

# Improving Technology Gender Gap in the United States: Can We learn from Other Countries?

**Myungsook Klassen, Manar Altamimi**

Computer Science Department, California Lutheran University, Thousand Oaks, CA  
91360, USA. [mklassen@clunet.edu](mailto:mklassen@clunet.edu), [maltamim@callutheran.edu](mailto:maltamim@callutheran.edu)

## Abstract

In a global society, the United States plays a major role in the world economy and in educating scientists and engineers. Yet in the United States, the technology gender gap persists in education and in the IT workforce. Women are underrepresented in computer science (CS) and other information technology positions in the United States. In this paper, two aspects are explored to understand the gender gap. One is to explore if similar trends exist in other countries of the world, and the other is to see if there is a difference of CS female enrollment among different age groups in a computer science higher education institute in the United States. Our preliminary conclusion is that the “geek culture”, predominant in USA computer science disciplines, does not exist in other parts of the world and plays a less significant role to an older group of female CS students.

## 1. Introduction

The issue of the underrepresentation of women in the information technology workforce has been the subject of a number of studies, and the studies must continue to increase the number of women in the IT fields and at the same time to reduce a labor shortage in the IT fields. The shortage of IT personnel still exists in the United States even after the dot com bust in year 2000.

The gender gap was an issue when the digital divide dominated discourse about women's use of the Internet[13]. But they are no longer numerically underrepresented in access to computers and the Internet. The technology gender gap persists in education and in the IT workforce. With a large gender gap in technology, women in the United States are not participating in globalizing engineering disciplines and technology in the world. Looking at women's position in relation to the increasingly techno-centric society reveals that women may have reached equality in access, but not equity in academic study and job opportunities. A broader and a deeper view is needed. That perspective would include the relation of women and IT in the communities in which they live as well as the larger society and education pipeline. Without proper training in computer science subjects, women cannot take jobs in the IT fields nor can they enjoy equal job opportunities, as men do.

Traditional computer science has been perceived as a discipline which prepares “stereo type” computer programmers. Studies show that this perception partly explains why female students are not interested in the subject. The computer science higher education pipeline may be best understood as a phenomenon where, beginning in middle/high school, the number of female students in proportion to white male students in computer science courses progressively declines during high school and continues to college.

Inequities tend to appear along both social class and gender lines, with male students and students from high socioeconomic status backgrounds well positioned to outpace female students and students from lower socioeconomic backgrounds in terms of computer skills and

knowledge [16]. Linebarger[15] pointed out three traditional digital divide constructs: 'family socioeconomic status', 'location of access to new technologies' and 'gender/race' for school age children.

In contemporary western society, the cultural basis for gender gap is deep rooted and perpetuating male domination of computer science. Women's employment in IT related fields is declining in most industrialized countries while it is increasing in some developing or third world countries[6] [8] [9] [13] [18] [19]. Remedying the gender deficit can be seen as a problem that can be overcome by a combination of different socialization processes.

In this paper, two areas are explored to have deeper understanding of gender gap and hopefully to find solutions to the problem. One is to understand CS education and IT fields in other countries. While there is a large gender gap in the United States in computer science, some other countries in the world show higher numbers of females studying computer science and working in the IT fields. Women in these countries may not enjoy a level of equality of women in the United States. We must identify and understand the cultural differences that attracts women. It is important to consider all cultural and societal factors in different countries to find appropriate solutions. Understanding this trend will allow us to shed lights on how to increase the number of women in technology fields.

The other is investigating if women do develop stronger self efficacy with computer science when they get mature and gain job experience in the IT fields. We specifically look at the number of female CS students who pursue their study at older ages.

This paper is organized as follows. First the gender gap in general is presented, the survey of published researches on computer science female students in other countries is presented, followed by a trend of CS/CIS female students in the program designed for mature working people at the author's university. Our data is not large enough to generalize the overall trend, but it provides a glimpse of a potential study in the field. The final section is discussion and future work.

## **2. Gender Digital Divide in the United States**

### **2.1 Equality in Access, but No Equity in IT Jobs**

The gender digital divide refers to the gap in access rates between men and women (Gorsky, 2001). Based on this traditional gender digital divide definition, the gender digital divide gap has narrowed to reach "access equality." In 2008, 83 percent of American family households owned a computer. About the same proportion of adult men and women had access to home computers. The digital connectedness of American families was increased through home computer ownership. In 2009, 78.1 percent [2] of American people used the internet close to a 20% increase from year 2001. The ratio of men versus women in 2008 was 48%:52% and is projected to be the same in the future.

The societal race and gender gaps in the United States as a whole have narrowed in the past 10 years, but in the IT field, the gender gap generally appears to be wider at all levels of employment. Overall growth in these IT occupations was so strong during the decade of the 1990's that women working in IT continued to increase through the year 1996. According to D'Agostino[7], in 1996 women were 41 percent in the IT field. In 2004, it is down to 34 percent according to Anita Borg Research Institute.

The situation is worse in highly professional positions such as computer programmers and computer systems analysts, where women tend to lag far behind men. Table 1 shows how women are overrepresented in lower IT positions while there are few women in professional computer science fields.

However, the potential exists for this situation to change. Kvasny[12] reported that minority women in low-income communities perceive IT as a means of escaping poverty while highly educated, middle-class and professional women regard IT as offering fewer opportunities for

advancement. Kvasny suggested that IT and gender studies recognize the diversity within women of different races and different cultural backgrounds.

Table 1: Representation of Women in various IT jobs in 2008[1].

Information Technology Occupations	% Women	Changes since 2002
Computer systems analysis and scientists	27.5 %	-0.3%
Operations and systems researchers and analysts	47.6%	-1.1%
Computer programmers	22.4%	-3.2%
Computer operators	46.8 %	4.4%
Data entry keyers	81.8 %	-4.5%

(Source: Bureau of Labor Statistics[1])

## 2.2 Gains in Access, but Loss in Computer Science Major

The problem of underrepresentation of women in IT starts from the math and science pipeline at school. Through high school, girls are less likely than boys to enroll in computer science classes, and the disparity increases in programming courses. Girls made up only a small proportion of students in such classes and the gap widens between grades eight and grades eleven. The study reported that boys exhibited a higher degree of self-confidence about computer skills than girls[20].

The trend continues to colleges. A fewer women choose to study computer science. Even when they choose computer science as their major, their relative (compared to men) lack of preparation for the coursework and male dominated classroom climate forces them to drop out of the program[7]. Women went from earning 36 percent of the computer science bachelor's degrees in 1985 to only 11.3 percent in 2009 as shown in Table 2. Figure 1 shows the past 15 year trends of BS degrees in the United States. It reaches the peak during years 2002 and 2004.

Why don't girls' recent gains in access to technology translate into long-term advancement in college majors and careers in the United States? Gurer and Camp[11] noted that attitudes, computer experience, computer games, mentoring and role models, self-confidence, computing environments, societal influence, teacher and family encouragement, all-female environments, perceived difficulties in balancing work and family are some factors contributing to the problem. The nerd image of the field, the fact that computer games are targeted mostly at boys, the perception of computing careers as boring, and the lack of role models for girls are a few reasons pointed out by Margolis[17].

Table 2: Gender of Bachelor's Recipient (2009,USA)[3]

	CS		CE	
Male	7031	88.7%	1394	91.3%
Female	892	11.3%	132	8.7%

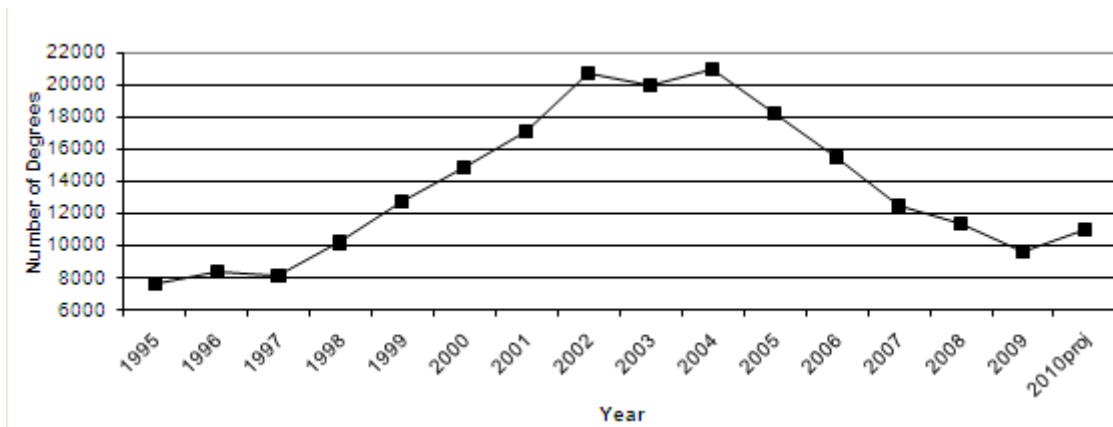


Figure 1: BS Product (CS & CE) in the United States[3]

In the next section, trends in some other countries which have vastly different socio-economic and cultural backgrounds are presented.

### 3. Gender Gap is Not a Universal Trend

Adams, Bauer and Baichoo[6] investigated women CS majors in Mauritius, country off Madagascar in Indian Ocean, They reported that University of Mauritius had seen increase of CSE major female students from 12 % in 1992 to 48% in 2001 with a peak of 54% in 1995[6]. With the fact that 68% of Mauritian household do not own computers, the authors concluded that the simple presence of computers in homes is insufficient to explain why fewer US women are choosing to study computer science as Linebarger[15] pointed out. However the article suggests that segregated secondary school education allows girls to discover their academic strengths and weaknesses without influence of stereotypes such as “CS is for geeks”.

Eidelman[8] studied two ethnic groups of high school students studying CS subjects in Israel. He reported that the percentage of female high school students studying advanced-level CS is about 50% among Arab students while it is about 25% among Jewish students. The result was explained that in Arab culture students are pushed by parents to higher scholastic achievement in order to improve their social status while in Jewish families students are much more independent and get less influence from their parents. He also reported that Arab female students perceived CS studies as a way to provide themselves with increased professional opportunities and social status.

Gender parity in Afghanistan was studied by Plane [12] with Kabul University computer science students. There women comprised over 36% of each graduating class from the computer science department when there were 25% of women population in the university in 2007. Few Afghan students have computers at home and few have training beyond basic data entry before considering studying CS at university. Plane pointed out that Afghan women in computer science received significant parental encouragement even from parents with no computer background. There is no negative “geek” stereotype influence in Afghanistan.

Gharibyan et al [10] reported a case in Armenia, a country with a traditionally male dominating culture. In Armenia, for almost two decades in 80's and 90's, the percentage of women in computer science department of Yerevan State University never fell below 75%, and in 2006 the number declined to about 44% still higher than that in the United States. Some of their findings were: computer science was considered mathematics rather than engineering, and was also considered a field that will provide a comfortable and secure future. They also reported

that absence of female role models is not a concern for Armenian women. Armenian culture does not emphasize on having a job that one loves; instead there is a determination to have a good profession that will guarantee a good living.

Valma[22] reported that women in India have increased their presence in CS education in most nationally accredited institutes[22]. In India in 2003, 32 % and 55% of women received BE and BS degrees respectively. Her study showed that despite the computer access gap by gender due to economic and social factors, CS has been perceived as a female friendly field in India. Female students choose CS because of strong possibilities for future employment. This echoes a view of Armenian and Afghan women. Her study also reported that the masculinity of the CS field was not practiced in India as it was framed in the United States.

Othman and Latih[18] studied CS female students in Malaysia and reported that the percentage of female students obtaining B.Sc was between 45% and 62% from 1998 till 2006. The percentage of females obtaining bachelor's degree in IT is higher with a range of 55% to 71% during the same period. They reported that there was no gender bias regarding computer science. Nor was a lack of role model a demotivating factor for female students to choose computer science. In Malaysia, Computer science is not viewed as a masculine field and females do not consider computer science as a technical and difficult subject. Lagesen[14] reported that Malaysian female students see developing software a good career for women.

No published studies on Saudi Arabia female computer science students were found. According to statistics provided by Saudi Arabia ministry of education, percentages of female computer science students are also high. The latest statistics available from the site shows that in 2008, 40.02% of students at a community college is female while 46% are female in 4 year colleges[4]. Through this author's personal communication with Saudi female graduate students in our computer science graduate program, they indicate that there is no "geek" stereo type perception to computer science subject in Saudi Arabia.

#### 4. Development of Self Efficacy among Older Female Students

The computer science department at California Lutheran University offers a CS major and a CIS major. Both majors are in the same computer science classes but CIS major students take two to four business courses. The department has two programs: a traditional day program and a working adult evening program. The working adult program is designed for students who return to school to finish their college degree they started awhile ago and their average age is 37. Most students work full-time, mainly in IT fields and receive tuition reimbursement benefit provided by their employers.

The author has been teaching at both programs over ten years and noticed that there were more female students in the working adults evening program. The formal statistics, Table 3 shows CIS majors of both groups past five years and year 2000. Years 2001 through 2004, not shown in the table, have a similar trend. There are more female CIS majors consistently in the mature working adults students program. When CS major is compared, there are slightly more female students in the traditional students program in 2006 and in 2008.

Table 3:CS & CIS female students percentage in undergraduate programs at CLU.

	CIS		CS	
	Traditional students	Mature working students	Traditional students	Mature working students
2000	20.8%	40.0%	15.7%	15.4%
2005	0.00%	29.40%	16.00%	25%
2006	11.80%	20.00%	15.40%	16.70%
2007	16.70%	23.10%	16.70%	10.50%
2008	0.00%	19.00%	11.10%	8.30%
2009	0.00%	32.10%	11.50%	19.40%

The data shows an interesting question. Why do more women in an older age group study computer subjects? There is very little study done on the subject. It is plausible to answer it with self-efficacy and cultural influence perspectives. Psychologists and educators[7] say that people with high self-efficacy believe they can perform well and are more likely to view difficult tasks as something to be mastered. In the United States, there is a leaky pipeline of math and computer science that discourages young females like math. Female students then become not good at math and science or get an idea that girls are inferior to boys in math and science. As a result, young female students in their adolescence form a rather weak self efficacy in math and science subjects.

When female students are in their adolescence, society's cultural influence, perception, and their desire to fit to peer's group play an important role in their choice of study. Choosing computer science therefore requires girls to sacrifice major aspects of their feminine identity. Once females reach an age past college graduating age, all those become less important. They may discover that they can be just about as good as male workers in the IT fields and slowly "restore" their self confidence and self efficacy. Then they choose to return back to school to study computer science subjects to advance themselves in the IT fields.

## 5. Discussion and Future Work

The lack of women's participation in computer science subjects and IT jobs is described as the phenomenon to the different influences to which girls are subjected[9]. Among others, factors such as gender discrimination, lack of role models, less experience of girls using computers while growing up, different childhood upbringing, and family socio-economic status contribute to the decrease. Math is often quoted as an import subject to be good at computer science and some studies [17] show girls are less prepared than boys.

According to Eidelman et al[8], Greece, Turkey, France and Italy have relatively high representation of women in the IT fields in contrast to the US, Anglo-Saxon countries, Scandinavian and German-speaking countries where the representation of women is relatively low. Some other countries show even much higher percentage of women who study computer science subjects and who work in the IT fields.

Research work on countries where there is a high percentage of female computer science students and IT workers show that factors such as a lack of role models, less experience of girls using computers and gender discrimination are not important ones. Countries studied in this paper, Afghanistan, Malaysia, India, Mauritius, Saudi Arabia and Armenia are a patriarchal society where males dominate the network of power where there is a large gender discrimination. Rather women in those countries consider computer science as a way to get a career and to improve their lives. The factors underlying these gender differences are different socio- cultural expectations from males and females.

There is little study done to answer if there are more older female students studying computer subjects and to explain why, if it is true. Statistics presented here from the author's university are too small to generalize the trend, but it provides a glimpse of potential research work. Not only the larger data base, but also deeper understanding of these older female students' perception and self-efficacy will be the next step of this important research.

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