Women and Computing

Barbara Ericson
Georgia Institute of Technology

Abstract

The percentage of women majoring in computer science in the United States has fallen from a high of 37% in the 1985 to just 22% in 2005 (Klawe, 2009). In 2008 the percentage of females taking the Advanced Placement (AP) Computer Science A exam was 18.6% and the mean score for females was 2.66 versus 2.92 for males. In 2008 the percentage of females taking the AP Calculus AB exam was 48.7% and the percentage taking the Physics B exam was 34.8% (see http://www.collegeboard.com/student/testing/ap/exgrd_sum/2008.html). This paper identifies some of the contributions women have made in computing, details some of the barriers that keep women from computing in the United States, and gives suggestions on how to increase the percentage of women in computing. It is imperative that we increase the percentage of women in computing not only to alleviate the expected shortage of professionals in the computing fields, but also to insure that more women have high paying, interesting, creative, and flexible work.

1. Women's Contributions to Computing

Women have been involved in computing since the beginning. They have made important, but often little known contributions to the field.

1.1 The First Computer Programmer

The first computer programmer was Augusta Ada King, Countess of Lovelace (often referred to as Ada Lovelace). In 1842-1843 she translated a description of Charles Baggage's Analytical Engine from Italian into English (see http://www.fourmilab.ch/babbage/sketch.html) and added copious notes (Menabrea, 1843). She wrote the first computer program to compute a sequence of Bernoulli numbers before the first mechanical computer was even created (Stein, 1985).

1.2 Female Computers Plot the Stars

A group of women known as the "Harvard Computers" performed complex astronomical calculations in the late 1800s at the Harvard Observatory (Shearer, 1996). Edward Pickering was the director and he hired the women as unskilled workers and paid them less than half what men would have earned for the same work. The "computers" identified 400,000 stars and created systems to classify the stars (http://www.womeninscience.org/then20.htm).

1.3 The Secret Rosies

During World War II the United States government secretly recruited female mathematicians as "computers." The women computed ballistic missile tables that helped win the war. They have been called "The Secret Rosies." Some of these women became the first programmers of the ENIAC (https://topsecretrosies.wordpress.com/).

1.4 The First Compiler

Rear Admiral Grace Murray Hopper was a mathematician and one of the first programmers of the Harvard Mark I. She also created the first compiler in the 1950s (see http://www.sdsc.edu/ScienceWomen/hopper.html).

Each year a conference called the Grace Hopper Celebration of Women in Computing is held and over one thousand people attend. I attended in 2007 and it was wonderful to be in a room with over one thousand women in computing. Georgia Tech always sends a large contingent of female students and they always find it exciting and inspiring. What I found especially interesting is that one of the students said that she was, "surprised to see so many older women in computing." But, back in the 1980s I often worked in groups that were 40-60% female.

1.5 Award Winning Contributions

The 2006 Turing Award was given to Frances Allen, who was the first women to win that award. The Turing Award is the highest prize in computing as there is no Nobel Prize for computing. Frances Allen won for her work at IBM on optimizing compilers and automatic parallel execution (see http://en.wikipedia.org/wiki/Fran_Allen). The 2008 Turing Award was given to Barbara Liskov. She was the first woman in the United States to obtain a doctorate from a computer science department and is currently a professor at the Massachusetts Institute of Technology (MIT) (see http://en.wikipedia.org/wiki/Barbara_Liskov).

2. Barriers to Women in Computing

While women have made many important contributions to computing, they have often faced substantial barriers as well.

2.1 Negative Stereotypes

The popular image of a computer scientist in our culture is one that many females (and males) do not find attractive. The stereotype depicts a white male who works long hours hunched over a computer all alone (Burger, 2007). Introductory classes in computing often insist that all

programming be done individually, which perpetuates this stereotype of having to work alone. In actuality, most people in this field work in teams, and one of the most important skills employers are looking for is the ability to work in teams.

The perception that you have to work long hours in computing also discourages many females. In our society many women are concerned about balancing work and family. Many students today want jobs that are flexible (Burger, 2007). But the good news is that it is often possible to work part-time and telecommute in computing. I have worked part-time (30 hours a week) since my first child was born. When I asked my boss if I could work part-time back in 1992, he said, "Sure, you are more productive in 30 hours than most people are in 40 hours."

Surveys of students show that many think that computing is difficult, boring, anti-social, not creative, and irrelevant (Burger 2007). Many introductory computing classes have assignments that students find boring, lack any opportunity to express creativity, and seem irrelevant to the students.

My father had a boring job as a low-level manager on an automotive assembly line for over 20 years and he hated his job. I love that my jobs have been interesting and creative and that I get to help people solve problems. I have helped car designers create 3D models of new cars. I have written software to help people fix phones. I have worked to help doctors diagnose brain tumors and strokes. There are many ways to use computers to help people.

2.2 Less Confidence with Computing

Girls often have less experience and confidence with computers than boys. Interviews with males in computing show that many become intrigued with computers early, while females often come to computing later and thus often have less experience with computers (Margolis, 2002). Many studies have also shown that females often have less confidence in their abilities than males even when their performance is equivalent (Burger, 2007). This can lead to females feeling like they do not belong in computing classes since some of the males act as if they have more knowledge and experience (even when they do not).

I have certainly seen males in computing classes who act like they know everything and who make fun of people who know less. They were not the majority of the males in my computing classes, but they were often loud and tended to be quite obnoxious. Teachers need to make sure the environment in their classes is welcoming and supportive and not hostile to females and minorities.

2.3 Lack of Access to Computing Classes

One study of girls that had indicated an interest in computing in middle school found that this interest disappeared in high school (Burger, 2007). The girls either did not have room in their schedules for computing classes, were not aware of any computing classes at their schools, or there were not any computing classes offered at their schools.

In a review of Advanced Placement (AP) Computer Science (CS) exam data for the last 10 years the Computer Science Teachers Association (CSTA) found that access to AP CS classes varies tremendously from state to state. One surprising finding was that 24 states never had more than 100 students take the AP CS A exam from 1998 to 2008 (http://csta.acm.org/rss/States-CS-AP-A-98-2008.xls).

2.4 Discrimination

The women that were the "Harvard Computers" back in the late 1800s made less than half what men made in the same job. While things have improved somewhat, women still make about 88-90% of what men make in the same IT job, even after adjusting for age, experience, education, and work level (Burger, 2007). The only positive thing about this is that this is better than women fare relative to men in many other professions.

Women often face difficulty getting to the highest levels in their fields. The proportion of women in top leadership positions in technology is quite low (Klawe, 2009). One interesting study at MIT from 1995-1999 found the female junior faculty did not feel discriminated against based on their gender at first, but as their careers progressed and they achieved tenure they increasingly felt marginalized and excluded from significant roles in their departments, even though these women were outstanding in their fields http://web.mit.edu/fnl/women/women.html#The%20Study.

Teachers, counselors, and administrators can also discourage students who are interested in computing (Margolis, 2008). A teacher told me a story about a girl that was on a robot competition team in middle school and yet when she tried to sign up for AP CS in high school her counselor would not allow it. The counselor told her that, "the course wasn't for her."

3. Increasing Female's Interest in Computing

There are many steps that teachers can take to help increase female's interest in computing. We know that we can do better. We had a higher percentage of women earn computing degrees in the 1980s (37%) and other countries have nearly 50% female computing students.

In countries that do not have a stereotype that says that women have less ability in science and technology (such as

in India, Brazil, and Argentina), the percentage of females in computing is much higher than in the United States. In many North African and Arabic countries there is a much higher percentage of women in computing. In 2004 Carnegie Mellon University (CMU) opened a campus in Qatar. The percentage of women in CS at that campus is over 50% (Burger, 2007).

3.1 Provide Early Computing Experiences

The Association for Computing Machinery (ACM) recently released a recommendation that all middle school students get some exposure to computer science (ACM, 2009). Since females often have less experience and confidence in computing than males, this recommendation is even more important for females (Margolis, 2002).

Georgia Tech has been offering Saturday computing workshops for Girl Scouts since 2005. In our four hour workshops girls learn about computing concepts by working with PicoCrickets (see Figure 1), building and programming LEGO robots, and programming in Scratch or Alice (see http://coweb.cc.gatech.edu/ice-gt/201). Our pre and post attitude surveys have shown statistically significant changes in attitudes towards computing after many of these workshops (Bruckman, 2005). We have found the largest number of statistically significant changes in attitudes with PicoCrickets, but we have also found statistically significant changes in attitudes with Scratch and Alice. Our computing summer camps have also shown statistically significant positive changes in attitudes towards computing.

The number of Girls Scouts participating in our computing workshops has been growing tremendously. We started with about 20 girls at a time and now our workshops often involve more than 60 girls and have long waiting lists. We offered two four-hour workshops in 20005-2006, four in 2006-2007, 10 in 2007-2008, and 15 in 2008-2009. In 2005-2006 we had about 190 Girl Scouts get some introduction to computing, in 2006-2007 it was 370, and in 2007-2008 it was 1595 girls. This growth shows that girls can be very interested in computing. These girls are paying money to spend four hours doing computing on a Saturday.

One exciting result from our surveys is that many girls enjoy the free software that can be used to introduce computing. We have used Scratch (http://scratch.mit.edu) to teach girls computing concepts by having them create two-dimensional animations and games. We have used Alice (http://www.alice.org) to introduce girls to computing concepts by having them create three-dimensional movies and games. And, we have used Media Computation (http://www.mediacomputation.org) to introduce girls to computing concepts by having them write programs that manipulate media, such as creating an image collage as shown in Figure 2. We have also used CS Unplugged (http://csunplugged.org/) activities which teach computing concepts without a computer.

Figure 1. Girls making a musical pickle with PicoCrickets

Figure 2. A media computation image collage

Teachers can offer computing summer camps, Saturday workshops, and/or after school programs using free software and activities to introduce girls to computing. Teachers can even charge enough for summer camps to pay themselves and any student assistants. Running computing summer camps should also help increase interest in your regular computing classes. For more information on our summer camps see http://coweb.cc.gatech.edu/ice-gt/915.

3.2 Provide Female Role Models

It is very important for students to see people like themselves in the field (Klawe, 2009). This is especially important to counter the stereotypes. If you do not have appropriate role models available, you can show a video

that shows female computer science graduates who work at Google, Microsoft, and Amazon. This video was made by the University of Washington (see "A Day in the Life" at http://www.cs.washington.edu/education/ugrad/prospective/outreach.html).

3.3 Get Parents to Support their Daughters

Parental support is very important and especially for non-traditional female fields (Burger, 2007). At Georgia Tech some of our Girl Scout computing workshops involve the parents. We have father and daughter teams program LEGO NXT robots as shown in Figure 3 and we have mother and daughter teams work with PicoCrickets.

Figure 3. Dad and daughter with a NXT robot

The parents see female role models in computing and we also give the parents materials about computing careers. Career brochures are available from the CSTA at http://csta.acm.org/Resources/sub/Careers.html. A "talking points" card that parents can use to talk to girls about careers in Information Technology (IT) is freely available from the National Center for Women in Information Technology (NCWIT). The card can be downloaded from http://www.ncwit.org/resources.res.outreach.talking2.html.

Another method for reaching parents is to send a letter home to parents of girls recommending that they take computing classes. Teachers in Georgia who have done this have increased the percentage of women in their Advanced Placement CS classes to 50%. I have example letters at http://coweb.cc.gatech.edu/ice-gt/611.

Some teachers also report that holding an open house night for parents and students can attract more students to computing classes. You can put want ads for computing jobs up on your walls. You can hand out career brochures. You can show examples of the kinds of things that students do in your classes.

3.4 Increase Access to Computer Science Classes

One of the biggest barriers to increasing females' interest in computing is a lack of access to computing classes. Lobby your school's administration to offer more computing classes and especially Advanced Placement Computer Science courses. The ACM Model Curriculum for K-12 CS says that all high school students in the United States should take the Computer Science in the Modern World course (for information on this ACM level II course go to http://csta.acm.org/Curriculum/sub/ACMK12CSModel.html). But most schools do not require any computing courses.

Many students do not take computing classes even if they are available at their schools. One reason for this situation is that computing classes are not seen as important for college bound students. One way to overcome this is to get at least AP CS accepted as a math or science credit. In Georgia, as of fall 2008, students can take an AP CS course and it will count as a science class. In Texas an AP CS course counts as a math class.

Why do I think that women should take a computing course in high school? Research has shown that prior programming experience is four times more predictive of computer science success in college for females than for males (Burger, 2007). I also predict that computing classes will become required for all college students. At Georgia Tech every undergraduate student must take an introductory computing class. Understanding computation is becoming a foundational skill that is important in many fields.

3.5 Make Computing Classes Interesting and Social

One of the common complaints about computing classes is that they are hard, boring, and irrelevant.

Work to make your computing classes interesting and relevant. Georgia Tech has increased the success rate for students in our introductory computing classes by teaching computing concepts in a context. We actually teach three different contexts.

Our introductory computing course for computer science majors teaches computing using a robotics context. Our introductory CS course for engineers teaches computing concepts using engineering problems. Our introductory CS course for other majors uses Media Computation which is teaching computing concepts by having students write programs that manipulate media such as reversing a sound, negating a picture, and writing out an html page (Guzdial, 2005). The success rate for students in these courses has increased from about 70% to 80-90% (Tew, 2005).

Several research studies have shown that using pair programming can also help students succeed in introductory computing classes (Williams, 2006). Pair programming also helps dispel the myth that programmers work alone. Pair programming also particularly helps women succeed in computing classes.

3.6 Recruit Females for Computing Classes

One way to get more females into computer classes is to recruit them (Margolis, 2002). One proven strategy is to recruit female leaders and have them recruit their friends. One of our AP CS teachers in Georgia, Ms. Ria Galanos, was able to get many of the varsity cheerleaders to take AP CS A. One of her cheerleaders won the science fair and another was accepted to MIT, but choose to go to Georgia Tech instead.

4. Summary

According to job projections by the U. S. Labor Department, we are facing a massive shortage of trained computing professionals. We need to attract more students and especially more females to the field. There are many things that teachers can do to attract more females to their computing classes. Some of the proven methods are to: provide early computing experiences, provide female role models, get parents to support their daughters, make computing classes interesting and social, and recruit females for your computing classes. If every computing teacher did at least some of these things, there would be a much higher percentage of females in computing. As an added bonus, many of these things would also attract more minority and male students as well.

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Author Information

Barbara Ericson
Director, Computing Outreach
College of Computing
Georgia Institute of Technology
801 Atlantic Drive
Atlanta, GA, 30332
404-385-2107
ericson@cc.gatech.edu
http://coweb.cc.gatech.edu/ice-gt/

Barb has been working to increase the number and quality of secondary computing teachers and the number and diversity of computing students since 2004. She enjoys finding interesting ways to introduce computing to teachers and students. She is an author on four books on Media Computation. Barb also has three wonderful children, a terrific husband (Dr. Mark Guzdial), a horse, a dog, and a cat.