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# The State of Research on Girls and IT

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This chapter critically surveys the scholarly social science literature about girls' involvement with IT, and the ways in which this involvement impinges on pathways into IT education or careers. Topics include school policy, curriculum, and course election; relationships with teachers; teacher training; the presence and use of computers; differences in attitude, confidence, interest, and experience between boys and girls; relationships with families and the local community; relationships to peers; life aspirations; popular culture; and computer games.

In a useful earlier literature review, Dryburgh (2000) classified research conducted in the 1990s on the underrepresentation of girls and women in computer science. She carefully distinguished studies that produced generalizable findings from those that were based on exploratory, pilot, small, or qualitative studies, and therefore needed more research. The factors that Dryburgh considered conclusively related to underrepresentation for girls include mixed-sex instruction, the lack of role models (though she recommends research into the degree to which role models lead to participation), and the fact that the beliefs of male peers about "who does computing" are stronger than those of females. This chapter has a broader scope than did Dryburgh's, expanding the analysis to more than computer science per se as well as reviewing the extensive literature that has appeared since the late 1990s.

## Scope

In preparing the literature review, we were challenged by the wide array of scholarly disciplines that address relevant issues. In order to keep this chapter manageable and focused on girls and IT, we have looked with differential depth at these various literatures. We have paid the most attention to articles focused directly on girls and IT, and because of that, certain journals are more heavily represented in our

presentation, such as the *Journal of Educational Computing Research*. Nevertheless, we have searched more widely; some of the other literatures we have looked at include the educational use of technology, girls in science and mathematics, psychological gender differences in children, socioeconomic influences on education and career choice, the influences of popular culture on children, and ethnographic studies on general and school culture.

The writing of this chapter was motivated by two factors. First, the literature has expanded in the past five years, in part because of the funding provided through the National Science Foundation ITWF program, and none of the existing literature reviews have fully captured the emerging literature. Second, the rapid spread of computing access through the increased availability of personal computers and the emergence of the Internet requires that we rethink some of the prior questions about girls and IT. For example, much of the literature on this subject in the 1980s and early 1990s focused on the differential access of boys and girls to computing technology. That difference has largely faded. According to the National Telecommunications and Information Administration (NTIA) report, *A Nation Online* (2002), as of September 2001, 90 percent of all U.S. children were using computers, 75 percent of all fourteen to seventeen year olds and 65 percent of all ten to thirteen year olds were using the Internet, two million additional Americans were beginning to use the Internet each month, and the use of the Internet by males and females was almost identical: 53.9 percent of males and 53.8 percent of females. Therefore, access to computers by boys and girls is much less important as a research topic today. Access across race/ethnicity continues to be a problem, however. In 2001, the National Assessment of Educational Progress (“The Nation’s Report Card”) surveyed more than three thousand students about computer use in the home. While 90 percent of white students reported having a computer in their home, only 72 percent of black and 68 percent of Hispanic students had computers (National Center for Educational Statistics 2004). We recognize that gender and race/ethnicity are inextricably linked. In a literature review, Harrell (1998) points to how gender, affluence, and cultural background are interrelated factors in determining enthusiasm for and participation in computing, implying that a focus on gender alone is too narrow. Still, because relatively little research has been conducted on girls who are members of minority groups, or because the representation of minority girls in samples is too small to measure difference, we have chosen a broad focus on girls in this chapter.

Increased access has caused us to concentrate on more recent literature. Access began to be much more universal in the United States in the early 1990s. As a result,

we have not considered here any literature that was published prior to 1994, and we eliminated from our analysis some of the literature published in the mid-1990s that we believe to be dated. Thus, even when there is a frequently cited journal article that introduced a relevant theme such as the gender biases in computer games (e.g., Kiesler, Sproull, and Eccles 1985), we have not discussed it here if the computer environment has changed sufficiently enough that there is a new generation of games whose gender bias creates concern.

With increased access comes new levels of familiarity with computers. A person considered a novice in 2000 might have been seen as an expert in 1990. A number of older studies used outdated scales to measure familiarity or confidence with IT by having outmoded tasks to test against as basic knowledge, such as the ability to turn on the computer and start up a program. Selwyn (1998) recognized this problem as early as 1997 and began to design new instruments for measuring attitudes toward computers. The problems of old measurement standards, as pointed to in Selwyn's study, is another reason why we limit our literature search to the past ten years.

We have limited the literature we consider to *research* publications. Many books and articles propound on the reasons for gender imbalance in IT. While there is value in these publications, we limit this review to only those based in empirical or scholarly theoretical work. Another body of literature discusses various implementations attempted as solutions to the imbalance. Those articles are considered here only when they include a scientifically sound evaluation of the implementation, so that the reader can learn about the underlying causes by examining the analysis of the empirical results.

The chapter is organized into sections corresponding to the topics listed above in the first paragraph. In addition to pointing to and describing briefly the publications that fit within a given theme, such as career aspirations, we also identify topics related to the theme that have not received adequate attention from the social science researchers. For example, the literature on career aspirations often gives statistics about the greater likelihood of boys than girls to be interested in pursuing a computer science degree in college and a career in computing, but the literature is surprisingly silent on the reasons for these aspirations.

The fact that we cite a particular article does not necessarily mean that we endorse its findings. It might be that there are methodological limitations to a particular study or the results might hold true in its domain but not more widely. We are relatively confident, however, that each article we cite meets the research standards we described above. We might have been more selective in which articles to

cite—for example, by more closely scrutinizing the method used in the research or considering only studies with large sample sizes. Instead, because of the limited availability of peer-reviewed research publications specifically about girls and their paths and issues with respect to IT careers (as opposed to information literacy, for one); because of the many methodological challenges in doing this kind of research (e.g., parental consent; difficulties in obtaining large sample sizes or control groups in educational settings); and because small or ethnographic studies often bring more value than large quantitative ones in suggesting issues or providing deep understanding, we have been encompassing in our selection of research articles to cite.

### **Methodology**

While the majority of the publications we cite are focused directly on girls and IT, we also include some other literature. This literature is intended to fill in gaps in the core girl-IT citations. For example, we did not find any literature specifically on how parents' educational level or socioeconomic standing affected the likelihood of a girl to pursue an IT education or career but we did find literature arguing that a higher educational level and higher socioeconomic standing of parents was strongly correlated with the child's decision to attend college and enter a professional career (Lankard 1995). This correlation seems to bear on a girl's likelihood of entering into a college degree program in IT and pursuing a professional career in IT. With the help of a professional librarian, we searched for a wide body of literature in the following ways, identifying through this search more than three thousand possible citations:

- We identified a number of education journals that consider computing issues and then scoured their tables of content back to 1994.
- We conducted searches using Google and the Digital Library of the Association for the Advancement of Computing in Education, using such terms in combination as gender, girl, computing, computer, curriculum, professional development for teachers, research, technology, popular culture, and so on.
- We hired a research librarian to examine the Social Science Citation Index, track down references we found in papers, and search various sources including Education Full-Text, PsychINFO, the IEEE Computer Society Digital Library, the ACM Digital Library, and Dissertation Abstracts.

- We used the resources of the U.S. Department of Education's Educational Resources Information Center (ERIC); in particular, we used their digests (miniliterature reviews on general topics such as the career aspirations of children) to understand the state of research in many related areas.

For each of the literatures described above, we employed selection criteria that enabled us to remain focused on our main topic. In this way, we reduced the number of articles for careful review to fewer than three hundred. We are unable to describe fully our selection criteria, which evolved as we searched through the literature and are based somewhat on subjective judgments, but the following selection decisions give a sense of what we both included and excluded:

- We have included research only from English-speaking and other Western European countries because we cannot be certain that other countries are sufficiently similar in culture, economic issues, and policy for us to draw inferences that might illuminate the U.S. situation.
- We were cautious in drawing inferences from studies about K–12 mathematics education because so much of the K–12 instruction on IT is carried out in a computer laboratory setting, unlike the setting for most mathematics instruction.
- We were more generally cautious about drawing inferences from the literature on girls' relation to mathematics and science because of the different patterns across fields in higher education. For example, mathematics undergraduate degrees have rough gender parity, whereas the percentage of women receiving computer science baccalaureates is persistently low. We do sometimes include literature on mathematics and science if it addresses how these disciplines are perceived by girls or teachers as belonging in the male domain.
- We have cited literature surveys in our chapter, not for their own intrinsic findings, but for the convenience of pointing the reader to other relevant literature. We have separately reviewed what appeared to us to be relevant publications cited in these literature surveys.
- We have excluded literature about undergraduate students because the K–12 and college environments are different; when undergraduates reported their earliest interactions with or interest in IT, however, we believe this to be relevant to K–12 students.
- We have not included articles on learning with computers (for instance, distance learning), even when they discuss gender differences.

- We have not included articles that examine gendered differences in interaction or communication styles online (when the sole basis for our consideration was that they employed IT).
- We have ignored a large body of literature on gendered differences of adults and technology because we are not sure of the applicability of these findings to children in their various developmental stages.
- We have not considered the gendered impacts of computer games that are unrelated to children's choices of IT education or career. (For example, we have not considered the claims that computer games make boys more violent or girls more communicative.)
- We have not considered stereotypical images of careers that just happen to be delivered through a computer medium, such as clip art. But we do consider what school Web pages say about gendered career patterns and the espoused beliefs of those who create them.
- We were not particularly interested in the literature on engendering computer or information literacy in children, although findings of differential use, experience, ownership, and related topics are reviewed.

With assistance from our graduate students, we reviewed each of these three hundred or so articles for objective, methodology, major results, study limitations, and citations to other literature. In this way, we selected from that set those articles and books actually cited in this chapter. Near the beginning of the project, based on our previous knowledge of the field, we identified a set of issue categories that we believed were relevant to understanding the involvement of girls with IT. We tested that categorization by seeing how well these three hundred articles fit within the categories, and ended up eliminating or merging some categories and creating several new ones. These categories are the topics of the main sections of this chapter.

Much of the research on girls and IT (and closely related topics as we have defined them here) is based in survey research, and implicitly assumes a male-female dichotomy and/or conflates sex with gender (see the next section for discussion). Our review includes this literature. Nevertheless, we feel that this literature presents a too narrow understanding of the issues. We have thus augmented our literature survey with theoretical writings on gender and culture. Yet it is probably fair to say that we have been more thorough in identifying and reviewing the empirical literature than in incorporating interpretive or critical literature.

The next section presents the theoretical underpinning of gender in our work as well as a brief discussion of the role of feminist theory in understanding gender issues in education. We then examine the reasons people seek to increase the participation of girls in IT. The review of research literature attempting to explain and understand girls' participation follows these sections.

## **Theoretical Underpinnings: Gender and Feminist Education Studies**

### **Gender and the Male-Female Dichotomy**

What it means to be male or female is culturally and situationally variable; it is neither genetically inherent in an individual nor defined or enacted in the same way across all social groups. In addition, being male in a social group is deeply related to being female in that group—each gender informing and defining the other through the roles one takes on (or does not take on) as well as the behaviors considered locally appropriate (or inappropriate) (Tracy 2002). Gender identity varies within particular contexts and forms, is reinforced within relationships and situations, and interacts with other types of identities in ways that influence beliefs about who takes on those identities. As Tracy writes,

In American society, for instance, the interactional identities of elementary school teacher, secretary, or nurse are expected to go with the master identity of being female whereas the interactional identities of surgeon, engineer, or manager are expected to go with the master identity of male. To the degree an interactional identity is strongly associated with some master identity, whether it be gender, race, or age, that interactional identity takes on some of the broader master identity features with which it is associated.

One's gender identity affects a group's expectations about the kinds of activities an individual will (or should) participate in. The tools and paraphernalia associated with those activities often take on meaning as male or female, accordingly (Christie 2004). For example, expecting parents find out the sex of their baby so that they can plan for clothing and nursery selections; the colors pink and purple are often associated with girls in the United States, and boys refuse to wear them. Certain types of discourse and behaviors are allowed and disallowed depending on one's identity, and these social expectations arise in a variety of situations, from interactions with one's own family, teachers, and religious leaders to interactions with peers and the media. Socialization begins the moment someone asks, "Is it a boy or a girl?" Infants are frequently dressed in gender-specific ways, indicating how one is supposed to interact with the infant: treat the baby like a boy or a girl (Paoletti 1997).

Gendered behaviors taken on by boys and girls (and shaping behavior through adulthood) are identifiable in many ways and evident to others. For instance, communication behaviors (e.g., the degree to which swearing is considered a norm violation; the amount of vocal pitch variation), ways of dressing, and ways of interacting with others can vary across gender.

We understand gender to be a set of social categories that shape not only tacit beliefs about how a girl or a boy believes that she or he her/himself should behave but also the way that others treat girls and boys as gendered beings, and the way others interact with boys and girls based on deeply ingrained expectations about how they *should* respond. We agree with Barnett and Rivers (2004), however, that males and females are not necessarily as different as they are often described in popular nonfiction. Barnett and Rivers point out that the research on which such writing bases claims about male-female differences (e.g., the value of interpersonal relationships, communication style, etc.) is often based on small, ethnographic studies with questionable capacity for generalization. Males and females may share many more similarities than research suggests, but authors frequently privilege statistical difference in reporting rather than not finding any variation.

When discussing how to gain wider and more diverse participation in IT, Brunner and Bennett (1998) and especially Bennett, Brunner, and Honey (1999) argue that one should not be trying to reinforce existing gender stereotypes or be looking for the gender-neutral solution but rather should seek ways to validate both masculine and feminine views of technology. Another important point that they make is to indicate clearly that not all men hold the so-called masculine view and not all women the feminine view. While these representations as masculine and feminine may be useful characterizations that reflect predominant stereotypes of males and females, any given individual may have both, neither, or either one of the stereotypical views. Some researchers have correlated their findings with categories from the Bem sex roles inventory (Bem 1974).

Although much of the literature that we review dichotomizes the male/female experience and identity, several other studies are consistent with the view of gender proposed above, including Thorne (1992, 1997 [cited in Stepulvage 2001]), Cassell and Jenkins (1998), Stepulvage (2001), Faulkner et al. (2004), and others. We also recognize the difficulty of studying gender as a set of social expectations, and the need to conflate gender and sex. In a later section on what we refer to as “difference” literature, we return to these issues of theory and gender. We review there empirical studies that examine differences between boys’ and girls’ confidence

and attitudes toward computer technology, confidence with computers, interest in machines and people, and computer experience. We also discuss some of the limitations of this difference approach.

### **Feminist Approaches to Gender in Education Research**

Philosopher of education Kenneth Howe (1997) has provided a theoretical discussion of two feminist approaches to gender and education, the humanist and relational approaches, which may prove useful in understanding girls and IT. Humanist feminism “defines women’s oppression as the inhibition and distortion of women’s potential by a society that allows the self-development of men” (Young 1990, 73; quoted in Howe 1997, 39). Under this view, women are limited by cultural norms and expectations, and are not given the same freedom to overcome these bonds as are men. Applying this view to education, one might simply remove obstacles that limit a woman’s right to choose certain educational paths (e.g., the Title IX legislation), or go further and take compensatory action such as special scholarships for women, affirmative action to redress gender balance issues in public school administration, or establish programs encouraging teachers to pay greater attention to girls in the classroom. This approach seeks to modify existing institutions while also preserving their fundamental values and methods.

Howe discusses and largely agrees with the criticisms of humanist feminism as an approach for solving problems of gender equity in education. He argues that institutions long privileging a “male clientele” will have numerous and deeply ingrained characteristics that favor males, and these compensatory acts suggested by the humanist feminists may actually be counterproductive. That is, their veneer of fairness or equity may mask those deeply ingrained features that still favor males. Howe applies this contention to science and mathematics education, but in a way that could also readily apply to computer education:

Consider the admonition to educators to treat boys and girls equally and to provide girls with additional resources and help in math and science. It may do little good to give girls extra resources and help if these are devoted to preparing them for a curriculum and modes of interaction that are foreign or hostile to who they are. What good does it do to ask girls more questions and to engage them more actively in classroom work if they find the classroom and the curriculum to be out of touch with their experiences and interests and to even devalue them? Even if the practices themselves are changed to include cooperative rather than competitive methods of teaching in order to, say, accommodate girls’ “learning styles,” this is not likely to achieve the same desired results if the goals of education remain the same—goals rooted in competition and the traditional ideal of the educated person [which as argued

earlier, means educated male]. (Howe 1997, 40 [footnotes and references excised from the quotation])

The second approach is relational (or gynocentric) feminism, which defines women's oppression as "the devaluation of women's experience by a masculine culture [and that] argues for the superiority of the values embodied in traditionally female experience" (Young 1990, 73–74; quoted in Howe 1997, 41). This approach has been adopted from Gilligan's (1982) theoretical psychological work on moral reasoning, in which she asserts that men and women have different beliefs about how one should interact with and value others, based on their own experiences, and neither is superior to the other. The approach has also been applied, more controversially, by Belensky and colleagues (1986) in educational theory to different patterns of learning and thinking in boys and girls. It is also the approach in Noddings's (1984) work in the philosophy of education. Howe writes of Noddings's philosophy:

She is critical of, among other things, the emphasis on competition and testing; the disciplinary knowledge that defines a liberal education; the same education for all in the name of equality of educational opportunity; and the evaluation of virtually every activity (even providing hungry children with food) in terms of how well it contributes to mastering the prescribed curriculum—characteristics that are presumably definitive of a male-oriented ethics of principles. (1997, 43–44)

Noddings is interested in a revolutionary reworking of public education. Her approach is in direct opposition to the Bush administration's more recent "No Child Left Behind" policy, which measures all students by a common metric and focuses on failures to meet those measures. Instead, Noddings wants to help each individual student develop to the maximum their own unique skills and interests. The emphasis in this philosophy is on sensitive and extensive mentoring, greater attention to discussion with and among students and less on didactic instruction of a canon of knowledge, and a complete remake attuned to a feminist perspective of the curriculum, the methods of instruction, and the structure of schools.

Neither Noddings nor Howe discuss how Noddings's philosophy might be applied to IT education, but we might draw some inferences. There would be less emphasis on classroom lecture on the principles of computing and more time devoted to letting students discover on their own in the computer laboratory, following their personal interests. Because effort would be taken to allow each student the time and facilities to discover things for themselves with the computer, teachers would have to take steps to ensure that no group of students monopolized access to the computer, the computer laboratory, or the teacher's time. More time would be devoted to discussion between teacher and student, and among students. Applications of

computing introduced in the classroom would be broadened and customized to the particular set of students. The curriculum would not be designed specifically with the purpose of preparing students for college computer science courses. Interestingly, some of these ideas are aligned with known best practices for female retention in undergraduate computing study (see Cohoon and Aspray, this volume).

In the next several sections, we describe the reasons offered for increasing the participation of girls and women in IT, followed by educational policies that function to keep girls out of computing, at both the national and school levels.

### **Why Involve Girls in IT Careers?**

There are at least four reasons why it is important to increase the representation of women in IT. First, increasing the number of women will increase the qualified labor pool that the United States depends on to drive the innovation and product development in IT that is so key to the U.S. economy. The United States had a critical shortage of IT workers during the dot-com boom—a shortage that could have been entirely met if women had been represented at the levels men were (Freeman and Aspray 1999). While there is not a critical shortage of IT workers in the United States today, the Bureau of Labor Statistics (2002) predicts that several IT occupations will be among the fastest growing over the decade 2002–2012.

Second, many IT jobs have favorable working conditions and pay at well above the national average. Many of these higher-skill, higher-pay jobs are filled by college graduates. Women make up more than half of college graduates, but they occupy less than one-third of these quality jobs. Making IT more gender inclusive will open new opportunities for financial well-being to a large sector of the U.S. population.

Third, many people have remarked on the value of a diverse workforce. For example, William Wulf (1999), president of the National Academy of Engineering, has written: “Since the products and processes we create are limited by the life experiences of the workforce, the best solution—the elegant solution—may never be considered because of that lack. . . . At a fundamental level, men, women, ethnic minorities, racial minorities, and people with handicaps, experience the world differently. Those differences in experience are the ‘gene pool’ from which creativity springs.”

Similarly, chair and chief executive officer of Lockheed Martin Norm Augustine stated: “If in your employment practices you ignore 85 percent of the newly available talent in this country, how are you going to be a great company? How

are you going to compete against companies that recruit from the country's entire pool of talent? And so, if for no other reason than self-interest, we ought to do more to maintain a diverse workforce" (quoted in Brainard n.d.).

A gender-balanced workforce is more likely to understand the needs and concerns of a wider segment of the customer base, and will design products accordingly (Wulf 1999). The automotive industry has recognized this fact. Ford organized a design team including an unprecedented number of women engineers for the Winstar minivan a few years ago. The hope was that this team would design in features that meet the concern of the many women who regularly drive minivans. More recently, Volvo formed an all-women team to design the YCC [Your Concept Car] prototype "by women, for women." As discussed in another section of this chapter, most software, especially game software, has been designed for male users. There are only a few examples of designing software specifically for female users, notably Brenda Laurel's failed company Purple Moon. Software that is more engaging to women, whether targeted at women or gender neutral, might go a long way toward improving the software available to the entire population.

Fourth, applying computing as a tool for solving big problems is considered critical to the U.S. future and economy. The National Science Foundation, for example, has recommended investing a billion dollars per year into the Cyberinfrastructure Initiative (Atkins 2003; Harsha 2004). Yet computing remains something akin to a craft, as was writing and reading during the Middle Ages, when understanding or producing the written word could only be accomplished through access to a person who had acquired these skills. Today, while most Americans can use a computer, most look on it as a magical box, with little or no understanding of what makes it work, leaving it to a specialized few to develop hardware and software or repair it. Such a critical need should represent and include the voices of all those who it is intended to serve.

These four reasons for increasing gender balance in the IT workforce can be addressed through various kinds of policy initiatives—labor and workforce, immigration, and research funding policies, for example. Three educational policies affecting the IT gender balance are the subject of the next section.

### **Educational Policies Affecting Girls' Participation in IT Careers**

In the 1980s and 1990s, policy was directed at access issues—at getting computers and, later, Internet connections into the classrooms. During the Clinton-Gore years,

these included the Technology Opportunity Program of the National Telecommunications and Information Administration, the Community Technology Centers Program of the Department of Education, the universal service provisions of the Telecommunications Act of 1996 that provided public schools and libraries with computer technology at discount prices, and the Snowe-Rockefeller-Exon-Kerrey Amendment that required private suppliers to offer service to these public institutions at affordable rates. While the digital divide issues of unequal access between rich and poor, urban and rural, and white and minority communities persist, great strides have been made to bring computing technology into U.S. schools. Unfortunately, as this one goal nears attainment, educational policy has not moved on to the next critical steps—of incorporating this technology into an effective learning strategy with teachers who, in spite of the efforts of the U.S. Department of Education’s Preparing Tomorrow’s Teachers to Use Technology Program, have been trained and have the time to be effective.

A second educational policy concerns the goal of computer education. The focus has been on “information fluency” or “information literacy” (National Research Council 1999; Snyder 2003). These skills are useful for every citizen to thrive in an emerging digital society where people increasingly have to obtain government and other essential information through the mediation of computers, and where more and more jobs are enabled by computers. But this education is not enough to prepare one for IT jobs. It does not teach students the fundamentals of computing and computer science that are crucial for these IT jobs. In almost all public high schools in the United States, either computer science courses do not exist, are elective, or are part of extracurricular activities. In each of these situations, only a small number of students will gain this valuable computer science education. The recently formed Computer Science Teachers Association, organized by the ACM, has prepared a “model computer science curriculum” for integrating computer science into all levels of education. What this means is that when they do learn deeper-level computing concepts, young people often obtain their first experiences with computers and computing in informal ways. The lack of computing instruction in formal settings allows computing to remain a mystery for the majority.

A third educational policy that affects computer education for U.S. children is President Bush’s No Child Left Behind policy. States and districts are narrowly focused on improving students’ test scores on existing subjects, possibly in order to qualify for federal education funding now distributed through states. According to a Rand Corporation study, such a concentration on testing can cause administrators

to focus resources on tested subjects at the expense of other subjects or distract their attention from other needs (e.g., the national need for a better-informed citizenry of information workers and developers) (Stecher 2002). The integration of computer science into all levels of education, as advocated by the Computer Science Teachers Association and supported by its model computer science curriculum (Tucker et al. 2003), is unlikely to happen, especially in this time of federal mandates for accountability and high-stakes testing under the No Child Left Behind mandate. The current policy functions to exclude the integration of knowledge and skills considered critical to the U.S. economy.

## **Formal and Informal Educational Settings**

### **School Curriculum and Course Election**

What is taught at school and what students are required to learn influence students' (and parents') beliefs about what knowledge is important and what is interesting. School curricula privilege certain subjects and ways of learning over others. For example, that reading and writing in middle school are required, but drawing is not, illustrates our societal beliefs about what kind of knowledge and means of expression are important. Those who excel in privileged subjects and ways of learning are rewarded. In most school districts in the United States, students are required to learn keyboarding and usually basic computing applications, just as they must learn to use a pencil in primary grades. Current educational policy, however, does not require that students study computer science or more advanced computer applications, even for those students preparing for college.

Computing is frequently taught as part of extracurricular informal education programs, such as Girl Scouts or summer camp. Its absence in the mainstream curriculum and presence in informal curricula give the implicit message that computer science is superfluous, something neither important nor required, but there to learn about if one has the inclination. In contrast, mathematics, biology, and chemistry are taught as part of the core curriculum, and these are on the college preparation list. As a result of these policies, students must learn something about these valued subjects since not only are students exposed to their content, but their parents, teachers, and counselors encourage them to do well in these subjects. By the time students get to the college level, they know what these subjects are about and have had some success in them.

There is variation across schools, particularly across secondary schools, in the degree to which students are exposed to computing applications other than basic ones (e.g., PowerPoint), communication tools, programming, and games. Some schools integrate the use of computing into subject areas, including familiarizing students with digital libraries (e.g., the Digital Library of Earth System Education) and designing Web pages. These curricula are better at showing the wide applicability of IT and the social uses to which it is put, thus potentially increasing girls' interest in this technology as well as their familiarity, experience, and comfort with IT. Even when students are required to study technology, though, their participation does not necessarily affect their interest, although it has been shown to improve their perceptions of the difficulty of studying and working with technology (Boser, Daugherty, and Palmer 1996). One Australian study suggests that if a technology curriculum is to be introduced for improving attitudes, it should emphasize a broad range of computing activities in preference to focusing on skill development within a single area since diversity of computing experience had a greater effect on changing attitudes for the better (Jones and Clark 1995).

The educational philosophy of course election provides a vehicle for gendered differences in preparation for college study of computing. Depending on a school's resources, middle school students can elect to take courses in the arts (e.g., drawing, music, and dance), technology (e.g., robotics, shop, and advanced computing), and foreign languages, among others. There are gendered differences in which courses are elected (American Association of University Women 1998). For example, boys take more classes in which computers are used than do their female peers (Colley et al. 1994; Shashaani 1994; all cited in Kirkpatrick and Cuban 1998, n. 11). In their 1996 study on gender differences in middle and high school technology classes (construction, woodworking, manufacturing, drafting, and communication) in four Connecticut school districts, Silverman and Pritchard (1993) found that girls and boys enjoyed technology classes for the same reasons; however, girls were much less likely than boys to enroll. The unfortunate effect of girls opting out of computing courses is that they may be less prepared not only for computer science but also for other subjects. For instance, enrollment in a computer course was a major success factor in applying spreadsheet problem-solving methods in a prealgebra course (Dugdale, DeKoven, and Ju 1998; this is the only recent study that we have found that shows the positive impact of formal computer education on K–12 course work).

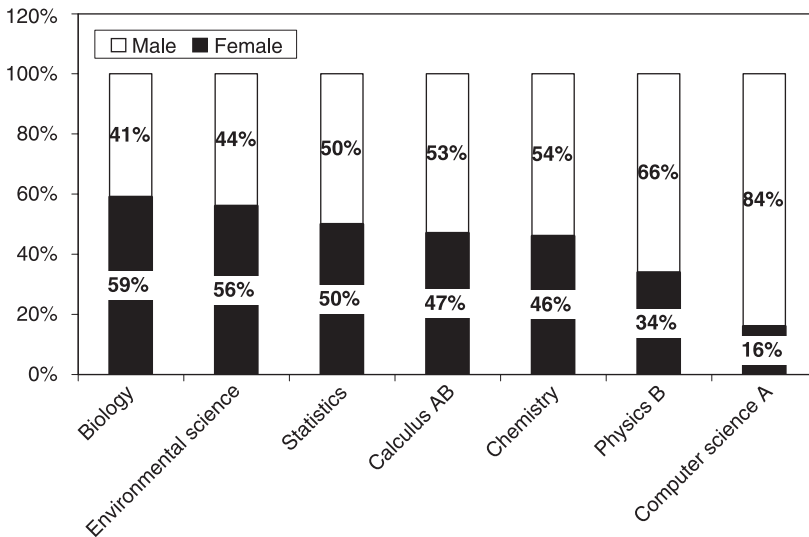
Computer science, as taught at the college level, includes technical, mathematical, and scientific components. Many—but by no means all—of the college students who excel in computer science courses have strong backgrounds in math and science. Many also have formal or informal training in computing before arriving at college. The students with this prior experience seem to be more comfortable and confident in college computer science courses, and there may also be something in their earlier math, science, and computing training that provides a foundational knowledge useful for the college computer science courses (e.g., algorithmic thinking). Certainly the students who have experience in computing are more immediately successful in introductory programming courses in college. The Cohoon and Aspray chapter in this volume, in a section on experience, presents five studies, and discusses both the positive relationship between prior experience and success in the first college computer science course, and the gendered differences in the effect of experience.

A few studies have examined factors influencing IT course election. In a 1995–1996 survey of 2,842 students (52 percent female) in five high schools in a southwestern U.S. state, Moses, Howe, and Niesz (1999) consider patterns of course election for the science, technology, engineering, and mathematics (STEM) disciplines, including computer science. They found that girls had slightly higher educational aspirations than boys, that boys planned to take more pipeline courses than girls (though the actual difference was negligible), and that boys had taken or planned to take significantly more of the most advanced pipeline courses. (A pipeline course is one providing the academic preparation for college study. In this study, pipeline courses included trigonometry, calculus, chemistry, physics, and computer programming. Advanced pipeline courses were the three most advanced subjects in the pipeline list: computer programming, calculus, and physics.) Boys showed more positive attitudes toward the pipeline courses: more so than girls, they liked the courses, understood what was covered in these classes, expected to use the courses as adults, and perceived that doing well in these courses was important for their future. The authors concluded that despite strong educational aspirations, girls are more likely to view these pipeline courses as undesirable, thus opting out of courses that are valuable preparation for later educational and career possibilities.

The policy of election, combined with a gendered view of computing, results in high school computer science classrooms dominated by boys. When the majority of students in a class are boys, girls are less willing to enroll in the class. In one study, most girls expressed an unwillingness to take classes where they would be one of a

few girls and did not picture themselves in careers that were in the masculine domain. Those who did enroll felt that they were “pathbreakers,” faced with proving that girls could do what boys could do (Silverman and Pritchard 1996). Girls often make these curricular choices under the subtle influences of the adults around them. A 1990 ERIC educational digest reviewed research showing that school counselors work with teachers to channel students into certain educational paths, sometimes discouraging girls from taking advanced math or science because of disciplinary stereotypes (Dunham 1990). We have no evidence of whether that has changed; however, we know that girls continue to be more likely to pursue traditional areas of study for women, with the exception of biology and statistics, as evidenced by Advanced Placement test takers (shown in figure 1.1; see also College Board 2004).

Factors influencing this gendered difference in course election are many and their interaction is not well understood. It could be that girls have internalized messages from peers or society at large that math and science courses are not appropriate choices for girls and have decided for themselves not to elect these courses. It may be that other decision makers in the school system—girls’ parents, teachers, and guidance counselors—are steering them away from these courses. In any event, it is



**Figure 1.1**  
Gender composition of AP test takers, 2004  
*Source:* College Board, 2004.

only because election is a standard part of the educational philosophy that college-bound girls can graduate from high school with a weaker background in math, science, and computing.

The causes for the gendered differences in election of high school courses in math, science, and computing need further examination. More specifically, are parents, teachers, and guidance counselors more likely to advise boys than girls to take these courses? Are there structural features in the school election system that contribute to the gender difference in course election noted here? For example, are elective courses that are thought by some to be more attractive to girls, such as literature and art courses, offered at the same time as the math and science electives so that the students have to make a choice between humanities and science courses? Are the course requirements of the school system sufficiently great that students have to choose between humanities and science courses because there is not enough room in their schedule for elective courses in both? Is the system so rigid in terms of both prerequisites and the grade levels at which these classes are offered that students who choose a humanities path (or a science one) of electives in middle school are locked into this path for the remainder of their K–12 education?

It would also be useful to look at the impact of K–12 course election on college behavior and performance. Are students who have more high school classes in math, science, and computing more likely to matriculate at technologically strong colleges and universities, enroll in computing courses or majors, achieve better grades in these introductory courses, or remain in the computing major? Do the students with this prior background in math, science, and computing feel more comfortable and confident in the lower-level undergraduate computing courses?

### **Relationships with Teachers**

Teachers' beliefs and attitudes about appropriate behaviors and roles for boys and girls, combined with their attitudes and beliefs about technology, can subtly influence girls to not study computers. Students and teachers maintain a variety of relationships, including those in the formal classroom environment, extracurricular activities, and one-on-one personal contact. Teachers are generally perceived by their students as having legitimacy, authority, and expertise; they thereby influence the opinions and behaviors of their students, both in the short and long terms. Research shows that teachers' expectations of students significantly influence student learning and that these expectations are internalized by students (Bamburg 1994; Raffini 1993). Through their verbal and nonverbal interactions with students,

teachers explicitly and implicitly communicate their tacit beliefs to students, who come to believe what teachers communicate. For example, studies have found that teachers smile more, make more frequent eye contact with, and move physically closer to students they perceive as having high abilities than they do with students they perceive as having low abilities.

Teachers express and act on their beliefs about appropriate and possible roles as well as behaviors for boys and girls, praising and scolding children accordingly (Fagot et al. 1985). For instance, teachers let girls give up more easily than they do boys, giving girls answers when they are having problems, while they are more likely to make boys figure out the answers for themselves (Sadker and Sadker 1995; Koch 1994). Further, teachers tend to overrate males' abilities, underrate females' abilities, and maintain more positive attitudes toward male students in mathematics classes (Li 1999).

In mathematics and science, subjects often considered to be in the male domain, teachers make more eye contact and interact more with boys than with girls; they also encourage boys more than they do girls (Li 1999; American Association of University Women 1998). This conveys an implicit message to girls that their input and learning is less important than that of boys in these subjects. In this way, many girls come to believe that they either cannot or should not solve problems on their own, which can undermine their confidence (American Association of University Women 1998).

Given the general belief about computing being in the male domain, we have no reason to believe that behavior in computing courses is different in the vast majority of U.S. schools from that reported here in the mathematics and science education research. In fact, the research supports this claim in mixed-gender high school computer science classes. In all-female classrooms, girls report significantly greater teacher support with technology use than females in mixed-gender classes (Crombie and Armstrong 1999; Crombie, Abarbanel, and Trinneer 2002). Teachers also perceive boys as having greater computer competence than girls. These perceptions are visible in teachers' discourse with students and others. In a small ethnographic Australian study of four elementary school classrooms, for example, Singh (1993) describes a primary classroom teacher who discusses his male students as being necessarily assertive, competitive, and competent with respect to the computer by virtue of the fact that they are boys. He believes one girl is also competent, but in fact, it turns out that she is not. Still, the teacher voices this erroneous opinion because he knows her mother and sisters, and believes that she comes from a "long

line of competent women"; that is, he marks this girl as different from other girls (47). Given the strength of teachers' expectations in shaping students' behaviors and achievements (Bamburg 1994; Raffini 1993; Gonder 1991), it might be unexpected and unlikely for girls to be able to achieve competency with computers without intervening requirements, such as information literacy standards.

Teachers also influence students by being role models, subtly and nonsubtly demonstrating to students appropriate topics of educational interest, social norms, and gendered behaviors. They are among the most common role models for young people because of the large amount of time they spend together and the authority relationship the teacher has with the student. The teacher training process and ongoing in-service expectations make teachers explicitly aware that students will mimic teacher behaviors, and thus it is expected that teachers will act intentionally to serve as positive role models. Even beyond the teacher's conscious attempt to serve as a role model, the student may identify with the teacher's personality, beliefs, and ways of acting. (Lee [1998] argues that this is true except in the case of girls in non-Catholic private girls' schools, where students are unlikely to see their teachers as role models or "possible selves.") Not surprisingly, teachers' attitudes toward technology can influence how students perceive technology (Brosnan 1997). Students may also draw inferences about the gendered division of labor from the mere presence of male and female teachers teaching certain subjects and having certain competencies. Based on a study in thirty Canadian primary schools, Jenson and Brushwood Rose (2003) present case studies showing that women teachers, regardless of their computing expertise, are unlikely to be thought of as technical experts; they describe male teachers making hardware and software decisions, and acting as gatekeepers for accessing computer equipment. They contend that their findings are consistent with several other qualitative studies. Computing is masculinized by virtue of who can easily access it, who fixes it, and who makes purchasing decisions (Bryson and de Castell 1998). Teachers are influenced and perceived within the same kinds of sociocultural beliefs as their students, and even if they wish to contest these relationships in their classes, existing power relationships and cultural assumptions inside and outside the schools makes it difficult for them to do so (Clegg 2001).

Many teachers continue to be low users of technology in their classrooms, although this situation is slowly changing as a result of several notable situations, including the U.S. Department of Education's significant funding of the Preparing Tomorrow's Teachers to Use Technology (PT3) program, the vast investment of

placing computers and Internet connections into schools, the fact that most students are coming into school with experience from home—leading to both students and their parents demanding computing resources and instruction at school—and the increasing ubiquity of computing in every aspect of our daily lives. Many teachers use computers only for the purpose of rewarding students or keeping students busy while others work, often leading to dominance of the computers by boys as they elbow out the girls (e.g., Kinnear 1995; Ertmer et al. 1999). When the computer is “just” a reward, the failure of some teachers to set rules about how long each child can use the computer also gives way to boys’ assertion over girls (Singh 1993). This lack of action is an implicit consent and condoning of this behavior. Teacher training, both in terms of skill with computing and classroom management, lags behind the placement of computers in classrooms.

### **Teacher Training for General Computer Use**

What teachers know regarding computers, and regarding teaching with and about computers, has an impact on children’s use, attitudes, and computing-related behaviors. The majority of elementary school teachers are women, and many of them have low computing skills. The U.S. Department of Education has attempted to rectify this problem with the PT3 program. Most schools of education in the United States begrudgingly integrated computer use into preservice programs. This frequently took the form of learning specific software packages (e.g., Inspiration) for concept mapping or requiring a threaded discussion for classes. The latter were often resisted by undergraduate preservice teachers for taking up too much additional time.

Teachers need training to be able to use computers effectively in the classroom as well as time to implement their use. Further, teachers need training for introducing fundamental computing concepts. Unfortunately, in several studies teachers reported not having enough time to become knowledgeable about effective ways of teaching with computers in the classroom, how to use a computer, or how to judge software for quality or gender bias (Bhargava 2002; Bryson and de Castell 1998; Guha 2003). To the extent that girls model their behavior after female teachers who feel uncomfortable using computers or have little knowledge about them, then the girls might continue feeling less comfortable (at least at school) using computers and see computing as a male activity.

Several studies show that teachers who have familiarity with computers are more likely than other teachers to use computers in class and teach about computers. In a

large study ( $N = 516$ ) using data from 1994, Becker (2000) found a positive correlation between teachers' use of computers in the classroom and formal training with computers. In a Dutch study of 236 teachers, Van Braak (2001) found that teachers who were technical innovators, taught a technology-related subject, and had greater computer experience were more likely to use a computer in their teaching. In a survey of 149 elementary teachers, Guha (2001) found that computer knowledge, training, and comfort with computers were positively correlated with computer usage in the classroom, regardless of other demographic variables such as years teaching, age, or gender. Guha (2003) surveyed and conducted in-depth interviews with elementary teachers with respect to their use of computers for instruction. Teachers who had lower computer abilities felt less comfortable with computers and feared to use them since they might lose authority in the event that children, who tended to have computers at home, would have greater computing skill than they did. Evans-Andris (1995) found that teachers unfamiliar with software or computers did not guide students during computer time. Consistent with Guha's (2003) findings, Evans-Andris also discovered that teachers unfamiliar with computers were often intimidated by children's superior knowledge, and were more likely to use the computer as a surrogate teacher for children to use passively than as a tool that the children would use to actively solve problems or otherwise apply.

### **Training for K–12 Computer Science Teachers**

Where computer science is taught in schools, it is a rarity to find a teacher who has both strong teaching credentials and strong technical training in computing (CSTA [Computer Science Teachers Association] Model Curriculum). Schools have reached out to people with IT-related degrees who often do not have a foundation in educational methodology. Although this is true of STEM teachers in general, it is especially problematic in IT because an IT professional can earn substantially higher wages in industry and because few preservice programs provide instruction in computer science education. In some states, the computer science major does not qualify for certification. Industry demand and state educational policies reduce the likelihood that public schools will attract computer science teachers who have a formal education in computer science. Thus, K–12 computer science teachers frequently are missing either educational or computing backgrounds. The consequence is that those teachers who have educational but not computing backgrounds deliver to their students what they have taught themselves; this tends to focus on learning a programming language or manipulating games more often than providing organized theoretical knowledge or applying that knowledge to real-world problems. Teachers

who have computing but not educational backgrounds are ill prepared to communicate these ideas and concepts to students, or design powerful learning opportunities and assessments; these teachers are also less likely to call into question their gendered beliefs about what kinds of people do what kinds of tasks, but instead to act on a lifetime of socialization and experience. In contrast, most teacher preparation programs require that students at least familiarize themselves with research on gender and minorities in school systems.

The Association of Computing Machinery has recently initiated the Computer Science Teachers Association, one goal of which is to train high school computer science teachers both for improving pedagogy and the gender balance of classrooms. Training for gender equity in IT in schools is rare. Bhargava (2002) reports on tools that have been developed to guide teachers in the use of non-gender-biased software, though it is not clear how widely these are used nor whether this has become a mainstream part of the preservice teacher curriculum. Sanders (2002) was involved in the professional development of teachers who needed to learn C++ for the computer science Advanced Placement test. Teachers spent half of their time learning the programming language, and the other half learning about gender equity issues and strategies for increasing the number of girls in their classes. Although there was a marked increase in the number of teachers attempting to increase the number of girls as a result of the training, the number of girls enrolling in the computer science classes did not increase. We do not know the reasons. It may be the result of teachers self-reporting their activities, professional development not aligned with best practices (i.e., sustained overtime), poor training, using male-oriented assignments, resistant girls, or some other reason. Administrators should also be aware of the persuasive power of school-related images. Based on her research on Web site images, Maboudian (2000) has argued that school Web sites contain gender-biased or gender-shaping messages. For example, one Web site shows only boys in the computer lab and presents girls only in cheerleading costumes. Teachers should be thoughtful about the meaning behind such images. School policies and teachers can have a significant influence on children, but no influence is greater than that of family.

### **Use of Computers at School and Home**

The availability of computers in the home, school, and other places influences children's experiences with computing, and shapes their perceptions of how they get used and who uses them. The presence and use of computers is one of the most studied

topics of any covered in this chapter. From the 1980s through the mid-1990s, access to a computer and the Internet was a major policy issue in the United States—an issue known as the digital divide. Poor, rural, and minority families had much less access to these tools than did the nation as a whole. The most recent data from the National Telecommunications and Information Administration (NTIA) indicate that access to both computers and the Internet is spreading rapidly in the United States, and that the divide in access that separated black and white, rich and poor, urban and rural is shrinking. The NTIA (2002) data indicate that 54 percent of the U.S. population was using the Internet in September 2001 and 66 percent used computers. Ninety percent of U.S. children between the ages of five and seventeen used computers, while 75 percent of fourteen to seventeen year olds and 65 percent of ten to thirteen year olds used the Internet. The presence of computers at school substantially narrowed the gap in computer usage rates for children from high- and low-income families. Increases in use (although from a smaller base) were rising most rapidly among blacks, Hispanics, and rural households (between a 24 and 33 percent increase in the period from August 2000 to September 2001). This led the Bush administration to announce the end of the digital divide.

To some degree, the NTIA 2002 report emphasizes those points that support the politics of the Bush administration. The report also shows the persistence of a digital divide along certain lines. Black and Hispanic children were more than three times as likely to have access to computers only at school, not at home. Black and Hispanic children were twice as likely as white or Asian American children to not be using a computer at all. For a good analysis of this report and the political context in which it is set, see Jesse (2004).

### **Use of Computers at School**

As we have mentioned above, the date when studies were conducted matters because of the rapid introduction of computers into the public schools in the United States throughout the 1990s. Several studies report on the relative use of computers at school by boys and girls. In a study of 500 middle school students in the Houston area, Miller, Chaika, and Groppe (1996) reported that 88 percent of girls and 90 percent of boys were using computers at school; this was not a statistically significant difference. Consistent with these findings, Miller, Schweingruber, and Brandenburg (2001) found no significant gender differences in knowledge of using a computer, how they learned to use a computer, use of the computer at school, use of computers with others, and Internet uses among 512 middle school students from

Houston. They concluded that the gender gap among children in access, use, and perceived expertise is narrowing considerably. As for what uses were made of computers by girls in school, Miller, Chaika, and Groppe report students using them to search the Internet, prepare documents with word processing, develop and present school projects, play games, do homework, view CD-ROM materials, check out library books, and view simulations.

An introduction to computers and keyboarding is now commonly taught in middle school in the United States. Children are not motivated to pursue further study of computing by these classes, however. For example, in an Australian study of thirty-three girls ranging from thirteen to seventeen years of age, Clarke and Teague (1996) reported that students were taught keyboarding, word processing, and other introductory applications. The students found these applications limited, boring, and menial—much more so than their home computer use. To the extent that this is the primary way children are introduced to computers and their use, the limited nature of the applications may be a real turnoff to both boys and girls.

### **Home and Other Extracurricular Uses of Computers**

Like computer use at school, home use of computers has also increased in general in the United States. Most studies show that boys use computers more frequently than do girls at their own homes and the homes of friends, summer camps, and after-school clubs. In older studies, access was much more common at home for boys than for girls: in the United States (Kirkpatrick and Cuban 1998), New Zealand (Fletcher-Flinn and Suddendorf 1996), Scotland (Durdell and Thomson 1997), and Israel (Levine and Donitsa-Schmidt 1995). In a more recent study of 1,400 Canadian children in seventh and tenth grades (Lupart and Cannon 2002), the authors found that more boys than girls used computers at home, boys were younger than girls when they began using computers, boys used the Internet more than girls, and boys used their computers at home on average more hours per day than girls. This latter point was also noted by Kirkpatrick and Cuban (1998) as well as Durdell, Glissov, and Siann (1995). Two somewhat older studies, however, report no gender difference for time spent on the computer for those who had their own computer at home (Fletcher-Flinn and Suddendorf 1996; Dugdale, DeKoven, and Ju 1998). These differences may be due in part to the age groups sampled. The 2001 National Assessment of Educational Progress (NAEP; National Center for Education Statistics 2004) study shows a difference across age groups in terms of amount of computer use. In this large study ( $N > 6,800$ ), fourth-grade boys and girls report about

the same usage of computers outside of school. Eighth-grade boys, though, report somewhat more usage outside of school than do girls.

Research on the purpose of computer use by girls and boys outside of school shows that boys and girls use computers for many of the same applications, but for different amounts of time. In a survey of 291 parents (Kafai and Sutton 1999), it was reported that boys use games, educational software, and the Internet more than do girls. Both Lupart and Cannon (2002) and Miller, Schweingruber, and Brandenburg (2001) identified e-mail and homework as the main use of computers by girls. The large NAEP study referenced above found that 90 percent of fourth-grade boys and girls report that they play games on the computer at home. By eighth grade, however, boys are significantly more likely to spend large amounts of time playing computer games than are females, while girls spend more time than boys communicating synchronously and asynchronously with others via the Internet (e.g., e-mail, instant messaging, chat) (National Center for Education Statistics 2004). Clearly, the routinizing of computer use in the home makes an impact on children's perceptions of computers.

### **The Impact of Experience**

There is a positive correlation between experience with computers and girls' attitudes toward them. In a study of ninth-grade German students (Schaumburg 2001), girls who were provided with a laptop computer used computers more at both school and home, and they learned more about computer hardware, software, and the Internet as compared to a control group. A broader range of experiences may make a greater impact than experience with a limited number of applications. In a study of 231 girls fifteen years of age in single-sex and coeducational schools in Australia, Jones and Clark (1995) found a positive correlation between the diversity (but not the quantity) of computer experience to girls' positive attitudes about computing. The presence of a computer in a home also seems to be positively correlated with attitude, according to two relatively large studies in the United States (Levine and Donitsa-Schmidt 1995; Frantom, Green, and Hoffman 2002).

### **Influences beyond the Classroom**

#### **Research on Differences in Attitude, Confidence, Interest, and Experiences**

One's attitudes toward, confidence with, and experience using a tool or set of tools are related to academic and career choices in which these are the predominant focus.

Therefore, a great deal of research has concentrated on the differences between boys and girls in terms of their attitudes toward, confidence using, and experience with computer technology. Generally speaking, these studies are not necessarily focused on developing IT but more often toward the use of computing technology in the service of some other goal (e.g., learning; communicating with friends via the Internet) or simply learning to use the computer itself (e.g., keyboarding; Web development). Such studies are extremely numerous. We thus present here a range of studies looking at different aspects of computing use, attitudes, and experience. Note that these studies are designed to look for differences and describe probabilities, not similarities nor generalities. A general criticism of research that looks for differences is that it fails to report on similarities that may be important (American Association of University Women 1998; Barnett and Rivers 2004).

One group of difference studies focuses on confidence and attitudes toward technology. These studies more frequently show that girls are less confident using computers than are boys. In their 1998 review article, Kirkpatrick and Cuban (1998) say that in early grades, the gap between males and females in achievement and attitude is minor, but the gap increases as they get older, as does the confidence gap. Levine and Donitsa-Schmidt (1998), however, found a positive correlation between computer experience, computer knowledge, and computer confidence. With the better access to computers in more recent years, one might speculate that the confidence gap will have decreased. Yet four studies show that the confidence gap persists (Fitzpatrick and Hardman 2000; Light et al. 2000; Schaumburg 2001; Frantom, Green, and Hoffman 2002). Yet Fitzpatrick and Hardman also found the gap widens as children grow older. They surveyed 120 seven- and nine-year-old boys and girls and discovered that the seven-year-old girls expressed more confidence working with computers than did nine-year-old girls. In addition, the younger girls were more motivated to work with computers than were their male peers.

The issue of girls' confidence is poorly understood and disputed in the literature. Reviewing research on adolescent girls from the 1980s to the 1990s, Eckert (1995) argues that adolescent girls experience a "crisis of confidence," in which girls have greater awareness and less satisfaction of their bodies, are more concerned about their popularity and being liked, and are more prone to depression and suicide. Barnett and Rivers (2004), though, call into question the research on which these confidence studies are based. They contend that Carol Gilligan's original study on which many others were based was a small, ethnographic study of upper-class white girls attending a private school and that an influential report by the American

Association of University Women was methodologically flawed (both cited in Barnett and Rivers 2004). They also present a meta-analysis of research including 150,000 subjects in which there was little difference between boys and girls in confidence (Kling, Hyde, Showers, and Buswell 1999; cited in Barnett and Rivers 2004).

Boys and girls hold different beliefs about who should study or be involved in computing. Durndell and Thomson (1997) administered three surveys to sixteen to eighteen year olds at three different times, the most recent being 1995. Female students were significantly more likely than males to believe they were not qualified to study computing. This may be explained by the fact that the data were collected ten years ago, since ten years ago boys were more likely to have and/or use a computer at home than were girls. In several studies, boys held more stereotypical beliefs about who should engage in computing than did girls (Fletcher-Flinn and Suddendorf 1996; Boser, Daugherty, and Palmer 1996; Whitley 1997). Nevertheless, such beliefs can change over time, as shown in a study where younger boys held more stereotypical views than did older children (Fletcher-Flinn and Suddendorf 1996). In contrast to findings that boys have stronger opinions on computing than girls, in a study of 574 students in ten rural school districts, Frantom, Green, and Hoffman (2002) report that boys were more likely than girls to agree that “girls can do technology as well as boys,” but they had higher variance in their answers than did girls. Boys were also more likely than girls to agree that “technology is as difficult for girls as it is for boys.”

Other difference studies concern interest in technology and assertiveness with technology. Durndell and Thomson (1997) reported that sixteen- to eighteen-year-old girls were more likely than their male peers to indicate greater interest in people than in objects. Similarly, in a study of 155 seventh graders, Boser, Daugherty, and Palmer (1996) found that girls expressed less interest in technology and perceived it as more difficult to learn than did males. In several studies, boys were observed dominating computer use at school, though not under all circumstances. Freeman and Somerindyke (2001) observed preschool children playing with two computer programs in a university laboratory school and noted boys dominating the computer. Likewise, Koch and Uptis (1996) observed a Canadian classroom of seventh and eighth graders for two years. They found that boys dominated computer use at school during free computer time, and girls were not likely to use the computer even if they did have free time, but especially if there were other students already sitting at the computer. In this case, a computer “in-group” was formed on the basis of frequency of use, further concentrating the gender disparity; students who had com-

puters at home were more likely to be part of the in-group at school. In a study of 120 seven- and nine-year-old students in England comparing behavior of same-sex and mixed-sex pairs, the authors found that boys dominated the computer when collaboration with girls broke down (Fitzpatrick and Hardman 2000).

Girls' gender identity may influence assertiveness with computer use at school. Stepulvage (2001) discovered that girls are more likely to take on passive roles when working alongside boys on the computer. She argues that although girls do engage with computer technology and occupy positions that enable development of expertise in IT, this computing competence must mesh with the constitution of a heterosexual gender identity. Finally, based on her teaching and research experience in a midwestern elementary school (not a formal study), Hanor (1998) contends that boys physically and verbally discourage girls from using computers. In her observations from teaching (again, not a formal study), Hanor describes access barriers as teacher training issues. She claims that teachers need to manage several access barriers for girls in the classroom: the boys' computer use discouraging the girls' use, not knowing that use of the computer is a choice, conflicts in scheduling, competing work requirements, and teaching assistants more likely to select boys than girls.

The majority of difference studies, such as those reviewed above, equate sex with gender and use gender as a monolithic category across socioeconomic groups. There have been attempts to avoid equating gender and sex, using psychological gender theory. Under this theory, persons are considered to have high or low masculinity scores, and these are not opposites but independent constructs. For example, Brosnan (1998) found that high femininity correlated with a poorer attitude toward technology and that high masculinity correlated with a better attitude and higher scores on a computer-based track. Yet Charlton (1999) found that both higher masculinity or femininity correlated with greater comfort, but that greater masculinity was related to greater engagement and greater femininity was associated with lesser overuse. Such studies, while more illuminating than those that conflate gender and biological sex, do not generally provide a deeper understanding of how gender identity interacts with the attitude toward IT. Further, "difference" implies that the determining variable is masculinity and femininity, rather than providing understanding of technologies as embedded in a cultural setting, where meanings are created and assigned as part of ongoing interactions among children and adults. In contrast, like Huff (1996), Clegg (2001) argues that attitudes and experiences with technologies are embedded in the technology (hardware and software) and the

social practices surrounding technologies. In other words, designers project themselves into the technologies they create.

Findings usually conclude that girls hold less positive attitudes toward and confidence with technology. To the extent that the underlying belief of these studies is that girls and boys both need to have positive values and high confidence with IT, conclusions generally point to a deficit among girls: they are lacking something boys have. Elkjær (1992) describes the issue differently, however, arguing that gender and gender differences are relative constructs, and that boys' behaviors (dominance; failure to admit lack of knowledge) create the problem for girls, who become passive in the presence of boys' dominance and believe that they know less simply because boys believe they know more. Studying actual skill and knowledge, rather than perceptions thereof, would furnish teachers and parents with concrete ideas about what girls and boys need to learn. Further, if the result of such assessments is insignificant difference, this message could be conveyed to girls to boost their confidence.

### **Influence of Families and Community**

A girl's relationships with her parents and siblings are usually her strongest early relationships, and her first exposure to beliefs about possible and appropriate roles for girls and boys. (This is similarly true for boys.) Despite the image of the rebellious teen, these relationships between child and parent persist over time. Families form their own ways of behaving, enacting their belief systems. There is disagreement, but what is shared is often larger than what is not. As a child grows up, she or he will often look to parents and older siblings to be role models and opinion leaders. As with the teacher relationship, beliefs are communicated in many ways, both explicitly and implicitly. It is traditional from birth for parents to treat boys and girls in gendered ways, by virtue of their sex. This is also manifest in the way parents often encourage boys and girls to take different educational paths as well as prepare for different careers.

Parents' religious beliefs frequently shape their views about gender-appropriate lives for their children. Because of the strong force of religion, parents will generally try to instill their personal religious belief in their children, and they will employ religious organizations to attempt to do so. Some religions maintain belief systems that place girls and boys in more traditional gender roles than others. Likewise, parents who value education or who themselves are highly educated are more likely to have children who value and pursue education. Even if parents value education,

there can be gender differences in the way they apply their desire for educating their children. They might not encourage their daughters, for example, to pursue science and engineering disciplines or believe that these are appropriate occupational goals—unless one or both of the parents are in these occupations (Rayman and Brett 1993).

In many U.S. communities, there is homogeneity across households in socioeconomic status, education level, and type (e.g., professional versus vocational) of occupations held. In cases where the parents are typical of other members of the community, the local community can reinforce the messages being delivered to students by their parents. For example, in a wealthy, well-educated community, it is expected that every child will go to college and form a professional family; this message is subtly communicated to children in every local contact they have.

Another influence of the community lies in the range of activities it offers to its youth. The availability and nature of activities is likely to vary by the demographics of the local community (rural versus urban or suburban, socioeconomic distribution, religious affiliation, etc). Opportunities for scouting, participation in clubs, sports, and service can enrich children's experiences and shape their beliefs. For instance, playing on a soccer team can be empowering (President's Council on Physical Fitness and Sports 1997; Zimmerman and Reavill 1999) and participation in Girl Scouts may provide girls with direct experience of computing.

Although hardly any literature explores the influence of parents and local community on children's attitude and behavior specifically toward computing, two studies offer small insights in passing. Margolis and Fisher's ethnographic study (2002) of undergraduate computer science majors at Carnegie Mellon University revealed that fathers often provided their sons with computers and spent time "tinkering" on the machine with them. Mothers were less likely to be involved in tinkering, and the males frequently described their mothers as either computer phobic or computer incompetent. Women much less frequently described similar bonding experiences on the computer with either parent. (Interestingly, in a study of single-sex schooling at Catholic and independent schools in the United States, Lee (1998) notes that in mixed-sex schools, schools with high levels of parental influence led to a greater gender gap in mathematics achievement, favoring boys.) Considering the growing ubiquity of computers, including school requirements that children be "technologically literate," we wonder to what degree parents continue to treat their sons and daughters differently with respect to computing. For example, are there gendered differences in their encouragement to use computers, what to use them

for, spending time at the computer with the child, encouraging education training and careers in computing, and making opportunities for them to attend computer camp?

### **Relationships with Peers and the Impact of Single-Sex Schools**

Peers are a powerful influence on children's beliefs and behavioral choices, and this influence is in force from the time that children begin having peers. Especially as children enter the teenage years, they have an amplified need to conform or to inhabit a persona that is acceptable to other children. For example, teenagers cast various kinds of persona as nerds, geeks, jocks, or the popular set. They are careful about which type they act like and form cliques with children of similar persona (Adler and Adler 1998).

Peers influence children's beliefs about the value of education, appropriate and possible gender performance, and academic choices. Eckert (1995) argues that childhood is a series of stages in which children are constantly looking toward the next step of being a child. That is, children are not making behavioral decisions based on what they think they will be as adults (who work and have careers) but instead toward the next stage forward, which may be eighth graders for sixth graders and high school students for eighth graders. Eckert writes, "Few kids in this life stage consider adulthood desirable, nor do they consider the behavior of adults to be particularly statusful [*sic*]." Rather, at this stage girls and boys work on more fully being heterosexual persons—not in the sense of sex or sexuality but in the sense of performing the interactive behaviors of persons who fit into appropriate roles for their sex.

Eckert's view has implications for girls' choice of course work. As discussed above in the section on course election, it is during early middle school when children begin to have choices about the courses they take. The choice of courses is based not solely on what they enjoy but on the type of person they hope to be and the type of person they hope their peers will believe they are. They are likely to choose courses that are locally considered more appropriate for one gender or the other. Those who make choices outside these norms may suffer from negative attention from their peers. Where math, science, or computing courses are considered "nerdy" or for boys, a powerful force is in play to quash girls' interest in these topics.

Single-sex schools and classes have been one approach taken to improve the engagement and achievement of girls, and several studies compare girls in single-sex

classroom environments with those in coeducational ones. Jones and Clark (1995) found that girls from single-sex schools had more experience and more positive attitudes toward computers than did girls from coeducational settings. Nevertheless, experience with computers was the variable that best predicted attitude and not the fact that the class contained only girls. Crombie, Abarbanel, and Trinneer (2002) surveyed 250 students in an elective eleventh-grade science course across a three-year period. One of the classes was all-female. Girls in the same-sex class had higher computer confidence, but lower confidence than the males in the mixed-sex class. Girls in the same-sex class were also more vocal than coed girls, and perceived stronger support from and interacted more with teachers; this was similar to boys' perceptions of teacher support. Lee (1998) found that in Catholic all-girl schools, girls had higher educational aspirations and greater intention to participate in non-traditionally female careers. In fact, girls in Catholic same-sex schools had higher mathematics and science achievement than did girls in Catholic coeducational schools. It is unclear the degree to which this is a function of parental choice and influence or of peers.

### **Life Aspirations**

A significant body of literature investigates career factors. Family situation, which includes socioeconomic status, educational level, and religion, are the single-greatest influence on a child's career development (see reviews in Naylor 1986; Lankard 1995; Whiston and Keller 2004). Lower levels of parent education are correlated with less likelihood of the child—boy or girl—going to college or entering a professional career (DeRidder 1990). Family income has a particular effect on girls' career development. Lower-income families may be more likely to take a strategy of devoting limited resources to their male children's career development or to being more likely to hold views that see homemaker roles for girls—for which less occupational preparation is needed (Lankard 1995). Children whose parents work in professional occupations perceive a wider range of career choices (Mullis, Mullis, and Gerwels 1998). To the extent that parents are aware of IT careers, girls will likely know more about and be more inclined to pursue them.

Girls and boys allow their (and their families') cultural beliefs about appropriate gender roles to guide their career explorations as opposed to their personal interests (Farmer 1995). In a longitudinal study of 208 children, Helwig (1998) explored children's perceptions of whether occupations were male or female. Occupations are considered to be male if at least 70 percent of the people holding those positions

currently are male, to be female if at least 70 percent of the people holding them currently are female, and otherwise are characterized as gender-neutral occupations. Eighty-three percent of second-grade boys chose male occupations, and the percentage increased to 93 percent by sixth grade. Fifty-six percent of second-grade girls chose female occupations, but the number decreased to 30 percent by sixth grade. For both boys and girls, career expectations are related to their parents' expectations for them, especially their mother's. By sixth grade (as compared to second grade), the career that the child desires, the career that the child expects, and the career their parents expect for them all match more closely. Instead, as girls got older, they were more likely to select male occupations (19 percent in second grade, and 48 percent in sixth grade). Helwig suggests that both boys and girls recognize the social rewards and higher pay of male occupations by the time they are sixth graders, thus accounting for this increased interest in male occupations. Another explanation may be that sixth-grade girls are beginning to perceive that women's traditional roles tend to be subordinated to those of males (Eckert 1994). It also could be inferred that many high schools are doing a good job of preparing both boys and girls for a variety of careers.

One could conclude that the vast majority of the boys and almost half of the girls at the sixth-grade level might be open to a computing career since it is high paying and is probably seen as having the high social rewards of a male occupation. Still, another recent and large study (Lupart and Cannon 2002) of seventh and tenth graders in an urban community in Canada showed much less enthusiasm by girls for IT careers. Girls self-report a greater likelihood of expectation of finishing high school and completing more than one university degree than do boys. Yet while both boys and girls rated highly "earning a great deal of money" and "high status in society" as significantly important factors in a career choice, boys rated these two factors significantly more highly than did girls. Seventh-grade girls rated most highly the career of artist (which included designer, interior decorator, musician, and actor), with health professional second highest and IT professional dead last. Also low in the rankings for seventh-grade girls were the occupations of engineer, architect, and geologist. Seventh-grade boys, by contrast, had IT professional (which included computer engineer and computer scientist) as their first choice. Girls in single-sex classes may be more likely to pursue an IT career, however. Crombie, Abarbanel, and Trinneer (2002) conducted a similar study of 250 students in elective computer science classes in Ottawa, Canada, but had access to both all-female and mixed-sex classes. Boys reported the highest intentions to pursue college study

of computing, followed by girls in the single-sex classes, followed by girls in the mixed-sex classes.

Most of the studies cited so far in this section do not describe what it is about an IT career that makes it much less attractive to girls than to boys. Two other studies provide some clues, although neither definitively answers this question. Clark and Teague (1996) studied thirty-three Australian girls, ages thirteen to seventeen, from diverse backgrounds. Most of the girls favored a career in a socially oriented or socially important field such as medicine, law, or business. Although it is not clear how they came up with these particular choices, they did report that they were most interested in jobs that provided job satisfaction as well as ones with social orientation such as communicating with and meeting new people. In school, these students had learned only mundane computing skills associated with keyboarding, word processing, and elementary applications. When asked about computing careers, they indicated that they saw computing as boring and menial. When asked, they could not provide the interviewers with examples of computing careers other than those directly associated with keyboarding and word processing. Interestingly, the girls were excited about their use of home computers, which they used for their own goals. The children in this study had a limited conception of the kinds of careers that fall under IT.

Many outreach programs are held each year to encourage girls to enter IT careers. Some extracurricular computing experiences, however, may reverse girls' decisions to pursue an IT career, despite the best efforts of teachers, counselors, and persons who arrange career experiences for students. Taylor (2003) evaluated the educational outcomes of an internship program for high-achieving high school students. Boys in the study were given highly technical jobs and integrated well into corporate life. In contrast, the girls involved were given jobs they considered boring (e.g., Web design) and felt unchallenged. Unlike many of the boys, none of the girls decided to pursue careers in IT. A conclusion to draw from this is that extracurricular computing experiences also involve a set of best practices, but these are out of the control of the teachers, counselors, and persons who arrange career experiences for students.

While the literature about career choice is abundant, much of it is not specific to careers in IT, and most of the studies that do consider IT careers address whether, rather than why, these careers are or are not ones made by girls. Research into ways girls can be recruited into IT study and careers is minimal (see the literature review in Barker, Snow, Garvin-Doxas, and Weston, this volume). For example, further study of the depth, extent, impact, and nuances of the widely held belief that boys

are interested in computers as toys while girls are interested in them as agents of social change would help inform interventions.

### **Images in Popular Culture**

An often-heard explanation for the underrepresentation of girls in computing is the media portrayal and a popular conception/stereotype of computer science or computer professionals (or even users) as so-called geeks or nerds, who are usually males. The images of males and females in mass media carry implicit and significant messages about idealized views of males and females in culture. For example, television commercials caricature women using vacuums (or showing men how to use these complicated machines) and men fascinated by an automobile's lock mechanism. Likewise, television programming and commercials, music, videos, movies, popular magazines, and books contain and transmit implicit as well as explicit messages about the values, expected behaviors, and communication styles of girls and boys at different ages. These messages often present boys and girls in terms of the traditional gender-role binary, as do games (arcade, computer, board, educational, etc.) and toys (e.g., lavender and pink bicycles for girls; racing flames for boys). The Internet presents a more diverse range of opportunities—some of which, like television, present gendered roles and others do not.

The degree to which explicitly and implicitly gendered messages from mass media, toys, music, and games influence children's behavior is unclear. In the early 1960s, scholars began studying the effects of television viewing, hypothesizing that long-term exposure to television cultivates attitudes and values in viewers, though they acknowledge that these attitudes and values are already present in a society (cf. Gerbner 1969). Goffman (1979) argued that magazine advertisements both reflect and influence our conceptions of appropriately masculine and feminine behavior. There is some evidence that adolescents are more influenced by the portrayals of appropriate sex roles in mass media than are adults (see the review in Chapin 2000).

Media images more frequently depict computer programmers and developers as males, and women as users. For example, in advertisements of technology products, women are often presented as passive and inexperienced users to show how simple some device is to use, suggesting that "this computer is so easy to use, even a woman can use it" (Jenson and Brushwood Rose 2003, 172). Men, on the other hand, are characterized as deep thinkers concerned with the future (Dilevko and Harris 1997). For many years, home computer and computer game sellers almost exclusively targeted male users and "toys for boys" (Bryson and de Castell 1998).

The popular image of computer people as geeks may or may not be a barrier to girls' study of IT. A computer geek is someone obsessed with computers or computing, and who is also antisocial (Webster's 2003). A full-page advertisement in *USA Today*, a national newspaper dropped in front of hotel room doors across the United States, shows Best Buy Co., Inc.'s new subsidiary Geek Squad described as "an elite tactical unit trained to seek out and eradicate evil computer activity." Consistent with "geek culture" (Svitavsky 2001), the employees are presented as though they are engaged in a role-playing game, pretending to be police officers. Five "agents" are shown in the advertisement, each wearing a "special agent badge," short-sleeved white shirts, and narrow black ties. The males' high-water black pants proudly expose white socks against black shoes, a fashion faux pas. The lone female wears a black skirt and black tights, and naturally she also wears glasses and has very short (blond) hair. In their book about children's peer culture in schools, Adler and Adler (1998) describe the social stratification of children based on cliques and groups—a social system that is likely familiar to many who attended large high schools in the United States. The kind of boys (and sometimes girls) who fit into the admittedly extreme portrayal in the Geek Squad advertisement tend to be members of marginalized groups, not of the coveted "popular" group in school. Thus as role models, such representations may work against efforts to involve girls in computing study or careers.

Many groups whose members are passionate about or even obsessed with computers have appropriated the term geek, subverting it into "proud self-identification" (Svitavsky 2001). The term has also been appropriated by female groups such as [GirlGeeks.org](http://GirlGeeks.org) and [www.GeekGirls.org](http://www.GeekGirls.org), and is intended to make it acceptable to like computers. The fact that these groups must explicitly take pride in their geek proclamation makes geekiness as unacceptable in larger culture. The statistics about girls' participation suggest that such labeling has not been an effective strategy. One might speculate that despite the rhetoric, girl geeks, like their male counterparts, continue to be alien others relative to their peers. Nevertheless, popular conceptions about what the term geek means might be changing. More research is needed to determine whether this strategy is working since younger people may now perceive geeks as "hipsters" who indulge in techie toys.

Little research has been conducted on children's perceptions of computer users. In a small qualitative study with high school students, Griffiths and Heath (1996) found that students did not have a clear conception of the physical attributes of technologists (e.g., male, bald). Two other small studies found that when asked to

draw either a computer user or a “technologist,” primary school girls drew pictures of males more often than boys drew females (Brosnan 1999; Levin and Barry 1997). Interestingly, in one study the boys who drew pictures of females as technologists attended a school with female computing teachers (Levin and Barry 1997), supporting the claim that role models in and of themselves influence perceptions of appropriate roles. In another study, boys drew males and girls drew females, with few exceptions (Sheehan 2003). Selwyn (1998) interviewed ninety-six twelfth- and thirteenth-grade Welsh students in focus groups, asking why students were not using computers in school and college. Student explanations included inability, inappropriateness, and perceived disdain for computers. About one-third of the students expressed a “global disdain” for IT, which was not focused on technology but on the users. This third of the students saw the students as either “hyperintelligent,” sad and unapproachable, or lonely and socially isolated.

### **Computer Games**

It has been argued that computer games, both for entertainment and education, are an important vehicle for becoming familiar and gaining confidence with computers (Cassell and Jenkins 1998). Computer games have typically been designed for, bought by, and overwhelmingly used by boys and young men to the virtual exclusion of girls and women (Huff 1996; Cassell and Jenkins 2000; Jenson and Brushwood Rose 2003).

Much research has looked at the content of games, finding them overloaded with violence and competition, and few, if any, females (Jenson and Brushwood Rose 2003). When there are females, they are often presented as hapless victims who need males to rescue them or “huge-breasted vixens with guns” (Lynn et al. 2003, 145). There was a concerted effort in the 1990s to build software that was more interesting to girls. These approaches included appealing to girls’ “traditional feminine” interests (e.g., playing with dolls like Barbie), nontraditional masculine interests, and gender-neutral interests (Lynn et al. 2003). For example, the company Purple Moon and its founder Brenda Laurel received considerable attention in the 1990s for their efforts to build software for girls (Cassell and Jenkins 2000). Most of these efforts failed, however. Girls continue to purchase a fraction of the computer games that boys do, so demand for and therefore supply of “girls” games remains relatively small (Lynn et al. 2003).

In spite of the considerable literature on who buys computer games and what the content is, there is little, if any, good analysis of the impact of these computer games

on attitudes, beliefs, and future behaviors. Much of the literature makes an interpretive leap that if it is being used, then it must be indirectly influencing children to enter IT study and careers. Yet we found no studies on effect on behavior (other than game playing itself) or attitudes toward computing. We also do not know the causality or directionality of the argument here; it might be that the people playing games were predisposed to certain attitudes and interests, and that they chose to play computer games on that account.

## **Summary**

### **Scope and Limits of the Literature Review**

In this chapter, we have surveyed the scholarly social science literature about girls' involvement with IT, and the ways in which this involvement impinges on future education or careers in IT. We have intentionally not considered the many books and articles that propound on the reasons for gender imbalance or proffer solutions, unless these publications are solidly grounded in research. Although the majority of articles that we have considered in this review are empirically based, we believe it is critically important also to consider publications grounded in theory. These theoretical works provide a framework for thinking about this intractable problem of underrepresentation and offer a way of examining assumptions (e.g., concerning the male-female dichotomy) that are implicit in many of the empirically grounded studies.

Boundaries for this review were determined on both practical and intellectual grounds. The body of social science literature on girls or children is vast, and even with the help of our graduate students and a research librarian, we could not consider the full range of potentially pertinent articles. Even the literature on girls in the STEM disciplines is so large as to make it problematic to survey. At least five reasons, however, make us cautious of including the STEM literature, based in the differences between the STEM and computing disciplines:

1. The patterns for participation of women vary across the STEM disciplines and are often strikingly different from those in computing (e.g., biology, chemistry, mathematics, and some engineering disciplines). The participation of women is dropping in computing.
2. Introductory STEM courses are a required part of the public school curriculum and thus are given the official imprimatur of importance. Computing beyond

information literacy is either not taught in the public schools or is only offered as an elective.

3. Computing is frequently seen as most like mathematics of all the STEM disciplines, but their methods of instruction are often quite different. Computing is taught in a laboratory setting, and mathematics is only occasionally taught this way.
4. The thrust of national educational policy is to move toward teaching all students the basics of information fluency that will enable them to function as citizens in the modern world. This education is not sufficient preparation for college-level courses in computer science. In contrast, most K–12 education in the STEM disciplines is oriented toward academic preparation, at least for those students in the academic tracks.
5. Whereas most STEM education is learned in the formal classroom, computers are introduced to children in informal ways, such as using a computer at home or at a friend’s house, participating in a computer club, or using a computer in an unstructured environment at school.

Thus, we have included STEM literature in this review only where we had a specific reason to believe it was applicable. One other restriction in the range of literature we reviewed concerns its currency. One of the most striking changes in the computing landscape is the rapid growth in access to computers in the past decade. Social science researchers of the early 1990s often attributed the underrepresentation of girls in computing in part to the lack of access, which was low for boys, but much lower for girls. But access has become much greater for both boys and girls, and there are serious questions about the relevance of access as a cause of underrepresentation today. Similarly, technological advances such as the Internet, the World Wide Web, multimedia, and a vast array of packaged software have changed the ways that boys and girls interact with computers. For these reasons, we have restricted our review to publications since 1994, except in cases where there was a specific reason to include an earlier work (e.g., research on influences on career aspirations).

In considering such a large body of literature, one encounters studies of varying methodological quality. It is difficult to critique in just a few sentences the methodological quality of theoretical or qualitative studies, and we will not try to do so here. Nevertheless, the most common type of study considered in this review is the quantitative empirical one.

It is not uncommon, especially in the older literature, to find that essentialist dichotomies are drawn between girls and boys, and the way each thinks and acts. In contrast, we understand gender to be a set of social categories that shape how a

girl or boy should behave, and also the way that others treat girls and boys as well as expect them to behave. These social categories, which are often locally contextualized, must be taken into consideration in order to understand how girls relate to IT; essentialist dichotomies have a limited explanatory value.

## **Reasons Explored for Underrepresentation of Girls in Computing**

### **National and Educational Policies**

Policy has been a tool used to redress the underrepresentation of women in IT. In particular, the national educational policy of the Clinton-Gore administration made computers and Internet access widely available, narrowing the access gap for girls and boys in the United States. Policy has not enabled teachers the time, training, or reward structure to incorporate this newfound access into effective learning strategies, however. Hence, the largely female teacher population (especially in primary grades) is unlikely to serve as role models who demonstrate competence with computing. A current policy that focuses on the goal of information literacy for the citizenry does not provide sufficient education for gaining IT employment. President Bush's No Child Left Behind policy redirects resources to testing (primarily mathematics and literacy) and away from other educational needs, including and especially the sciences.

The educational philosophy of course election provides a vehicle for gendered difference in preparation for college study of computing. Computing courses are an elective rather than required, and girls are less likely to enroll in these preparatory courses. As a result, the public school computing courses are dominated by boys, raising a further barrier for girls with an interest in preparing for a computing career. The literature does not make it clear, though, what are the direct causes for gendered difference in election of computer science courses nor how to change the minds of girls who avoid them. Instead, several indirect influences are explored; these factors likely work in combination.

### **Relationships with Teachers and Teacher Training**

Relationships with teachers are a powerful shaping force on children, in both formal and informal settings. Given a widespread belief among teachers that computing is a male domain, their action inside and outside the classroom communicates that attitude to their students—boys and girls alike—through a variety of explicit and implicit mechanisms.

What teachers know regarding computers, and with regard to teaching with and about computers, has an impact on children's use, attitudes, and computing-related behaviors. The predominantly female, often computer-challenged population of elementary school teachers reinforces among students the idea that females are not good at computing. It is unusual to find a K–12 teacher with both strong teaching credentials and a strong mathematics-science-computing background. Little training is given to teachers to teach computing subject matter effectively or in a way that encourages girls as well as boys, and few tools are available to help. Perhaps because of the limitations in teacher training and science backgrounds, teachers are all too frequently not in a position to provide a learning experience that captures the interest of all students, offers the appropriate preparation for the college study of computer science, or shows that computing can be about more than games or hacking.

### **Use of Computers at School and Home**

Patterns of use in computers have changed over time. With computers more widely available in schools today than there were a decade ago, some studies show little difference in the percentage of boys and girls using computers in school (at least in the United States). Yet despite the availability of computers, other studies have shown that boys dominate the actual use of computers at school and elect to take more courses that study computers. Other studies (not entirely consistent with one another) show that more boys use computers at home (and for more hours) than girls do, boys were younger when they first began using computers, and boys and girls primarily use computers for different purposes, particularly as they move toward adolescence. While use is a major area of study, little research explores the relationship between computer use and entry into IT careers.

### **Differences in Attitude, Confidence, Interest, and Experience**

A large body of literature explores differences between boys and girls in attitude, confidence, interest, and experience. These studies generally show that girls have less positive attitudes, less confidence, less interest, and less experience with computers than do boys. While most readers will find this evidence compelling, a few recent studies have begun to question these results because of their concerns that this literature conflates issues of sex and gender while neglecting the socioeconomic context. Studying actual skills and knowledge, rather than perceptions of skill and

knowledge, as do most of these studies, would improve understanding of these issues.

### **Family and Community**

Family and local community are a powerful influence on a girl's interests along with her educational and career aspirations. The literature on influence of home and local community on a girl's interest in and attitudes toward computing is sparse, but some evidence suggests that the home environment is more supportive of boys than girls being interested in computing.

### **Influence of Peers**

Peers have a strong influence on children, especially in the teen years. Girls and boys are unlikely to choose elective courses in computing if they believe that these courses are inappropriate for their gender. Several studies show that children believe that computing is most appropriate for boys. Single-sex schools have been one approach for providing greater engagement and achievement for girls. The literature indicates that girls attending single-sex schools tend to have more positive attitudes toward computers than girls in coeducational settings and to be more open to nontraditional careers for their gender. Socioeconomic status is also a consideration: children in single-sex settings are more likely to have relatively affluent parents and therefore to enter professional careers of one type or another.

### **Life Aspirations**

Another body of literature discusses life aspirations and how they affect a girl's interest in computing along with her decisions about whether to participate in computing inside and outside of school. A more general body of literature shows that socioeconomic variables of family affect aspirations for college education and professional career. Children's expectations about their lives are related to their parents' expectations. Although girls show higher expectations of graduating from high school and attending college, several studies indicate that girls are less likely to aspire to a degree or career in computing. Some of these general studies about career choice are old, however, and it is unclear whether they would still hold in this era when it is more acceptable for women to pursue a professional career. Much of the literature is not specific to IT. We do not know if, as several studies suggest, attitudes toward IT change as children move from elementary to middle school. We

also do not have studies on whether the widespread belief is true that boys are interested in computers as toys while girls are interested in computers as agents of social change, or if true, how this difference might affect career aspirations.

### **Images in Popular Culture**

It is widely believed that images in the media and popular culture more generally reinforce the message of computer professionals as geeks or nerds. Studies of television and magazine advertisements show how gender stereotypes are reinforced, and suggest that popular culture can be a powerful shaping force on gender identity development and maintenance for children. Still, little research is available on children's perception of computer users, although there is some evidence that both girls and boys perceive computer users as male. The image of geek may be changing, becoming more attractive for both boys and girls.

### **Computer Games**

There is a widespread belief that computer games are one of the reasons why girls are less likely than boys to pursue computing. Computer games are widely regarded as a way for a child to become familiar and gain confidence with computers. There is clear evidence that most games are designed for and bought by boys and young men, and that the content is often violent and reinforces sexual stereotypes. The scholarly community, like other interested parties, altogether too often makes this interpretive leap from being used to having impact. Yet little research studies the impact of playing computer games on computer skills, knowledge, attitudes and beliefs, and future behavior with respect to career entry.

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## References

- Adler, P., and P. Adler. 1998. *Peer power: Preadolescent culture and identity*. New Brunswick, NJ: Rutgers University Press.
- American Association of University Women. 1998. *Separated by sex: A critical look at single-sex education for girls*. Washington, DC: American Association of University Women Foundation.
- Atkins, D. 2003. *Revolutionizing science and engineering through cyberinfrastructure: Report of the National Science Foundation blue-ribbon advisory panel on cyberinfrastructure*. Washington, DC: National Science Foundation.
- Bamburg, J. 1994. *Raising expectations to improve student learning*. Oak Brook, IL: North Central Regional Educational Laboratory.
- Barnett, R. C., and C. Rivers. 2004. *Same difference: How gender myths are hurting our relationships, our children, and our jobs*. New York: Basic Books.
- Becker, H. J. 2000. How exemplary computer-using teachers differ from other teachers: Implications for realizing the potential of computers in schools. *Journal of Research on Computing in Education* 26, no. 3:291–321.
- Belensky, M. F., B. M. Clinchy, N. R. Goldberger, J. M. Tarule. 1986. *Women's Ways of Knowing: The Development of Self, Voice, and Mind*. New York: Basic Books.
- Bem, S. L. 1974. The measurement of psychological androgyny. *Journal of Consulting and Clinical Psychology* 42:155–162.
- Bennett, D., C. Brunner, and M. Honey. 1999. Gender and technology: Designing for diversity. In *Report from the Center for Children and Technology*. New York: Education Development Center.
- Bhargava, A. 2002. Gender bias in computer software programs: A checklist for teachers. *Information Technology in Childhood Education Annual*, no. 1:205–218.
- Boser, R., M. Daugherty, and J. Palmer. 1996. *The effect of selected instructional approaches in technology education on students' attitude toward technology*. Reston, VA: Council on Technology Teacher Education.
- Brainard, S. G. n.d. Globally diversifying the workforce in science and engineering. Concept paper, Global Alliance for Diversifying the Science and Engineering Workforce. <[http://globalalliancesmet.org/about\\_concept2.htm](http://globalalliancesmet.org/about_concept2.htm)>.
- Brosnan, M. J. 1997. The fourth “R”: Are teachers hindering computer literacy in school children? *Educational Review* 21, no. 1:29–37.
- Brosnan, M. J. 1998. The impact of psychological gender, gender-related perceptions, significant others, and the introducer of technology upon computer anxiety in students. *Journal of Educational Computing Research* 18, no. 1:63–78.

- Brosnan, M. J. 1999. The “draw-a-computer-user” test: A new methodology, an old story? *European Journal of Psychology of Education* 3:375–385.
- Brunner, C., and D. Bennett. 1998. Technology perceptions by gender. *Education Digest* 63, no. 6:56–58.
- Bryson, M., and S. de Castell. 1996. Learning to make a difference: Gender, new technologies, and inequity. *Mind, Culture, and Activity* 3, no. 2:119–135.
- Bryson, M., and S. de Castell. 1998. New technologies, gender, and the cultural ecology of primary schooling. *Educational Policy* 12, no. 5:542–567.
- Bureau of Labor Statistics. 2002. *The ten fastest growing occupations, 2002–12*. <<http://www.bls.gov/news.release/ecopro.t04.htm>>.
- Cassell, J., and H. Jenkins, eds. 1998. *From Barbie to Mortal Kombat: Gender and computer games*. Cambridge, MA: MIT Press.
- Cassell, J., and H. Jenkins. 2000. Chess for girls? Feminism and computer games. In *From Barbie to Mortal Kombat: Gender and computer games*, ed. J. Cassell and H. Jenkins. Cambridge: MIT Press.
- Chapin, J. R. 2000. Adolescent sex and mass media: A developmental approach. *Adolescence* 35, no. 140:799–841.
- Charlton, J. P. 1999. Biological sex, sex-role identity, and the spectrum of computing orientations: A reappraisal at the end of the 90s. *Journal of Educational Computing Research* 21, no. 4:393–412.
- Christie, A. A. 2004. How adolescent boys and girls view today’s computer culture. Paper presented at the National Educational Computing Conference, New Orleans.
- Clarke, V., and J. Teague. 1996. Characterizations of computing careers: Students and professionals disagree. *Computer Education* 26, no. 4:241–246.
- Clegg, S. 2001. Theorising the machine: Gender, education, and computing. *Gender and Education* 13:307–324.
- College Board. 2004. *Advanced Placement national summary report*. Available at <<http://apcentral.collegeboard.com>>.
- Colley, A. M., M. T. Gale, and T. A. Harris. 1994. Effects of gender role identity and experience on computer attitude components. *Journal of Educational Computing Research* 10, no. 2:129–137.
- Committee on Information Technology Literacy. 1999. *Being fluent with information technology*. Washington, DC: National Academy Press. Available at <<http://www.cra.org/govaffairs/blog/archives/000084.html>>.
- Crombie, G., T. Abarbanel, and A. Trinneer. 2002. All-female classes in high school computer science: Positive effects in three years of data. *Journal of Educational Computing Research* 27, no. 4:385–409.
- Crombie, G., and P. I. Armstrong. 1999. Effects of classroom gender composition on adolescents’ computer-related attitudes and future intentions. *Journal of Educational Computing Research* 20, no. 4:317–327.

- DeRidder, L. 1990. *The Impact of Parents and Parenting on Career Development*. Knoxville, TN: Comprehensive Career Development Project.
- Dilevko, J., and R. Harris. 1997. Information technology and social relations: Portrayals of gender roles in high tech product advertisements. *Journal of the American Society for Information Science* 48, no. 8:718–727.
- Dryburgh, H. 2000. Underrepresentation of girls and women in computer science: Classification of 1990s' research. *Journal of Educational Computing Research* 23, no. 2:181–202.
- Dugdale, S., E. DeKoven, and M. K. Ju. 1998. Computer course enrollment, home computer access, and gender: Relationships to high school students' success with computer spreadsheet use for problem solving in pre-algebra. *Journal of Educational Computing Research* 18, no. 1:49–62.
- Dunham, P. H. 1990. *Procedures to increase the entry of women in mathematics-related careers*. Columbus, OH: ERIC Clearinghouse for Science Mathematics and Environmental Education.
- Durndell, A., P. Glissov, and G. Siann. 1995. Gender and computing: Persisting differences. *Educational Research* 37, no. 3:219–227.
- Durndell, A., and K. Thomson. 1997. Gender and computing: A decade of change? *Computers and Education* 28, no. 1:1–9.
- Eckert, P. 1994. Entering the Heterosexual Marketplace: Identities of Subordination as a Developmental Imperative. Working Papers on Learning and Identity 2. Palo Alto, CA: Institute for Research on Learning.
- Eckert, P. 1995. Adolescent trajectory and forms of institutional participation. In *Pathways through adolescence: Individual development in relation to social contexts*, ed. Lisa Crockett and Ann Crouter (pp. 175–196). Hillsdale, NJ: Lawrence Erlbaum.
- Eckert, P. 1997. Gender, race, and class in the preadolescent marketplace of identities. Paper presented at the ninety-sixth annual meeting of the American Anthropological Association, Washington, DC.
- Elkjær, B. 1992. Girls and information technology in Denmark: An account of a socially constructed problem. *Gender and Education* 1/2:25–40.
- Ertmer, P. A., A. Addison, M. Lane, E. Ross, and D. Woods. 1999. Examining teachers' beliefs about the role of technology in the elementary classroom. *Journal of Research on Computing in Education* 32, no. 1:54–72.
- Evans-Andris, M. 1995. An examination of computing styles among teachers in elementary schools. *Educational Technology Research and Development* 43, no. 2:15–31.
- Fagot, B., R. Hagen, M. Leinback, and S. Kronsberg. 1985. Differential reactions to assertive and communicative acts of toddler boys and girls. *Child Development* 56:1499–1505.
- Farmer, H. S. 1995. Gender differences in adolescent career exploration. *ERIC Clearinghouse on Counseling and Student Services*. Greensboro, NC: ERIC Digest.
- Faulkner, W., K. Sorensen, H. Gansmo, E. Rommes, L. Pitt, V. Lagesen Berg, C. McKeogh, P. Preston, R. Williams, and J. Stewart. 2004. *Strategies of inclusion: Gender and the information society*. Edinburgh: SIGIS.

- Fellows, M. R. 1993. Mathematicians and education reform, 1990–1991. *Conference board of the mathematical sciences: Issues in mathematics education* 3:143–163.
- Fitzpatrick, H., and M. Hardman. 2000. Mediated activity in the primary classroom: Girls, boys, and computers. *Learning and Instruction* 10, no. 5:431–446.
- Fletcher-Flinn, C. M., and T. Suddendorf. 1996. Computer attitudes, gender, and exploratory behavior: A developmental study. *Journal of Educational Computing Research* 15, no. 4:369–392.
- Frantom, C. G., K. E. Green, and E. R. Hoffman. 2002. Measure development: The children's attitude towards technology scale (CATS). *Journal of Educational Computing Research* 26, no. 3:249–263.
- Freeman, N. K., and J. Somerindyke. 2001. Social play at the computer: Preschoolers scaffold and support peers' computer competence. *Information Technology in Childhood Education Annual*: 203–213.
- Freeman, P., and W. Aspray. 1999. *The supply of information technology workers in the United States*. Washington, DC: Computing Research Association.
- Gerbner, G. 1969. The television world of violence. In *Mass media and violence*, ed. D. Lange, R. Baker, and S. Ball. Washington, DC: U.S. Government Printing Office.
- Gilligan, C. 1982. *In a different voice*. Cambridge, MA: Harvard University Press.
- Goffman, E. 1979. *Gender advertisements*. Cambridge, MA: Harvard University Press.
- Gonder, P. O. 1991. *Caught in the middle: How to unleash the potential of average students*. Arlington, VA: American Association of School Administrators.
- Griffiths, A. K., and N. P. Heath. 1996. High school students' views about technology. *Research in Science and Technological Education* 14, no. 2:153–162.
- Guha, S. 2001. Integrating computers in elementary grade classroom instruction: Analysis of teachers' perceptions in present and preferred situations. *Journal of Educational Computing Research* 24, no. 3:275–303.
- Guha, S. 2003. Are we all technically prepared? Teachers' perspective on the causes of comfort or discomfort in using computers at elementary grade teaching. *Information Technology in Childhood Education Annual* 24, no. 3:317–349.
- Hanor, J. 1998. Concepts and strategies learned from girls' interactions with computers. *Theory into Practice* 37, no. 1:64–71.
- Harrell, W. 1998. Gender and equity issues effecting educational computer use. *Equity and Excellence in Education* 31, no. 13:46–48.
- Harsha, P. 2004. *NSF funding outlook grim but cyberinfrastructure's a priority, says NSF director*. (<http://www.cra.org/govaffairs/blog/archives/000084.html>).
- Helwig, A. A. 1998. Gender-role stereotyping: Testing theory with a longitudinal sample. *Sex Roles: A Journal of Research* 42, no. 5–6:403–423.
- Howe, K. 1993. Equality of educational opportunity and the criterion of equal educational worth. *Studies in Philosophy and Education* 11:329–337.
- Howe, K. 1997. Gender. In *Understanding equal educational opportunity: Social justice, democracy, and schooling*. New York: Teachers College Press.

- Huff, C. 1996. Unintentional power in the design of computer systems. *Computers and Society*: 6–9.
- Huff, C., and J. Cooper. 1987. Sex bias in educational software: The effect of designers' stereotypes on the software they design. *Journal of Applied Social Psychology* 17, no. 6:512–532.
- Jenson, J., and C. Brushwood Rose. 2003. Women@work: Listening to gendered relations of power in teachers' talk about new technologies. *Gender and Education* 15, no. 2:169–181.
- Jesse, J. K. 2004. The digital divide: Political myth or political reality? In *Chasing Moore's law: Information technology policy in the United States*, ed. W. Aspray. Raleigh, NC: SciTech Publishing.
- Jones, T., and V. A. Clark. 1995. Diversity as a determinant of attitudes: A possible explanation of the apparent advantage of single-sex settings. *Journal of Educational Computing Research* 12, no. 1:51–64.
- Kafai, Y., and S. Sutton. 1999. Elementary school students' computer and Internet use at home: Current trends and issues. *Journal of Educational Computing Research* 21, no. 3:345–362.
- Kiesler, S., L. Sproull, and J. S. Eccles. 1985. Pool halls, chips, and war games: Women in the culture of computing. *Psychology of Women Quarterly* 9, no. 4:451–462.
- Kinnear, A. 1995. Introduction of microcomputers: A case study of patterns of use and children's perceptions. *Journal of Educational Computing Research* 13, no. 1:27–40.
- Kirkpatrick, H., and L. Cuban. 1998. Should we be worried? What the research says about gender differences in access, use, attitudes, and achievement with computers. *Educational Technology* 38, no. 4:56–61.
- Kling, K. C., J. S. Hyde, C. Showers, B. Buswell. 1999. Gender differences in self-esteem: A meta-analysis. *Psychological Bulletin* 125:470–500.
- Koch, C., and R. Uptis. 1996. Is equal computer time fair for girls? Potential Internet inequities. In *Proceedings of the 6th Annual Conference of the Internet Society*. Reston, VA: The Internet Society.
- Koch, M. 1994. No girls allowed! *Technos: Quarterly for Education and Technology* 3, no. 3:14–17.
- Lankard, B. A. 1995. *Family role in career development*. ERIC Digest, no. 164. Columbus, OH: ERIC Clearinghouse on Adult Career and Vocational Education.
- Lee, V. 1998. Is single-sex secondary schooling a solution to the problem of gender inequity? In *Separated by sex: A critical look at single-sex education for girls*, ed. American Association of University Women. Washington, DC: American Association of University Women Foundation.
- Levin, B. B., and S. M. Barry. 1997. Children's views of technology: The role of age, gender, and school setting. *Journal of Computing in Childhood Education* 8, no. 4:267–290.
- Levine, T., and S. Donitsa-Schmidt. 1995. Computer experience, gender, and classroom environment in computer-supported writing classes. *Journal of Educational Computing Research* 13, no. 4:337–357.
- Levine, T., and S. Donitsa-Schmidt. 1998. Computer use, confidence, attitudes, and knowledge: A causal analysis. *Computers in Human Behavior* 14, no. 1:125–146.

- Li, Q. 1999. Teachers' beliefs and gender differences in mathematics: A review. *Educational Research* 41, no. 1:63–76.
- Light, P., K. Littleton, S. Bale, R. Joiner, and D. Messer. 2000. Gender and social comparison effects in computer-based problem solving. *Learning and Instruction* 10:483–496.
- Lupart, J., and E. Cannon. 2002. Computers and career choices: Gender differences in grades seven and ten students. *Gender, Technology, and Development* 6, no. 2:233–248.
- Lynn, K.-M., C. Raphael, K. Olefsky, and C. M. Bachen. 2003. Bridging the gender gap in computing: An integrative approach to content design for girls. *Journal of Educational Computing Research* 28, no. 2:143–162.
- Maboudian, W. 2000. Gender representation in visuals on school Web pages: Course for in-service teachers. *Society for Information Technology and Teacher Education International Conference 2000*, no. 1:276–281. Available at <<http://dl.aace.org/489>>.
- Margolis, J., and A. Fisher. 2002. *Unlocking the clubhouse: Women in computing*. Cambridge, MA: MIT Press.
- Miller, L., M. Chaika, and L. Groppe. 1996. Girls' preferences in software design: Insights from a focus group. *Interpersonal Computing and Technology: An Electronic Journal for the Twenty-first Century* 4, no. 2:27–37.
- Miller, L. M., H. Schweingruber, and C. L. Brandenburg. 2001. Middle school students' technology practices and preferences: Reexamining gender differences. *Journal of Educational Multimedia and Hypermedia* 10, no. 2:125–140.
- Mortimer, J., K. Lee, and C. Lee. 1992. *Influences on adolescents' vocational development*. Berkeley, CA: National Center for Research in Vocational Education.
- Moses, M. S., K. R. Howe, and T. Niesz. 1999. The pipeline and student perceptions of schooling: Good news and bad news. *Educational Policy* 13, no. 4:573–591.
- Muller, C. B. 2002. The underrepresentation of women in engineering and related sciences: Pursuing two complementary paths to parity. In *Pan-organizational summit on the U.S. science and engineering workforce*, ed. Marye Ann Fox (pp. 119–126). Washington, DC: National Academies Press.
- Mullis, R. L., A. K. Mullis, and D. Gerwels. 1998. Stability of vocational interests among high school students. *Adolescence* 33:699–707.
- National Center for Educational Statistics. 2003. National Assessment of Educational Progress. *Education Statistics Quarterly* 5, no. 4.
- National Center for Educational Statistics. 2004. *NAEP data tool*. <<http://nces.ed.gov/nationsreportcard/naepdata/getdata.asp>>.
- National Research Council. 1999. *Being fluent with information technology*. Washington, DC: National Academy Press.
- National Telecommunications and Information Administration, with the Economics and Statistics Administration. 2002. *A nation online: How Americans are expanding their use of the Internet*. Washington, DC: NTIA.
- Naylor, M. 1986. Family influences on employment and education: Overview. *ERIC Digest*, no. 56. Columbus, OH: ERIC Clearinghouse on Adult Career and Vocational Education.

- Noddings, N. 1984. *Caring, a feminine approach to ethics and moral education*. Berkeley: University of California Press.
- Oberman, P. 2002. Academic help-seeking in the high school computer science classroom: Relationship to motivation, achievement, gender, and ethnicity. PhD diss., Emory University.
- Paoletti, J. 1997. The gendering of infants' and toddlers' clothing in America. In *The material culture of gender/the gender of material culture*, ed. K. Martinez and K. Ames. Wilmington, DE: Henry Francis du Pont Winterthur Museum.
- President's Council on Physical Fitness and Sports. 1997. *Physical activity and sport in the lives of girls: Physical and mental health dimensions from an interdisciplinary approach*. Washington, DC: U.S. Department of Health and Human Services.
- Raffini, J. 1993. *Winners without losers: Structures and strategies for increasing student motivation to learn*. Needham Heights, MA: Allyn and Bacon.
- Rayman, P., and B. Brett. 1993. *Pathways for women in the sciences*. Wellesley report, vol. 1. Wellesley College Center for the Study of Women, Wellesley, MA.
- Sadker, M., and D. Sadker. 1995. *Failing at fairness: How our schools cheat girls*. New York: Touchstone.
- Sanders, J. 2002. Snatching defeat from the jaws of victory: When good projects go bad; girls and computer science. Paper presented at the annual meeting of the American Educational Research Association, New Orleans.
- Sax, L. J., M. Ceja, and R. T. Teranishi. 2001. Technological preparedness among entering freshmen: The role of race, class, and gender. *Journal of Educational Computing Research* 24, no. 4:363–383.
- Schaumburg, H. 2001. Fostering girls' computer literacy through laptop learning: Can mobile computers help to level out the gender difference? Paper presented at the National Educational Computing Conference, Chicago.
- Schott, G., and N. Selwyn. 2000. Examining the “male, antisocial” stereotype of high computer users. *Journal of Educational Computing Research* 23, no. 3:291–303.
- Selwyn, N. 1998. What's in the box: Exploring learners' rejection of educational computing. *Educational Research and Evaluation* 4, no. 3:193–212.
- Shashaani, L. 1994. Gender differences in computer experience and its influence on computer attitudes. *Journal of Educational Computing Research* 11, no. 4:347–367.
- Sheehan, R. 2003. Children's perception of computer programming as an aid to designing programming environments. In *Interaction design and children: Proceeding of the 2003 conference on interaction design and children*. New York: ACM Press.
- Silverman, S., and A. M. Pritchard. 1993. *Building their future: Girls in technology and education in Connecticut*. Hartford: Connecticut Women's Education and Legal Fund.
- Singh, P. 1993. Institutional discourse: A case study of the social construction of technical competence in the primary classroom. *British Journal of Sociology of Education* 14, no. 1:39–58.
- Snyder, L. 2003. *Fluency with information technology: Skills, concepts, capabilities*. Washington, DC: Addison-Wesley.

- Stepulvage, L. 2001. Gender/technology relations: Complicating the gender binary. *Gender and Education* 13, no. 3:325–338.
- Stepulvage, L., and S. Plumeridge. 1998. Women taking positions within computer science. *Gender and Education* 10, no. 3:313–326.
- Stecher, B. M. 2002. Consequences of large-scale, high-stakes testing on school and classroom practice. In *Making sense of test-based accountability in education*, ed. L. S. Hamilton, B. M. Stecher, and S. P. Klein. Santa Monica, CA: Rand Corporation.
- Svitavsky, W. 2001. Geek culture: An annotated interdisciplinary bibliography. *Bulletin of Bibliography* 58, no. 2:101–108.
- Taylor, A. 2003. Finding the future that fits. Paper presented at the eighty-fourth annual meeting of the American Educational Research Association, Chicago.
- Thorne, B. 1992. Girls and boys together ... but mostly apart: Gender arrangements in elementary schools. In *Education and gender equality*, ed. J. Wrigley. London: Falmer Press.
- Tracy, K. 2002. *Everyday talk: Building and reflecting identities*. New York: Guilford Press.
- Tucker, A. E., F. Deek, J. Jones, D. McCowan, C. Stephenson, and A. Verno. 2003. *K–12 task force*. <<http://www.acm.org/education/k12/>>.
- Van Braak, J. 2001. Individual characteristics influencing teachers' class use of computers. *Journal of Educational Computing Research* 25, no. 2:141–157.
- Webster's. 2003. *New millennium dictionary of English*. Los Angeles: Lexico Publishing Group, LLC.
- Whiston, S. C., and B. K. Keller. 2004. The influences of the family of origin on career development: A review and analysis. *The Counseling Psychologist* 32, no. 4:493–568.
- Whitley, B. E., Jr. 1997. Gender differences in computer-related attitudes and behaviors: A meta-analysis. *Computers in Human Behavior* 13, no. 1:1–22.
- Wigfield, A., and J. Eccles. 2000. Expectancy-value theory of achievement motivation. *Contemporary Educational Psychology, Special Issue: Motivation and the Educational Process* 25:68–81.
- Wulf, W. A. 1999. Diversity in engineering. In *Moving beyond individual programs to systemic change*. West Lafayette, IN: Women in Engineering Programs and Advocates Network Member Services.
- Wulf, W. A. 2001. *Testimony to the commission on the advancement of women and minorities in science, engineering, and technology development*.
- Yelland, N., and M. Lloyd. 2001. Virtual kids of the 21st century: Understanding the children in schools today. *Information Technology in Childhood Education Annual*: 175–192.
- Young, I. M. 1990. *Throwing like a girl and other essays in feminist political theory*. Bloomington: Indiana University Press.
- Zimmerman, J., and G. Reavill. 1999. *Raising our athletic daughters*. New York: Main Street Books.