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## EXPOSURE, TRAINING, AND ENVIRONMENT: WOMEN'S PARTICIPATION IN COMPUTING EDUCATION IN THE UNITED STATES AND INDIA

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*The number of women pursuing a degree in computing education has been declining in the United States, whereas it has been increasing in India. This article addresses how the participation of women in computing education varies between the United States and India. It is based on in-depth interviews conducted with 60 female students majoring in computer science and computer engineering in the United States and with 60 female students majoring in computer science in India. The findings suggest that although female students are not exposed to the computer in India, as compared with the United States, strong training in mathematics makes Indian female students feel confident about their computing skills in contrast to American female students. Most importantly, the image of computing is of a women-friendly field in India, whereas in the United States, it is of a masculine field.*

### INTRODUCTION

In the United States, the percentage of women earning bachelor's degrees in computer science (CS) is relatively low. For instance, between 1984 and 2005, the share of CS bachelor's degrees awarded to women fell from 37% to 22%. Alarming, the proportion of women who thought they might major in CS has fallen from 4.1% in 1982 to 1.5% in 1999 to 0.3% in 2005 (National Science Board, 2008). Freshmen interest levels have been more or less an accurate predictor of trends in the number of bachelor's degrees granted 4 and 5 years later. In contrast, most indicators suggest that there has been a significant increase in the number of women pursuing bachelor's degrees in CS in India (Parikh & Sukhatme, 2004; Press Trust of India, 2005). For instance, in 2003 women received 32% of the bachelor's of engineering degrees awarded in CS and 55% of the bachelor's of science degrees awarded in CS (Government of India, 2004–2005).

Women's underrepresentation in computing education in the United States has been scrutinized from many angles over a decade (see, e.g., Ahuja, 2002; Cohoon & Aspray, 2006; Singh, Allen, Scheckler, & Darlington, 2007). Although some have studied the issue from cross-ethnic/racial perspectives, to the author's knowledge, no one has examined the issue from a cross-national perspective. Most studies on women in computing education outside the United States have been country specific (e.g., Kvanne & Rasmussen, 1989; Rasmussen & Hapnes, 1991; Shashaani & Khalili, 2002; Adam, Bauer, & Baichoo, 2003; Lee, 2003; Fan & Li, 2004; Lie, 2003; Lagesen, 2008). A cross-national

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comparison is likely to provide new insights into the issues women face in computing education in the United States.

A comparative study of women's participation in computing education between the United States and India is interesting on two grounds. Economically, the most noticeable difference between the United States and India has been framed as "first world vs. third world" or "developed vs. developing" country. Since World War I, the United States has emerged as the world's leading economy. It has the largest national gross domestic product (GDP) in the world (\$14.3 trillion), about 4% less than the combined GDP of the European Union (Central Intelligence Agency, 2008). The United States has a strong domestic market, high investment in foreign countries, a relatively low population density, and a high standard of living (National Science Board, 2008). Most importantly, it holds the major world market share in information technology (IT) (Organization for Economic Cooperation and Development [OECD], 2008).

India emerged as underdeveloped in relation to the West following its independence from the British in 1947. India has sought to catch up to scientific and technological advances made in the West. Modernization is seen in terms of the attainment of "scientific temper" (as India's first prime minister, the late J. N. Nehru, called it), the acquisition of modern technology, industrialization along Western lines, and the spread of technical roles (Tharoor, 2003). Before 1990, India controlled its development with licenses and regulations; the economic liberalization reforms of 1991 ended such control. India has implemented policies to provide favorable business environments to both national and multinational corporations (Lieberman, 2004). In addition, the Indian government has made the IT industry a viable option to strengthen its national economy and emerge as a "soft-power," so that the world would find India attractive. The Indian IT sector has grown tremendously. According to one estimate, in 1986–1987, there were only 6,800 IT workers in India; this number rose to 650,000 in 2002–2003 (Basant & Rani, 2004). It is projected that the total number of IT workers will grow to 3,750,000 by 2015–2016 (Aggarwal, 2008a). Although it began as a demand for low-end skilled IT workers, the demand patterns of IT have changed in favor of high-end skilled workers, requiring CS or an equivalent degree, such as electrical engineering and mathematics (Aggarwal, 2008b). The IT industry is expected to provide quality employment to a large number of qualified people in the coming years. Still, India continues to have different production functions in the advanced and traditional sectors of the economy. The country suffers from high levels of poverty, malnutrition, and illiteracy. Nearly half of India's population lives on less than \$1.25 a day (Special Correspondent, 2008).

Socially, women have had fewer rights and opportunities in the United States and India. Traditionally, women were expected to be wives and mothers; the stereotype that a "woman's place is in the home" assigned their social role. Consequently, formal education for girls was secondary to that for boys in both countries. Whereas the United States has moved toward an egalitarian form of social organization, India's social system remains largely what Mukhopadhyay and Seymour (1994) have called "patrifocal." Under the patrifocal system, females are subordinated to family; inheritance is patrilineal; residency is patrilocal; family roles are differentiated on gender lines; marriage is controlled by family; and women are expected to practice chastity, domesticity, and obedience. Patrifocality results in a strong preference for sons over daughters. India's existing sex ratio (the number of females per 1,000 males) is 933 females per 1,000 males (Census of India, 2001). In

the United States, women constitute 51% of the total population (U.S. Census, 2000). The social context for Indian women is vastly different from their American peers.

Despite economic and social advantages in the United States, women in India seem to have levels of success in computing education that appear to somewhat outstrip those of American women. This article examines variations in women's participation (or lack thereof) between the United States and India on three key topics: early exposure to and use of the computer, academic preparation for a computing major at the university level, and the perceived environment of the computing field for women. The importance of each of these topics within the context of scholarly literature is outlined prior to the presentation of findings pertaining to the topic. This article is based on two qualitative studies of women's participation in computing education, which were undertaken first in the United States and then in India.

This article shows that before entering universities, female students in both countries had experienced the digital divide. However, the digital divide for American female students meant they did not use the computer for computing purposes or did not spend enough time tinkering with it; for Indian female students, the digital divide meant not being exposed to a computer, either at home or in school. In both countries, female students considered themselves strong in mathematics before enrolling in a CS or computer engineering (CE) program. Yet, once in the program, American female students underestimated their abilities in CS/CE, mostly due to inadequate pre-university training in mathematics and computing. Indian female students, on the other hand, did not have any anxiety about CS because they were confident in their strong preparation in mathematics. Most importantly, the field of computing is constructed to be women-friendly in India, whereas it is masculine in the United States. Finally, this article briefly outlines four feminist theoretical frameworks, as identified by Wajcman (2004), on the relationship between gender and computer technology. It then discusses whether the findings from the two case studies support these frameworks.

## METHOD

In 2004–2005, primary qualitative data were gathered in the United States through in-depth interviews with 150 students, divided into groups of 30 (15 females and 15 males) belonging to one of the following five major ethnic/racial groups: White, African American, Hispanic, Asian American, and Native American. These students were from seven different universities that granted 4-year undergraduate degrees in CS/CE and were designated as Minority-Serving Institutions. These subjects were selected because claims have been made about women in computing, even though the sample has been limited to White women. Random sampling was used to select subjects who were in their 2nd and more years of studies on sites with sufficient numbers of students. However, purposive sampling was used on sites where the numbers of some groups (e.g., Native Americans) in CS/CE disciplines were small. None of the students declined to participate in the study, once approached. The author conducted all interviews, which were recorded, subsequently transcribed, and inserted in the Nvivo program for analysis. Two independent coders coded the same data to ensure reliability. Interviews with 60 female students from White, African American, Hispanic, and Native American

groups provided the specific data for this article; 15 Asian American students were excluded because some of them had pre-college schooling in China, India, South Korea, Taiwan, or Vietnam.

In 2007–2008, a similar study was carried out in India. In-depth interviews were conducted with 60 female undergraduates majoring in CS. The study involved two engineering institutes and two universities that granted 4-year undergraduate degrees in CS. One campus was a top national engineering institute and the other a well-known regional engineering institute. To ensure that main minorities in India were included, one campus was historically Muslim and the other was predominantly Sikh. Random sampling was used to select 15 subjects who were in their 2nd and more years of studies from each campus. Once selected, all students participated in the study. To ensure that data collection was consistent with the earlier study in the United States, the author conducted all interviews. These interviews were recorded, subsequently transcribed, and inserted in the Nvivo program for analysis. Two independent coders (different from the U.S. study) coded the same data to ensure reliability.

The interview questions used in India were the same as in the U.S. study, although some new questions were added to address the Indian situation. The interview questions, which formed the basis for this article, are outlined below:

1. When you were growing up, did you have a computer at home? If yes, did you use it? What did you use it for? If no, how did you have access to a computer?
2. Were computers available for you to use while you were in high school/intermediate college? If yes, did you make use of the computers? What did you use them for? How easily were they available to you? Where were they located? (Note: High schools in the United States are from the 9th to 12th grades; in India, they tend to be from the 9th to 10th grades, followed by a 2-year college program, before enrolling for undergraduate studies).
3. What was your best subject in high school/intermediate college?
4. Did you go to a private or public/government high school/intermediate college? (Note: Public schools in the United States are equivalent to government schools in India.)
5. Did your high school/intermediate college classes prepare you well to study CS/CE at the university level? If yes, how well were you prepared? If no, what was lacking in preparation?
6. Have you considered changing your major from CS/CE to something else? If yes, why? What would you have changed to?
7. What is the typical perception of the computing field?
8. How are people in the computing field perceived? What are their characteristics?
9. Are careers with a CS/CE degree attractive to women? If yes, how? If no, why not?
10. *Background questions:* What is your age? What is your marital status? Do you have children? If yes, how many? What are your parents' occupations? How would you characterize your family's economic background in terms of upper class, middle class, lower class, or other? Do you have a job in addition to attending the university? Are you a full-time or a part-time student? Typically, how many courses do you take in a semester? How do you characterize your ethnicity (U.S.)/religion (India)?

## FINDINGS

### Demographics

Demographic details of female students interviewed in the United States and India show an interesting contrast between traditional and nontraditional makeup of the subjects. Generally, traditional students are those students who enroll in undergraduate education immediately after graduation from the 12th grade and complete their bachelor's degrees in 4 or 5 years at a young age of 22 to 23. They pursue undergraduate studies on a full-time basis, and if they work, it is mostly in the summer. They are financially dependent on family for education and living expenses. They are single and do not have any children. Typically, nontraditional students are those students who do not enroll in undergraduate education immediately after graduating from the 12th grade; instead, they work for a number of years to save money for their education. They are older than the traditional students. Nontraditional students are married, have young children, or are single parents. They work full-time (minimum 35 hours a week) or part-time during the academic year to support their studies and families.

Female students interviewed in the United States showed attributes common to both traditional and nontraditional students. A little over half of the female students were over 24 years of age. Almost 30% of the female students were married, and nearly 25% of them had at least one child living with them. Over 60% of the female students held a full- or part-time job during the academic year to support their studies. Almost half of the female students characterized their family background as middle class, a little less than one third as lower middle or lower class, and the rest as upper class. Their depiction was reflective of the occupations of their parents, many of whom were professionally employed in the public or private sector, some had their own business, and the others were workers. Although over 80% of the female students were studying on a full-time basis, only one third of them were enrolled in four or more courses per semester; most of them were enrolled in two or three courses.

In contrast, all female students interviewed in India were traditional. They were young, single females between the ages of 19 and 22. Other than being a full-time student (four or more courses per semester), none of these female students held a job while attending their university. Almost all of the female students characterized their family background as middle class, with many specifying that they fit into an upper middle-class category. Their class portrayal reflected the occupations of their parents, especially their fathers, who were professionally employed. Another indicator was that 40% of the sample had both parents working; generally, female students' mothers also held a professional career.

### Exposure

Greater access to and use of computers and other IT at home and in schools are viewed as generating interest among students to pursue CS/CE majors at the university level (Adya & Kaiser, 2005). Students will be more interested in CS/CE studies if they had access to computers and spent some time using them as tools. Schools are expected to expose students to computers and other IT, so that the society is not divided into those who are information-rich and those who are information-poor (Coley, Cradler, & Engel,

1997). Nonetheless, students attending high-poverty schools are likely to have less access to computers and other IT. Further, computers and other IT may not be widespread at home for the economically poor strata of students. Differential access to computers and other IT in schools and at home is likely to contribute to unequal participation in computing education.

Limited access to computers and other IT has been noted as a disincentive for women to pursue IT-related majors at universities in the United States and European countries (Clegg, Mayfield, & Trayhurn, 1999; Weinman & Pamela, 1999; Kahle & Schmidt, 2004). Either boys are more forceful in securing computers than girls at home and in school, or boys receive more guidance from family members and teachers in using computers than girls. As a result, boys end up developing an interest in computing, but girls remain marginalized. It has been proposed that girls do not see themselves as becoming computer scientists or computer engineers while growing up, partially because of less use of computers for programming, educational purposes, and fun activities.

Findings from the two case studies show that access to computers and other IT is drastically different between the United States and India (Table 1), mostly due to their respective economic contexts outlined earlier.

The study conducted in the United States showed that almost 60% of the female students interviewed did not have a computer at home while growing up. Often, their elementary and middle schools did not possess computers, mostly because at that time the use of computers was not widely dispersed. Generally, their high schools (9th to 12th grades) provided access to a computer. A large majority of female students (76%) either had good or limited access to computers in their high schools; only a small number of female students (24%) had no access to computers. Their high schools had some computers inside the classrooms and others in the library and/or in the instructional rooms. By the time female students went to high school, their family members had acquired at least one computer at home. This was despite the fact that many female students characterized their family's economic status as middle class, lower middle class, or lower class. Nonetheless, very few female students used computers either at home or in high school for simple programming, solving mathematical problems, and/or learning computer languages. Most of them used computers for word processing in their language or social studies classes, painting, playing games, web searching, and emailing.

There was a variation in female students' access to and use of computers that was based on ethnic/racial lines. More White female students were exposed to computers at an earlier age than minority female students. Among minorities, more African American female students had used a computer earlier than Hispanic female students. Native American female students hardly ever had a computer at home. Even their high schools had very few computers, and these computers tended to be outmoded.

In contrast, the study conducted in India showed that most female students interviewed (55 out of 60) did not have a computer at home. Often, family members did not see the importance of having a computer at home. It was rather expensive, even for the middle class, which most female students belonged to. A little over half of the students had access to a computer in their high schools (9th to 10th grades) or intermediate college (11th to 12th grades). These computers were placed in the laboratory, but they rarely had the Internet, CD-ROM technology, a local area network, or satellite dishes. Moreover, teachers were reluctant to let students use computers, to avoid

**Table 1.** Early Exposure to the Computer

Female students	Comments
<i>In the United States</i>	
White	"Yeah, we had a computer at home, probably we had two. I know I had my own computer. I do not know what I used mine for, most likely to play games or type up an essay or something for school."
African American	"We had a computer in the main family room so everyone would use it. . . . I used it for spreadsheets, word processing, schoolwork and some recreational stuff like playing games and listening to music."
Hispanic	"Not until I was in high school. But in high school, we mainly did word processing. We did not use it for important applications."
Native American	"The first time I ever used a computer was in my sophomore year in high school. We were offered one computer class, but I cannot remember what we did in that class."
<i>In India</i>	
Hindu	"I rarely used a computer because it came to my home when I was in the 11th grade. . . . I had to concentrate a lot on my studies to appear in the [entrance exam], so, I became really familiar with the computer only after my [entrance exam] when I had free time."
Hindu	"Not at that time. We had no clue that it was important to own a computer. But, eventually my father bought a second hand computer for my brother for his studies. . . . Time to time my brother would let me use it for movies, music and stuff like that."
Muslim	"If you decided to take the non-medical stream, you could take a subject called computers. It was getting familiar with the computer. . . . My teacher talked about all the features a computer had and all the capabilities a computer could perform. He used pictures and diagrams, but not a real computer."
Sikh	"No, very frankly I was able to use the computer in the second year of my B-tech. In the first year, we did basic courses in physics, chemistry, etc., and did not do any computer courses so there was no need to use them."

potential damage. Typically, students were allocated a couple of hours per week to use the computers. However, electricity was unreliable, with fluctuations in voltage and frequency. The places where they could use computers were cyber cafés, which offer computing facilities such as Internet access. Cyber cafés have proliferated in India since the late 1990s, and they are inexpensive. However, these female students were also preparing for the entrance exam to gain admission to a good university. Thus, because they

were spending their time in the coaching centers after school, they rarely had time to use cyber cafés.

There was a little variation in female students' access and exposure to computers along religious lines. Slightly more Hindu, and to some extent Sikh, female students were exposed to computers, both at home and in school, at an earlier age than Muslim female students.

It should be noted that access to computers and the Internet has become more widespread, both at school and at home, in the United States since the completion of the study in 2005 (National Science Board, 2008). However, the gap between those with access to computers and other IT and those without it along socioeconomic and geographic location lines in India remains a major concern (Department of Telecommunications, 2007).

### **Training**

In most countries, students from kindergarten to the 12 grade (K-12) are required to take mathematics, regardless of what they wish. They are not allowed to skip mathematics because they do not have an interest in it; mathematics is seen as teaching abstract thinking, analytical skills, logic, and problem-solving abilities, in addition to calculation and deduction. The special role of mathematics in education is a consequence of its universal applicability (Paulos, 1995). A certain level of "mathematical sophistication" is seen as essential for a CS major by the Association of Computing Machinery and the Institute of Electrical and Electronics Engineers Computer Society—two major professional societies (ACM & IEEE Computer Society, 2005).

A lack of proficiency in mathematics has been described as a persistent barrier to dealing with the underrepresentation of women in science and engineering (S&E) in the United States (Vetter, 1990; Clewell, Anderson, & Thorpe, 1992; Snyder, Hoffman, & Geddes, 1997). Before 1990, standard academic achievement tests for high school students showed that males scored higher than females in mathematics. They also showed underrepresentation of females among the highest scores. When Mattel released *Teen Talk Barbie* in 1992, Barbie proclaimed that "math class is tough." In the early 1990s, the gap between female and male students' scores in mathematics began to narrow down; a recent study found that mathematics scores show no gap for girls (Hyde, Lindberg, Linn, Ellis, & Williams, 2008). However, it has been found that women lack confidence in their mathematical skills when compared to men (Lundeberg, Fox, & Puncchar, 1994; Seymour & Hewitt, 1997; Valian, 1998; Margolis & Fisher, 2002). The stereotype that boys are "naturally" better than girls in mathematics is widely held in the United States. For instance, on January 14, 2005, former Harvard University President Lawrence H. Summers questioned women's "intrinsic aptitude" for S&E at the National Bureau of Economic Research (NBER) conference.

In India, female representation in S&E remains low, despite the fact that over the years, there has been a steady rise in the proportion of women entering universities (Indian National Science Academy, 2004). Generally, this gender gap is attributed to a lack of resources and opportunities rather than male superiority and female deficiencies in mathematics (Gupta, 2007). It should be noted that India neither compiles national mathematics scores by gender at elementary, middle, and high school levels, nor par-

ticipates in the international standardized student assessment of mathematics. In the absence of data, a recent study tested the Fennema-Sherman Mathematics Attitudes Scales on Indian students. This instrument was developed by Elizabeth Fennema and Julia Sherman in 1976 and is one of the most popular instruments in research about attitudes toward mathematics by females and males. It showed that there are no statistically significant gender differences in mathematics as a male domain scale (Mukhopadhyay, 2004). The general perception in India seems to be that girls perform extremely well in mathematics.

Findings from the two case studies show that pre-university academic preparation in the United States and India is different in the learning environment created for mathematics, curricula emphasis placed on mathematics in schools, and the number and quality of computer courses offered (Table 2).

The study conducted in the United States revealed that many female students interviewed held mathematics to be their strongest subject in high school, followed by the sciences. Yet, almost half of them believed that their high schools did not prepare them "at all" for CS/CE education at the undergraduate level, and another 40% talked about being "moderately" prepared. This was mostly because of what female students perceived to be inadequate computer courses at their high schools. They felt computer classes were centered on word processing rather than on programming. They further felt that their mathematics training in high schools was deficient for CS/CE at the university level, which are rigorous, hard, mathematical, and demanding technical fields. At the university, they were expected to absorb a large volume of course work in a very short time period, which became challenging for these female students without strong training in computer and mathematics in high schools. In addition, many female students, especially minority students, were nontraditional: they were married, had young children, were single parents, or worked to support their studies/families. They found the program hard because they lacked the time required to do well in CS/CE courses. The difficulty of the CS/CE curricula was the single most common reason cited by minority female students to seriously consider leaving the program.

The study conducted in India showed that almost all female students interviewed asserted that mathematics was their strongest subject in high school, followed by physics. A little over half of the students also believed that their high school and intermediate college did not prepare them "well" for the study of CS at the university level, and another one third felt "partially" prepared. These female students qualified their responses by stating that their schools either did not expose them to computers or did not teach details, applications, and basic languages of CS. However, they were extremely confident about their mathematical skills and, thus, their logical thinking and analytical abilities. Therefore, even though they found CS a hard, demanding, technical field, female students felt their mathematical training enabled them to do well in CS at the university level. Slightly more Hindu and Sikh female students felt prepared (fully or partially) than Muslim female students. However, no one ever considered changing their field from CS to something else due to difficulties. It should be pointed out that all female students were traditional; they were young, single, without children, and devoid of jobs. Further, they were financially supported by family members, and often a part of their education was subsidized by the Indian government.

**Table 2.** Preparation for a Computing Major at the University

Female students	Comments
<i>In the United States</i>	
White	"I am very disappointed with my high school. They did not push us to do well in math. They offered math courses, and they offered Calculus I and Calculus II. But, they had no interest for us to do well."
African American	"It is not easy at all to do well in mathematics in high schools because nobody sees you as competent as boys, nobody sees you as capable as boys. At least that was the case in my high school."
Hispanic	"My high school did not give me a good foundation in math. . . . I really had to learn a lot on my own to catch up in college."
Native American	"I do not really belong in CS. I do not seem to have the skills to do well in CS. I think it is because my high school did not offer computer classes. If they did, it was like beginner's typing or pictorial designs; mostly superficial. . . . My math training is also not helping at all. If you are good in math you can survive in computer science."
<i>In India</i>	
Hindu	"I received strong training in math and physics before I came here. So, even when I did not learn computer languages in my [high school], I had a better orientation for CS."
Hindu	"I had a math teacher who pushed me so hard that I even cried sometimes. But, now I thank him. Actually, he pushed everyone in the class very hard. He really cared how we did in math. He would not let us off the hook."
Muslim	"I am not the smartest person in CS over here. It is not because I am a girl. It is because I do not have much of a background in CS. . . . [Boys] are starting from the position of knowing the subject before the CS courses begin. . . . But, I can successfully compete with them in mathematics."
Sikh	"I would not say I was prepared for CS. What we study here is nothing close to what we study in [high school and college]. But, we are prepared in math and in science, so we can prepare ourselves for CS study."

### Environment

There are many reasons why women should find IT-related fields attractive. With the information revolution, IT has grown rapidly in the recent past and is likely to do so in the near future throughout the globe (Dutta, Lopez-Claros, & Mia, 2006). IT knowledge is increasingly used in most sectors of the global economy and is not limited to just the IT industry itself. Further, IT jobs are spread throughout the country. Unlike some pro-

fessions, the work in IT is increasingly office based, and graduates in IT-related fields tend to receive high starting salaries.

A consistent theme in Western literature has been that a masculine culture dominates academic and work environments in the computing field, which discourages the participation of women in CS (Rasmussen & Hapnes, 1991; Bunderson & Christensen, 1995; Clarke & Teague, 1996; Bjorkman, Christoff, Palm, & Vallin, 1998; Stepulevage & Plumeridge, 1998; Margolis & Fisher, 2002; Larsen & Stubbs, 2005). Commonly known as the "geek/hacker/nerd" culture, this conveys the notion that computers are for men who crave to have a close relationship with a powerful technology. At the heart of geek/hacker/nerd culture is a set of idealized male norms, such as falling in love with computers with the first exposure, being extraordinarily well-versed in the inner workings of computers, myopically being focused on them to the point of obsession, and being antisocial (Varma, 2007). The geek/hacker/nerd culture projects the male way as the only way to be and do computing. It has been proposed that such stereotypical images of computing results in fewer females enrolling in CS, and those who do join the program begin to question whether they belong in CS and, thus, leave before completing the degree.

Findings from the two case studies show that the image of the computing field, career opportunities for women, and the work environment are drastically different between the United States and India (Table 3).

The study conducted in the United States showed that almost half of the female students interviewed believed there is a stereotypical computer culture mostly consisting of geeks/nerds/hackers (which are substantially overlapping), even though most of them viewed themselves as different from the stereotypes. Nearly one third of the female students claimed that the computing culture was gradually changing from being geek/nerd/hacker to one that comprises hard-working people. The remaining female students did not think there is a typical computing culture of geeks/nerds/hackers. According to the female students, the main characteristics of the computing culture include two intertwined elements. First, geeks/hackers/nerds are predominantly White males, fascinated with technology, sit in front of the computer all day and sleep near it, narrowly focused on programming, and secure perfect scores in mathematics and CS/CE courses. Second, they lack social skills to the extent they do not have a life other than talking about and playing with computers, unaware of how to dress up and what to say, and take pride in being antisocial. Furthermore, some female students felt that the emphasis on computer programming made the field very narrow and limited their intellectual potential. By entering CS/CE, they were perceived as being less feminine. Several female students also found the classroom atmosphere to be cold towards them from both male faculty and male peers. This made them rather uncomfortable about asking questions and liking the program. Lack of female faculty further reinforced that CS/CE fields are not meant for women.

White and minority female students differed on the impact of the geek/hacker/nerd culture on them. Whereas such a culture made White female students rethink whether they truly belonged in CS/CE fields, issues of persistence and departure for minority female students seldom arose on the basis of the geek/hacker/nerd culture. When minority female students considered changing their major, they wanted to move to information management, an IT field that they considered less demanding than CS/CE; White female students, on the other hand, preferred to change to psy-

**Table 3.** Environment of the Computing Field

Female Students	Comments
<i>In the United States</i>	
White	"The problem with studying computer science is that at some point you will face a conflict. You will have a conflict between doing computer science sitting in front of a box, solving codes versus being social, and interacting with people."
African American	"Computer science culture is of geeks. They are obsessed with computers. They spend all their time in front of computers. Their social life is centered on computers."
Hispanic	"[Male students] think that we are not anywhere as good as they are. They are all extremely egotistical."
Native American	"I think [male faculty] are not patient when it comes to answering questions from a female student. . . . If a female is asking for help with her program, he gets frustrated easily when she does not understand certain things. And if he is helping a male student, he spends more time and he is less likely to get frustrated."
<i>In India</i>	
Hindu	"Computer scientists are considered very intelligent, very tactful, code decrypting and everything like that. So they are respected everywhere."
Hindu	"I became interested in computer science because other branches were having few jobs. From the beginning I did not like the challenges society placed on girls especially after a certain age-you are not supposed to study, but get married. So, I wanted a field which could make you independent."
Muslim	"You get white-collar jobs, sit in an office, and do the work. That is what parents want for us. They do not want us to go to the factory and work with some men in the field."
Sikh	"People inside [university] think we are studying all the time because it is a tough degree to pursue. They think we have creative minds. People outside [university] think we are smart brains, with good jobs waiting for us. . . . Some of my friends tease me saying that I do not have fun. But, this is not true. I go out. I watch films. I am learning to dance."

chology, biology, or liberal arts, which they considered to be people-oriented and, thus, friendly to women.

The study conducted in India showed that most female students interviewed believed that the computing field is changing from being dominated by men to increasingly

being penetrated by women. Female students believed that the typical computing culture consists of dedicated, hard working, intelligent, meticulous, and smart students. These students were consistently at the top in their schools before coming to a university. Generally, they are extremely good in mathematics and the sciences. They love the details needed in CS and put forth effort until programs are perfect. They help those needing assistance and it is pleasant to be around them. They are active in social and cultural events held at their universities, as well as participate in sports. Most importantly, female students believed CS to be a field in which women could excel. According to them, economic rewards for a woman with a CS degree are much higher than with a degree in other S&E fields. Women who study CS are well respected by faculty and peers in the educational arena and by family members, friends, and neighbors in the social arena. After attaining a CS degree, women will be working mostly in offices and laboratories rather than on the shop floor or construction sites, which are dominated by men. Some female students indicated that employment in IT companies is appreciated, which alleviates concerns their families had about marriage. Women with employment potential have become desirable due to their ability to add income to the household. For all these reasons, female students have strong support from parents for their CS studies. An overwhelming majority of female students had not entertained the idea of changing their major from CS to something else. This was mostly because of the benefits, opportunities, and independence they could gain from a degree in CS. All female students were in agreement on the use value of CS for women; there was no variation in their views along religious lines.

## DISCUSSION

Feminist scholars in the West have been preoccupied with whether technologies have a gender. Four main theoretical frameworks have been identified in the feminist scholarly work on women and computer technology (see, e.g., Wajcman, 2004). Initially, reconfiguration feminists (e.g., Cockburn, 1983) analyzed the relationship between gender and technology to show how men have used new technologies to maintain their control over women and have excluded women from participation in them. Their main goal was to generate awareness in the technical arena, from gender-blindness to gender-consciousness. Much research has shown how women have been excluded from the computing field and how such exclusion has given it masculine characteristics. Cyber feminists (e.g., Plant, 1997) moved to a specific area of cyber culture and gender to show the inclusion of women in World Wide Web, Internet, and other net-based communication technologies. Their key objective was to celebrate new cyber technologies, which have been central in the fundamental shift in power from men to women. Cyborg feminists (e.g., Haraway, 1991) argued against naturalism (all phenomena can be justified in terms of natural causes) and essentialism (all entities of the same kind possess a common set of characteristics), since they tend to exclude women who do not conform to such ideals. Instead, they proposed taking into account race and class to show complexities and contradictions in the relationship between gender and IT. Their major intention was to create coalitions based on affinity instead of identity since IT technology comprises extensions of the human body. Finally, techno feminists (e.g., Wajcman, 2004) contended

that technologies are gendered both in their design and use and women will not find computer technology liberating to them until they start designing it. Their main intention was to engage feminists in the technical arena to find a balance between pessimistic ideas about gender and IT on the one hand and utopian ideals on the other hand.

How do the two case studies provide a confirmation for the four feminist theoretical frameworks outlined above? There is support for reconfiguration feminists in the American case, where women are underrepresented in computing. The case of Indian women, however, shows that women are not excluded from computing, as suggested by reconfiguration feminists. Enrollment trends by gender show a decline in the number of women in the CS field in the United States and an increase in India. Many women in the United States stay out of computing and prefer to do something else; in contrast, computing has not lost its allure for women in India.

The American case provides partial support for cyber feminists. American women's interest in computing seems to be one among multiple educational paths available to them. They do consider changing their major from CS/CE to information management, which shows their preference for communication with respect to computers. Indian women's attraction to computing, however, is not limited to just communication, as should have been the case according to cyber feminists. Instead, Indian women are interested in computing because it is a means for them to secure financial rewards, gain prestige, become career-oriented professionals, and attain an economically independent status. Nonetheless, it is not clear whether women in both countries are hyped about cyberspace as affirmed by cyber feminists.

There seems to be some support for cyborg feminists in both the Indian and American cases. Both show complexities and contradictions in the relationship between gender and computer technology. For instance, a CS degree offers new possibilities for women in India to be computer scientists, become independent, and feel valued. Yet, all of this cannot be achieved without consent from the parents with whom they reside and on whom they depend financially and socially. Similarly, American women enroll in CS/CE despite its image of geek/hacker/nerd because they feel skilled and are fascinated with computer technology. Yet, once in the program, they feel odd because men dominate the CS/CE field.

Finally, the American case shows some support for techno feminists. Women's organizations (e.g., the National Center for Women in Information Technology, Multi-national Development of Women in Technology) have been encouraging the participation of women in IT-related fields. In addition, the U.S. government (e.g., National Science Foundation's Information Technology Workforce Program from 2000 to 2005 and Broadening Participation in Computing Program since 2005) has been supporting projects to increase the representation of women and minorities in computing education and the workforce. The representation of Indian women in CS, however, has little to do with feminist politics or women's organizations. Instead, India has made the IT industry a national priority area for its economic growth and standing in the world, and CS is being perceived as a women-friendly field. In fact, there is little special provision for women in higher education by the Indian government. At the same time, India has reserved seats in government-funded, educational institutions of higher education for students belonging to scheduled castes (they are considered to be lowest in the caste hierarchy), scheduled tribes (they have functioned outside the mainstream of urban and

rural life), and other backward castes (they are specified by the central government on the basis of 11 social, economical, and educational factors).

All four feminist theoretical frameworks—reconfiguration, cyber culture, cyborg, and techno feminism—differ on reasons behind and solutions for gender and IT but converge on computing as a masculine field, an area that is dominated by men and, thus, inclined to keep women out. According to them, a special community within the computing world, which possesses traditional masculine characteristics such as fascination with technology and lack of social skills, maintains this image. Women are seen as “naturally” afraid to fiddle with the computer, whereas men are “naturally” brave to have a close encounter with the powerful technology. Such gendered constructions of computer technology portray women’s natural professions to be in areas other than computing.

The American case study shows that computing is indeed perceived as a masculine field, whereas that is not the case in India. American women acknowledged the prevalence of the masculine culture, even though they viewed themselves as different from the traits of such culture, and differed on the impact of it on them. Indian women, however, viewed the computing field as women-friendly, mostly because it will provide good careers for them. There was no disagreement among Indian women on the suitability of computing for women.

Masculinity and gender issues are prevalent in both countries, but in different forms. For Indian women, being indoors in an office in front of a computer means they are protected from the outside environment, which is seen as unfriendly to women. Construction sites and factories are the work sites where a degree in other engineering fields, such as mechanical or civil, are seen as more suited for men. For American women, working indoors in an office appears a normal routine, and, thus, there is little excitement for it. Sitting in front of a computer and being confined to a desk does not go well with their desire to interact with people. The fields of biology, psychology, and the social sciences are seen as people-oriented fields and, thus, suited for women.

Most importantly, the Indian case study has shown that women do not feel that teachers neglect them in mathematics and computing classes. This is one of the reasons that these fields do not emerge as a male domain. From early on, female students are taught to invest in hard work, which is seen to solve scientific and technical problems and, thus, a requirement to succeed in life. The American case, however, has shown that women feel that teachers tend not to favor them when it comes to teaching mathematics and computing. It is, therefore, no surprise that these fields appear to be in the male domain. It is not hard work for students to do well in mathematics and computing, but rather gender differences between boys and girls are seen as reasons for girls to do poorly in these fields.

## CONCLUSIONS

This article has shown that before entering a university, female students in the United States were exposed to computers and other IT resources. Even though they rarely learned any computer language, they had experience in word processing and Web searches. Unlike their peers in the United States, very few female students in India knew word processing, e-mail, or the Internet before enrolling in a university. Most female

students in India began using a computer on a regular basis after they were admitted to a university. Despite being exposed to and using the computer, Indian female students entering universities in the United States underestimated their abilities in mathematics and in CS/CE. Even though female students in India had less prior computer experience, they were confident to handle CS because they considered themselves very strong in mathematics. Unlike their peers in the United States, female students never entertained the idea of changing their major from CS to some other field. This is mainly because the image of CS in India is of a lucrative and woman-friendly field. People who enter the CS field are seen as smart and intelligent, without being antisocial. In contrast, the image of the computing field in the United States is of a White male, who is a geek and antisocial, which makes many female students rethink whether they truly belong in the CS field. When they are not affected by the masculine image of CS, inability to handle the rigorous curriculum makes many female students consider changing their major from CS to other fields.

To sum up, unlike their peers in the United States, women in India have practical reasons (e.g., economic benefits), educational reasons (e.g., strong background in mathematics and sciences), and social reasons (e.g., higher status in society and support from family) to enroll and do well in computing. Most importantly, computing in India is not portrayed as a masculine field, as it has been framed in the United States. These findings in India are consistent with the studies conducted in Iran (Shashaani & Khalili, 2001), Hong Kong (Lee, 2003), Mauritius (Adam et al., 2003), Taiwan (Fan & Li, 2004), and Malaysia (Lagesen, 2008). The gender imbalance in the United States seems to be specific to the country; it is not a universal phenomenon, as it has been presented in the scholarly literature.

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