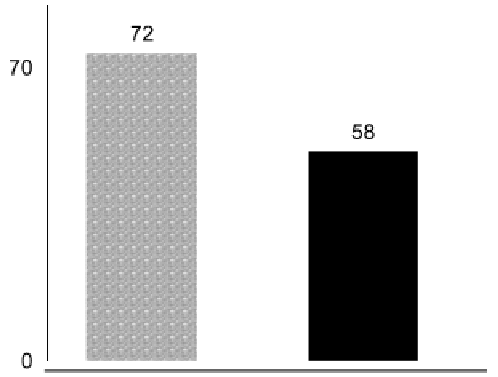

Fig 3 Mean number of steps completed successfully on the graphing programme.

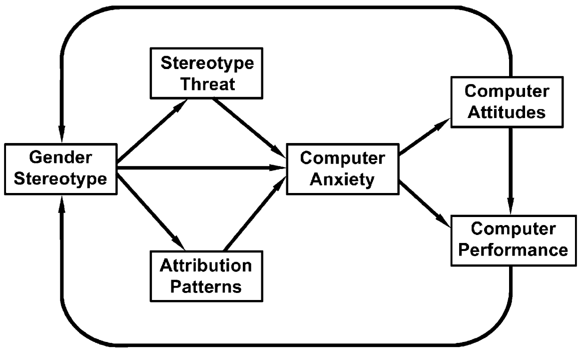

Fig 4 A model of gender-based digital divide.

mance reduced for those who were primed with their female identity, but there was also a significant increase in anxiety in this group. The implication of these findings is that the mere knowledge of a stereotype that holds that girls are not good at computers causes girls to suffer stress when learning from a computer and leads to decrements in computer performance. . . at least when their identity as females is made salient.

A model of the digital divide and suggestions for change

Figure 4 suggests a model for understanding at least some of the important factors that create the digital divide for gender. I assume *no* innate differences between boys and girls in their ability to use the computer or to learn from computerized instruction. Instead, we see that girls begin their socialization into computers in a world in which gender stereotypes for computers already exist. The gender stereotypes unleash a number of influences that lead girls, even at the youngest ages in the educational process, to experience computer anxiety. These include the design of software packages that are built to conform to the formal features of what boys like rather than what girls like and the social context of computer learning that relies on mixed-gender group learning. The effects of the gender stereotypes are exacerbated by the ways in which boys and girls are taught by their parents and teachers to make attributions for success and failure at computers. In the end, these factors cause girls to experience a high degree of computer anxiety, which, in turn, causes them to have more negative attitudes about computers, which, in turn, affects their willingness to approach computers. The negative attitudes adversely impact their computer performance.

The negative impact of gender stereotypes on computer anxiety and computer attitudes has a recursive effect that feeds and nourishes the negative gender stereotypes. Knowing that girls have negative attitudes towards computers and are reluctant to use them only reinforces the stereotype that computers are for boys and not for girls. This leads to a greater likelihood of creating boy-toys on computers rather than genuinely solid learning experiences for both genders. And merely knowing that the stereotype exists contributes an independent source of computer anxiety through the operation of the stereotype threat process.

In order to allow girls to benefit from the ongoing revolution in technology, we need to pull together as a society to reduce the digital divide. It would be wonderful to be able to wave a magic wand and eliminate the gender stereotypes that presume that girls cannot and will not successfully use computers. Although there is no such magic wand, we can alter the stereotypes by attacking the phenomena that support it. For example, software manufacturers need to concentrate their efforts on producing educational software that is either gender neutral or providing software that appeals to girls as much as the current software appeals to boys. Ultimately, professional educators and parents are the final arbiters of what is purchased for the classroom and the home. It is they who must be vigilant to make certain that the computer software does not reify the current stereotypes.

Second, schools should make it possible for girls to interact with computers either in small same-sex groupings or alone. Research has made it clear that the social context of computing matters, and computing in large, mixed-gender groups works to the detriment of girls. At least until the gender divide is neutralized and the stereotypes are allowed to change, the social context of computing needs to be more conducive to girls' education.

Third, parents and teachers need to be instructed in the deleterious consequences of girls' making personal attributions for computational failures and attributions of effort and luck for computational successes. The socialization that encourages the status quo is typically unwitting and non-conscious. Awareness and education can alleviate the problem.

The problem of stereotype threat is difficult to handle as long as the negative stereotype exists. In addition to the suggestions already advanced, it may be possible to reduce the gender stereotype of computers by focusing on females as role models in the classroom and workplace. To the extent that girls see women as successful computer experts and to the extent that they see evidence that girls are enjoying and learning from the computer, the stereotype that computers are solely the province of boys can be diminished. In the main, as we work to reduce gender stereotypes, we will not only reduce the problems that arise from computer anxiety but also insulate girls from the problems caused by stereotype threat.

Solving the problem of the gender digital divide will not be easy. In order to allow girls to benefit from the most important innovations of modern society, we must even the playing field and encourage girls and boys to partake of technology as a function of their interest, not as a function of their gender. Being aware of the existence of the digital divide as a pervasive phenomenon, and being committed to its reduction, are the first steps towards overcoming it.

References

Abdelhamid I.-S. (2002) Attitudes toward computer: a study of gender differences and other variables. *Journal of the Social Sciences* **30**, 285–316.

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

Aronson J., Lustina M.J., Good C., Keough K., Steele C.M. & Brown J. (1999) When white men can't do math: necessary and sufficient factors in stereotype threat. *Journal of Experimental Social Psychology* **35**, 29–46.

Atwell P. & Battle J. (1999) Home computers and school performance. *The information society* **15**, 1–10.

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

Colley A. & Comber C. (2003) Age and gender differences in computer use and attitudes among secondary school students: what has changed? *Education Research* **45**, 155–165.

Colley A.N., Gale M.T. & Harris T.A. (1994) Effects of gender role identity and experience on computer attitude components. *Journal of Educational Computing Research* **10**, 129–137.

Cooper J. & Weaver K.D. (2003) *Gender and Computers: Understanding the Digital Divide*. Erlbaum Associates, Mahwah, NJ.

Cooper J., Hall J. & Huff C. (1990) Situational stress as a consequence of sex-stereotyped software. *Personality and Social Psychology Bulletin* **16**, 419–429.

Dambrot F.H., Watkins-Malek M.A., Silling S.M., Marshall R.S. & Garver J.A. (1985) Correlates of sex differences in attitudes toward and involvement with computers. *Journal of Vocational Behavior* **27**, 71–86.

Devine P.G. (1989) Stereotypes and prejudice: their automatic and controlled components. *Journal of Personality and Social Psychology* **56**, 5–18.

Diener C.I. & Dweck C.S. (1978) An analysis of learned helplessness: continuous changes in performance, strategy, and achievement cognitions following failure. *Journal of Personality and Social Psychology* **36**, 451–462.

Dundell A. & Haag Z. (2002) Computer self-efficacy, computer anxiety, attitudes toward the Internet and reported experience with the Internet, by gender, in an east European sample. *Computers in Human Behavior* **18**, 521–535.

Farina F., Arce R., Sobral J. & Carames R. (1991) Predictors of anxiety towards computers. *Computers in Human Behavior* **7**, 263–267.

Fabio R-A. & Antonietti A. (2002) How children and adolescents use computers to learn. *Ricerche-di-Psicologia* **25**, 11–21.

Huff C. & Cooper J. (1987) Sex bias in educational software: the effect of designers' stereotypes on the software they design. *Journal of Applied Social Psychology* **17**, 519–532.

Karavidas M.K. (2004) The effects of computer usage on the retired older adult population. *Dissertation Abstracts International: Section B. Science and Engineering* **64**, 4076.

Lepper M.R. & Malone T.W. (1987) Intrinsic motivation and instructional effectiveness in computer-based education. In *Aptitude, Learning and Instruction: Conative and Affective Process Analysis* (eds R.E. Snow & M.J. Farr), pp. 255–286. Lawrence Erlbaum Associates, Hillsdale, NJ.

Licht B.G. & Dweck C.S. (1984) Determinants of academic achievement: the interaction of children's achievement orientations with skill area. *Developmental Psychology* **20**, 628–636.

Light P., Littleton K., Bale S., Joiner R. & Messer D. (2000) Gender and social comparison effects in computer-based problem solving. *Learning and Instruction* **10**, 483–496.

Littleton K. & Hoyles C. (2002) The gendering of information technology. In *Ghosts in the Machine: Women's Voices in Research with Technology* (eds N. Yelland & A. Rubin), pp. 5–32. Peter Lang, New York.

Littleton K., Light P., Joiner R., Messer D. & Barnes P. (1998) Gender, task scenarios and children's computer-based problem solving. *Educational Psychology* **18**, 327–340.

Mitra A., Lenzmeier S., Steffensmeier T., Avon R., Qu N. & Hazen M. (2001) Gender and computer use in an academic institution: report from a longitudinal study. *Journal of Educational Computer Research* **23**, 67–84.

Mucherah W.-M. (2003) Dimensions of classroom climate in social studies classrooms where technology is available (middle school students). *Dissertation Abstracts International Section A: Humanities and Social Sciences* **60**, 1451.

Nelson L.J. & Cooper J. (1997) Gender differences in children's reactions to success and failure with computers. *Computers in Human Behavior* **13**, 247–267.

Nicholls J.G. (1975) Causal attributions and other achievement-related cognitions: effects of task outcome, attainment value, and sex. *Journal of Personality and Social Psychology* **31**, 379–389.

Nicholson J., Gelpi A., Young S. & Sulzby E. (1998) Influences of gender and open-ended software on first graders' collaborative composing activities on computers. *Journal of Computing in Childhood Education* **9**, 3–42.

Okebukola P.A. & Woda A.B. (1993) The gender factor in computer anxiety and interest among some Australian high school students. *Educational Research* **35**, 181–189.

Parsons J.E., Meece J.L., Adler T.F. & Kaczala C.M. (1982) Sex differences in attributions and learned helplessness. *Sex Roles* **8**, 421–432.

Pinkard N. (2005) How the perceived masculinity and/or femininity of software applications influences students' software preferences. *Journal of Educational Computing Research* **32**, 57–78.

Reinen I.J. & Plomp T. (1997) Information technology and gender equality: a contradiction in terminis? *Computers and Education* **28**, 65–78.

Robinson-Staveley K. & Cooper J. (1990) Mere presence, gender, and reactions to computers: studying human–computer interaction in the social context. *Journal of Experimental Social Psychology* **26**, 168–183.

Rosenthal R. & Jacobson L. (1968) *Pygmalion in the Classroom: Teacher Expectation and Pupil's Intellectual Development*. Holt, Rinehart, Winston, New York.

Schofield J.W. (1995) *Computers and Classroom Culture*. Cambridge University Press, Cambridge.

Shih M., Pittinsky T.L. & Ambady N. (1999) Stereotype susceptibility: identity salience and shifts in quantitative performance. *Psychological Science* **10**, 80–83.

Snyder M., Tanke E.D. & Berscheid E. (1977) Social perception and interpersonal behavior: on the self-fulfilling nature of social stereotypes. *Journal of Personality and Social Psychology* **35**, 656–666.

Solvberg A.M. (2002) Gender differences in computer-related control beliefs and home computer use. *Scandinavian Journal of Educational Research* **46**, 409–426.

Spencer S.J., Steele C.M. & Quinn D.M. (1999) Stereotype threat and women's math performance. *Journal of Experimental Social Psychology* **35**, 4–28.

Steele C.M. (1997) A threat in the air: how stereotypes shape intellectual identity and performance? *American Psychologist* **52**, 613–629.

Steele C.M. & Aronson J. (1995) Stereotype threat and the intellectual test performance of African Americans. *Journal of Personality and Social Psychology* **69**, 797–811.

Stone J., Perry Z.W. & Darley J.M. (1997) 'White men can't jump': evidence for the perceptual confirmation of racial stereotypes following a basketball game. *Basic and Applied Social Psychology* **19**, 291–306.

Stone J., Lynch C.I., Sjomeling M. & Darley J.M. (1999) Stereotype threat effects on Black and White athletic performance. *Journal of Personality and Social Psychology* **77**, 1213–1227.

Temple L. & Lips H.M. (1989) Gender differences and similarities in attitudes toward computers. *Computers in Human Behavior* **5**, 215–226.

Tiedermann J. (2000) Parent's gender stereotypes and teachers' beliefs as predictors of children's concept of their mathematical ability in elementary school. *Journal of Educational Psychology* **92**, 144–151.

Todman J. & Dick G. (1993) Primary children and teacher's attitudes to computers. *Computers and Education* **20**, 199–203.

Weil M.M., Rosen L.D. & Sears D.C. (1987) The computerphobia reduction program: year 1. Program development and preliminary results. *Behavior Research Methods, Instruments, and Computers* **19**, 180–184.

Weiner B. (1979) A theory of motivation for some classroom experiences. *Journal of Educational Psychology* **71**, 3–25.

Whitley B.E. Jr. (1997) Gender differences in computer-related attitudes and behavior: a metal-analysis. *Computers in Human Behavior* **13**, 1–22.

Wilder G., Mackie D. & Cooper J. (1985) Gender and computers: two surveys of computer-related attitudes. *Sex Roles* **13**, 215–228.

Wilson K.R., Wallin J.S. & Reiser C. (2003) Social stratification and the digital divide. *Social Science Computer Review* **21**, 133–143.

Word C.O., Zanna M.P. & Cooper J. (1974) The nonverbal mediating of self-fulfilling prophecies in interracial interaction. *Journal of Experimental Social Psychology* **10**, 109–120.

Yelland N. & Lloyd M. (2001) Virtual kids of the 21st century: understanding the children in schools today. *Information Technology in Childhood Education Annual* **13**, 175–192.

Zanna M.P., Sheras P.L., Cooper J. & Shaw C. (1975) Pygmalion and Galatea: the interactive effect of teacher and student expectancies. *Journal of Experimental Social Psychology* **11**, 279–287.