



## ***The Experiences of Women in Computer Science*** **The Importance of Awareness and Communication**

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**Abstract:** For years, researchers have been discussing why there are fewer women than men enrolled in computer science programs. By comparing previous studies with a new set of data, in the form of interviews, this study examines the effects of a variety of influences, including parents, educators, and stereotypes. This project is a part of a combined directed study in writing and undergraduate honors thesis, which began in the spring of 2006, and ended in December. The final product is a document that is over 80 pages in length. This is an abridged form of the original document, summarizing some of the more prominent sections. Women studying computer science are affected by a number of factors that influence their decision making and retention in programs. Some factors, such as initial programming classes, have had the same effect from the past decade to the present. Other factors have changed over the course of time. Interaction with classmates has become a factor that is more commonly cited as important to women. Perceptions of computer science were another changing factor, mainly because the field has changed dramatically within a short period of time. By openly and honestly exploring how a variety of factors affect women in computer science, this study reaches a number of conclusions. First, it highlights the need for continued research. As time passes, these factors will change in function and importance. Additionally, there is a need for awareness and communication in the computer science field. Awareness comes in the form of making sure that everyone who is connected with the computer science field understands what is going on in the field itself and with women in that field. Without awareness, little can change. Communication requires increased interaction between faculty and students so that a better learning environment can be fostered. In the end, greater awareness and communication will not only benefit women; they will make the computer science field a more inclusive environment for all who are involved.

### **PURPOSE**

For years, researchers have been discussing why there are fewer women than

men enrolled in computer science programs. The National Science Foundation indicated that in 2002 out of all the undergraduate freshmen intending to major in science and

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Mia L. Parviainen completed this project during December 2006, her final semester as an undergraduate at the University of Massachusetts Lowell. She majored in English, with a concentration in writing, and minored in both computer science and mathematics. Her project began during the spring of 2006 as a combination of a directed study in writing and as an undergraduate honors thesis. Since her focus was on both writing and computer science, she worked with two faculty advisors: Susan Kirtley, Ph.D., of the English Department, and Holly Yanco, Ph.D., of the Computer Science Department. The findings of this project were presented to UMass Lowell's Computer Science department in an effort to raise awareness about gender equity in their program. Mia is currently finishing an M.Ed. in Curriculum and Instruction at UMass Lowell's Graduate School of Education, and plans to begin teaching secondary English in the fall of 2008.

engineering programs, 5.2% of those students were women majoring in computer science and 27.1% were men (NSF "Intentions of Women"). There is an obvious gap at the graduate level as well. In 1977, there were 1559 female graduate students in computer science programs, making up 17% of the total graduate computer science population. Although the number of female graduate students in computer science has expanded roughly ten times, to 14,791 in 2003, women represent only 27% of the total population (NSF *Graduate Students*, Table 4, Table 5). Strides have been made, but women are still underrepresented in computer science.

As a result, educators, social scientists, and computer scientists have been trying to find the answers to two questions: Why do fewer women than men enter computer science programs? Why do women drop out of these programs? As research has been conducted over the years, several causes have been identified, along with a number of solutions.

## METHODS

By comparing previous studies with a new set of data, in the form of interviews, this study examines the effect of a variety of influences, including parents, teachers, educational history, and stereotypes. The intent in this comparison is to note what is being done in response to literature, specifically noting which factors are still problematic and what progress has been made. I chose to form my line of inquiry around the things that motivate women to pursue computer science: classes, advice, and programs. I decided to see how these factors affect the experiences of women in computer science, hence the title of this study. Specifically, I wanted to look at what classes and programs women participated in during college, what advice they had been given, and how their perceptions of computer science had changed over time.

I began the planning for this project in May 2006. I assembled a project committee, met with the Honors Program director, and prepared a proposal of my project. Because I planned to tape interviews with participants, my research needed to be approved by the University of Massachusetts Lowell's Institutional Review Board (IRB). Specifically, I prepared an informed consent form and developed questions to use in my interviews. All of the participants in this study signed an informed consent form, assuring protection of their privacy. I received my approval from the IRB on June 13, 2006.

Over the course of the summer, invitations to be interviewed were sent by email to over one hundred women, in the hopes of forming a randomized purposeful sample. They were referred through contacts, referrals, and social networks. In one example, a student at one university heard about my project and graciously offered to pass a memo to the women's list at her computer science department. All of the women that were invited were either current students or students who had graduated within the past two years from area colleges and universities. They ranged from entering freshman to women who had completed doctoral studies, to capture both initial impressions and to have input from more experienced members of the computer science community.

My goal was to conduct at most twenty interviews. By the end of August, I conducted 15 interviews. The participants ranged in age from 18 to 30, with an average age of 22. They have attended public and private colleges and have pursued additional majors and minors in history, biology, engineering, linguistics, mathematics and biological information systems. Most of the students were American; one was from India and another was from the Czech Republic. The diversity in the group reflects the variations in the larger computer science community. Although it was clear that each participant had her own unique pathways, the consistency in many of their remarks shows that there are some experiences that

transcend demographics.

Each interview was transcribed into a word processor, omitting false starts and filler phrases. Since I do make specific referrals to participants, I decided to use pseudonyms to identify them. In cases where the women had names of a particular ethnicity or nationality, I chose names that reflected those backgrounds. After the interviews were transcribed, the transcripts were analyzed to identify different factors that were consistently mentioned, such as early computer science classes or teachers' influences. From there, relevant sections were placed on memo pages by topic, with all of the quotes identified by participant. The memo pages were analyzed to find themes and common thoughts. Once I derived themes and thought processes, I compared them with a review of the current literature that I conducted.

In essence, this study was designed to mimic and build on previous studies, which is a foundation of research. Working from previous studies is vital for research concerning women and computer science. In five years, the observations made in this study and the conclusions drawn might be obsolete. The next generation of students will be growing up with the Internet and computer use as a daily part of life, not just something that has been gradually integrated into their lives. The way that women relate to computers will progressively change over time. Because of these changes, the computer science community cannot rest on the research that is conducted today.

## SUMMARY OF SELECTED FACTORS

### *The Influence of Parents and Educators*

There is disagreement among scholars about the influence of parents, in the form of perceived approval or disapproval. Klawe and Leveson's study stated outright that "student, teacher and parental attitudes discourage girls from pursuing science and

math despite the fact that females, in general, get better grades in math and science than males" (30). However, another study conducted by Scragg and Smith concluded that they "found no evidence of peer, parental or personal perceptions that computer science is a career inappropriate for women." Tillberg and Cohoon cited parents as a source of inspiration or persuasion for women choosing computer science as a major (128-129).

In this study, participants who mentioned their parents as an influence noted that their parents were involved in computer science or engineering. For example, Kara mentioned that her mother studied computer science, and her father was an engineer. She pointed out, "This is the sort of thing I hear at home." Most of the descriptions cited by participants were characterized as subtle.

At the secondary level teachers are also influential, since this is when most students start to make decisions about college and career development. Of the influential teachers noted by participants, almost all of them were women. This might be attributed to factors such as being more comfortable working with a female advisor and the balance of power in the classroom. For some women, it is possible that there is an enormous difference between being the only woman in a class of twenty and having a male teacher, or being the only woman in a class of twenty and having a female teacher. As stated in the next section, women often develop their interest in studying computer science during high school programming classes, often with the encouragement of their teachers. If teachers are able to have this kind of influence with students, it is imperative that they are aware of this and take care to give their students useful, accurate advice.

### *No Experience Necessary?*

Overwhelmingly, women in computer science programs typically have far less ex-

posure to computer science when compared to their male counterparts (Klawe and Leveson; Scragg and Smith; Fisher, Margolis and Miller). Parents of male students are more likely to provide for them access to computers at younger ages through the purchase of home computers and enrollment in computer-related programs (AAUW 52). Additionally, most of the computer and video games, which serve as an impetus for many male students, have been designed with male users in mind, making it less likely that women will have this sort of exposure at an early age (Pearl et al.; Spertus 3-4).

The participants in this study confirmed this. Many of them first developed an interest in computer science through an early programming course that they took in high school. The participants took these classes for a variety of reasons, including parents' recommendations, choosing electives, and fulfilling requirements. Given that initial programming classes have been identified as a primary entry point for women into computer science, there is surprising inconsistency in the types of programming classes that are being taught in high schools. Some students had the benefit of sequences of classes at math and science focused schools, while some had simple programming classes. Additionally, the style of teaching in high school classes often varied from what the students experienced in college. Participants were also asked about any computer science related outreach programs that they participated in during high school. While some of the participants were involved in these programs, they typically had a prior interest in computer science and indicated that their participation reinforced their interest.

### *Joining the Geek Squad*

Stereotypically, computer scientists are categorized as white, antisocial males, often obsessed with late night programming. Several studies cite the overall negative image of computer scientists as geeks (Fisher, Mar-

golis and Miller; Spertus; Pearl et al.; Kekelis, Ancheta and Heber; Siek et al.; Margolis and Fisher; AAUW). These negative portrayals become a double-edged sword: they do not encourage women to enter computer science, and they make women who do not fit the stereotypical image feel inadequate. Researchers suggest that women in computer science are affected by these images because they do not want to become a female counterpart to these stereotypes, although they might equate embracing a "geeky" persona with success in the field.

Several of the women in this study noted that upon entering college, they held some stereotypical ideas of computer scientists. For example, Gina quickly responded that she thought computer science was "Boys, caffeinated, programming all night." When I asked her how that had changed, she quipped, "Ok, boys caffeinated, programming all night, working on some really interesting, cool stuff." It should be noted that Gina's clarification still identifies computer science with a largely male population. It became clear that many of the participants revised their perceptions after entering college, but still held to some stereotypes.

The appearance of the experience gap combined with stereotypes had been unsettling for the participants. Although many of them were highly qualified, and in some cases bypassed their first year programming courses, they were still skeptical of their own abilities. Ruth, who had taken several programming courses in high school, said, "I thought I was too far behind compared to other people I knew. I thought had to, to be good at it you sort of had to be a hacker who played on your computer for four hours every night." In this case, Ruth felt that she did not measure up to her mental image of the successful computer scientist—and that image was based on a stereotype. It should be a concern when women who have had extensive experience in computer science discount their abilities because they do not align with stereotypes of successful com-

puter scientists.

It is necessary to re-educate both students and educators about computer scientists. The stereotypes need to be challenged and called what they are—inaccurate depictions and caricatures. Although this will require more endurance and effort than some think it is worth, it is necessary for promoting a positive, inclusive image of computer scientists. As time passes, the image of the computer scientist will change and progress towards a more well-rounded image, including both men and women.

### *Awareness & Career Outlooks*

The participants in the study noted that they often had inaccurate perceptions of the computer science field, formed by their own observations and the advice of influential adults in their lives. Because freshmen level college classes often involve only programming, some held the perception that computer science is mostly programming. Several participants noted that parents and teachers who gave them advice about computer science maintained ideas about the field that were outdated by at least five years. Furthermore, students in general do not seem to have the awareness that in the typical four years that it takes to complete a bachelor's degree in computer science, the industry will have made significant changes. This can be problematic for those who enter the field, swayed by reports about the industry.

Finally, participants have also noted that acquaintances often associate their field with stability and financial security—which might not always be the case. In order to better serve current students and prospective students, both male and female, those who do influence them need to have a true understanding of the nature of the field—both in the academic world and in industry—and they need to be able to constantly change that understanding as computer science changes.

### *Exposure Programs*

Because girls “form beliefs about their relationships with technology when they are quite young” (AAUW 53), it is necessary to develop opportunities for early exposure to computers for girls. In an effort to combat the experience gap and foster positive perceptions, researchers advocate programs that expose girls to computers at an early age (Scragg and Smith). The participants' related high school activities tended to encourage their interest through awareness days, clubs, and competitions. For those who had additional involvement in college, they found such groups useful for networking, support, and collaborative research.

If more women are to successfully enter computer science as a field, they need to have more exposure to the field at a younger age. It is necessary to develop a solid continuum of exposure so that girls with an interest in computer science will be able to maintain their interest and keep an accurate perception of the field. Exposure programs should be focused on promoting well-rounded images of computer scientists, a narrowing of the experience gap, and the development of valuable skills that can be applied to a variety of disciplines.

### *Composition of Classes*

Many computer science departments have been striving to increase the numbers of women enrolled in their programs. A study by Cohoon identified a number of factors associated departments that had an equal retention of men and women, including a “sufficient number of women.” Unfortunately, the problem with this factor is that the solution is the problem. More than half the participants mentioned taking classes and being the only woman, or one of a few.

Although the participants noted that they were often in the minority, they did indicate that positive social interaction with classmates was beneficial, since it placed less of an emphasis on the gender composi-

tion of the classroom. Interaction with their classmates led them to a stronger sense of community and belonging in their departments. This is interesting to note, since many hold the idea that increasing the number of women in programs is the only way to improve the conditions for women who are already in computer science. While the intent of increasing numbers should be pursued, the responses of the participants contradict this line of thinking. Emphasizing that women “need” other women in their classes has two problems: first, it creates a dependence on other women to feel comfortable, and, second, it can further isolate women from their male classmates. Some of the participants noted that small classes aided positive interaction with classmates. While this is not always feasible for all schools, working in small groups could mimic the success of smaller classes and stimulate more interaction between classmates.

Women still face sexism in computer science programs. One participant in the study, Hannah, stated, “The students are a bit like, it’s mostly guys, obviously, and the guy students are a bit skeptical of my abilities. So, working in groups and on projects is kind of annoying because until it got underway I would get relegated to ‘sit there and look pretty’ work.” As a result, Hannah felt that her work was not being taken seriously. Unfortunately, women like Hannah often have no means of communicating their feelings or concerns in a way that will make effective changes. Sexism in some cases is unintended; men might even think that they are being helpful, or are unaware of how their actions affect women. In order for this problem to be addressed, computer science departments must foster an environment where students can interact more and learn to understand one another. As students and faculty increase interaction, open discussion of concerns regarding sexism can be better addressed.

### *Role of Faculty*

Computer science departments need to recognize developments in industry, research about women in their field, and act on suggestions made by researchers. They need to constantly examine their own interaction and influence with students. A study by Ellen Spertus recommends “Educating all members of the academic community—including board members, administrators, faculty, students, and staff—about professional climate issues; the various forms differential treatment takes; and the institution’s commitment to ensure equitable treatment” (64). An informed faculty is better able to make adjustments and make changes.

In some cases, this might come in the form of challenging ideas built into the structure of computer science programs. For example, faculty members need to learn to challenge the idea that experience is a sure-fire indicator of a student’s ability. While experience certainly helps students grasp concepts earlier in computer science programs, it is not the case that women with less experience are unable to learn or are poor students. Given time and the opportunity to catch up with more experienced classmates, inexperienced students can match their classmates’ performance and even surpass it.

The participants described influential faculty members as being genuinely interested in their work and serving as a positive influence for their students. They can be excellent sources of research, networking, and mentoring. Cassandra described one of her mentors,

I think it was probably around my junior year of college. I started doing research with one of my computer science professors and I really enjoyed that project. And she kind of encouraged me to look into going to grad school and continuing doing researching computer

science. And she helped me choose which schools to apply to and different fellowship programs.

This sort of interaction with faculty members not only creates a welcoming environment—it gives students a foothold in the world of research, connections, and knowledge of fellowships and graduate schools.

As computer science departments try to implement policies to level the playing field, they need to be careful about differential treatment. The impact that policy changes make on students is paramount—apparent favoritism can fuel hostility and tension. In order to enact these policies, it is necessary to constantly gather feedback from both faculty and students, and then make revisions to policies. By gathering feedback, faculty members might also benefit from recognizing misconceptions that they have had about students' ability and performance, as well, resulting in a more welcoming environment for women in their departments.

## CONCLUSIONS

The different factors that affect women in computer science seem to be like a tangled web, filled with threads wildly run from point to point. Amid the overlapping layers of influences and sources of misconceptions, there are some common threads. Awareness and communication, both between classmates and between faculty and students, are the underlying solutions to many of the problems that women face in computer science. While they appear to be broad topics, they are at the root of many issues.

Awareness of computer science programs needs to be addressed on a number of levels. The general public is not aware of what computer science actually involves—many people do not know what the course work entails, nor do they know what work computer scientists do. For those who do know what computer science involves,

some of them base their perceptions on what the state of the industry and academy were five or even ten years ago. If the general public has a misguided idea of computer science, then it is not likely that students will acquire an accurate view themselves.

Of course, educating the general public is a daunting task. Such an effort could neglect reaching the most important influences in the lives of students that need greater awareness: parents and secondary educators. They have tremendous influence on students' college choices, both in the actual process of making choices and in the years leading up to those decisions. Parents and secondary educators form students' relationships with computers, influence stereotypes, and help students make college and career decisions. As a result, they need to be made aware of their influence so that they can help the students in their lives form accurate perceptions and make informed decisions.

Likewise, communication is another factor that needs to be addressed on more than one level. Communication between classmates involves creating an environment for students where interaction and discussion is encouraged. The participants in this study made it clear that knowing their classmates was an enormous benefit—they did not feel marginalized or isolated even when they were the only women in their classes. Communication is more important than a strict focus on the gender composition of a classroom since in the long run it encourages students to interact regardless of gender. If women are placed in classes together to make them more comfortable, they will become dependent on having other women in class. If this dependence is continued, by the time that the field of computer science reaches a point where there are equal numbers of women and men, students might interact with others based on gender, with an invisible divide still between them.

Finally, communication between faculty members and students should be emphasized. By constantly evaluating their effec-

tiveness, departments can better meet the needs of students and become aware of how their methods and behavior affects students. By making their expectations clear to students, students are able to understand what is expected of them and adjust their perspectives accordingly.

There are many points in the web of factors that have some impact on students studying computer science. As time passes, more research should be conducted, exploring the overlap and common points between these various factors. As these assessments are made, they should keep the common threads in mind. After all, change in society's awareness of computer science, communication between classmates, and communication between faculty members and students are the threads that will improve the experiences of women in computer science.

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