# GEEK MYTHOLOGY AND ATTRACTING UNDERGRADUATE WOMEN TO COMPUTER SCIENCE

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## Introduction

In 1997 at a leading university for computer science, it is not unusual for a female undergraduate computer science student to be the sole female, or one of a tiny handful of women, sitting in class. It is also not unusual for women students to feel inadequate and inferior to the stereotypes of what it takes to be a good computer scientist. During two years of research with students at Carnegie Mellon University, we will have interviewed approximately 120 female and male computer science students and non-CS majors about their histories with computers, experiences and decisions in regards to computer science. Some students have been interviewed multiple times. Some of our findings have been surprising and somewhat counterintuitive.

While we are aware that much of the gender imbalance in computer science is inherited from the tracking and socialization that occurs at the pre-college level,[1] we believe that critical innovations can occur at the university level. A critical part of our research is to conceive of programmatic innovations that speak to the experiences of undergraduate women as learners and as members of the computer science community. While this paper focuses on the gender imbalance in computer science, we are alarmed about the abysmally low number of students from U.S. minority groups. While we have taken special care to monitor these students' progress, their numbers at CMU are too low for us to comment on in this paper. Here wer present several "working hypotheses" and questions about the gender imbalance in computer science that we are currently refining or exploring in greater depth.

## I. Perceptions of the Field: "Geek Mythology"

### Question: How do perceptions and stereotypes of the field become one of the deterrents to recruiting more women at the college level into computer science?

From interviews with students both in and out of computer science we have heard many references to what people think it is like to be a computer science student. This ranges from students needing to be "super smart," to experiencing work overload, to liking to "sit in front of the computer all day" and "talking about nothing but computer science." Yet most of the computer science students, both male and female, feel they themselves are different from the stereotypes. Are they? What are the accurate perceptions and what are the stereotypes? How are these beliefs a deterrent to recruiting students to computer science

who would otherwise excel in the field? We have heard how the histories and behaviors of the "boy wonder" super hackers become the dominant image of what it takes to be a computer scientist. Yet, we have witnessed alternative models of becoming successful computer science students. We surmise that "Geek mythology" is especially pernicious for discouraging and repelling women students. How can the image of the field be changed to reflect a more inclusive picture?

## II. Coming to Computer Science: An Alternative Model

### Question: What accounts for the success in the computer science program of students with the least prior computing experience and intrinsic interest in the subject?

Many of the female students enter the department with the least prior computer experience. Most do well. While these women may have to work much harder than many men (and therefore the playing field is not level), it is clear that their experiences counter the suggestion that one must be a high school hacker obsessed with computers to succeed in computer science. Considering how the world of hackers is predominately male, this information is important for guidance counselors, teachers, parents, and female students themselves.

Interviews with the high number of international female students in the CMU CS department have been especially thought-provoking. The numbers first caught our attention: 45% of the female undergraduates studying computer science at CMU are international students, primarily educated in countries other than the United States. Few studies of women in the sciences address the comparative experiences of US and international women.[2] We suspect that the contradictions and complexities raised by the myriad of cultures discourages this. But, here at CMU we could not ignore the "different voice" we heard in interviews with the international women. These women were amongst those with the least prior computing experience. Some of these women had the least prior intrinsic interest in the field. And, yet, they do well.

For these international women, issues such as math ability, practice and confidence, parental role models, cultural expectations, personal determination and pragmatic necessity are suggested by our data as some of the reasons for these students' success. Their stories of education in their home countries where higher levels of math is required for both males and females (if one is educated at all) raise questions about our own US education: how does the lack of upper level math requirements further the gender divide in which larger numbers of males than females take upper level math courses? Their stories highlight how cultural expectations impacts women's participation in the field, and counter the stereotypes of who can do computer science.

### Question: If girls and women develop interest in computer science at a different pace than typical male students, how can academic programs be re-designed so that women students are recruited and retained in the field?

Seymour and Hewitt's study "Talking About Leaving" found that intrinsic interest is the most important factor in retaining students (male and female) in the sciences.[3] Our interviews concur with the importance of interest. In fact, two of the top female students of

this year's sophomore class have cited lack of interest as their reason for leaving the major. But, in our interviews, we have heard females describe their interest developing differently from the male model of development. Rather than epiphany moments of falling in love with computing at an early age as described by many of our male students, female stories reflect a process in which their interest in computers emerges over a longer amount of time.[4] Due to the variety of obstacles girls/women find in their computing path, it is not surprising to find that it takes women more time to be drawn to computers. The challenge for education is to consider how admissions requirements, curriculum content, and pacing may possibly be based on the male model of coming to computer science, and how to re-design a program so that academically strong women students are recruited and retained in the field. We have already restructured the entry levels of the CMU curriculum to accommodate this observation, and will be assessing the success of our new approach as part of our research (See Section VII on Interventions).

## III. "Boy Wonders"

**Question: What do students and faculty think are the ingredients for success for a computer science student?**

Sheila Tobias describes one of the characteristics of the ideology of science as a belief that *"science is a calling, something that a scientist wants to do, needs to do above all else and at all costs.... Another is that both scientific talent and interest come early in life -- the boy wonder syndrome. If you don't ask for a chemistry set and master it by the time you are 5, you won't be a good scientist. Since far fewer girls and women display these traits than boys and men, you end up with a culture that discriminates by gender."* [5]

Computer science is certainly a field liberally populated by "boy wonders"--those who were mostly white adolescent hackers, tinkering with computers since they could read (or before). Many of those who rise to the top of the field reflect this profile. While our interviews with female computer science majors have revealed an alternative profile of a successful computer science student, we wonder what criteria students and faculty members use to gauge individual students. On what are faculty members' expectations based? Do their models for success replicate their own, or are they aware of different models of coming to CS?

## IV. Computing with a Purpose

**Question: What is the glue that ultimately attracts and attaches women to computer science? How do the curriculum and pedagogy of the CS program support these factors (or not)?**

From our two years of interviews we have heard many male students consistently describe the computer as the ultimate toy, as an alluring object; with many developing a fascination in the machine quite early on in life. The stories from women are more contradictory: Among the first group of women we interviewed, interest in computing was clearly linked to a larger agenda, i.e. what can computers do in the world for the betterment of people; in the second group of interviews, a larger subset of women described more of an intrinsic interest in the computing process. Amongst this group there was much talk of computers

being part of the future and of their interest in computer science as a practical application of math. We believe that gathering more data, and being able to track students longitudinally, will help us monitor women's terms of attachment to computing, and how and if they change over the four year program.

## V. Pedagogy and Climate Issues

**Question: Considering the wide range of conceptions of computer science that exists among faculty, what about the nature of the field is communicated to existing and potential students? How does this specifically attract or deter female students?**

A key question that pervades students' accounts of their relationship to computing is their understanding of the nature of the field, both the intellectual and social aspects. High among the issues that seem to deter women from pursuing computer science is the conception that computer science is narrowly focused on programming and other technical issues, and that people who enter CS become narrowly focused themselves. In our ongoing study, we will work to elucidate these issues and develop models of pedagogy to communicate a "big picture" earlier to first-year and prospective students. If women prefer to learn about the computer in a purposeful context (i.e. "programming for a purpose, not just to program"), how does the curriculum respond? Are assignments more in line with what seems to be young male desires, such as focusing predominantly on the machine and speed? Is this necessary? Although the CMU department here has made improvements, it is arguably still true that early curriculum (here and nationwide) fails to paint a complete picture of the field's possibilities.[6,7] Do these concerns of women students increase or decrease as they progress through the program? We are aware of the possibilities of different pedagogical approaches to programming.[8] One question we are analyzing is whether females and males differ in their cognitive preferences in programming.

Through focused and longitudinal interviews and classroom observations, we are sharpening our picture of climate issues. So far, we hear very contradictory accounts of what it is like being a woman in the department. Some women report that it is a non-issue, and others feel they are not respected by their peers because of their gender. How do we most effectively address sexism amongst peers? We have heard quite a few complaints about poor teaching, based largely on students' (both male and female) perceptions that the professor is making too many assumptions of what students know. Because of women's lesser prior experience with computing, we surmise that poor teaching takes a larger toll on the women students.

## VI. The Haunting Issue of Self-esteem and Confidence

**Question: What can be done at the higher education level to ameliorate female students' shaky self-esteem and underestimation of their abilities?**

The female computer science students that we interviewed (both international and American) have somewhat escaped the damage of math and science gender-bias. All described math as one of their strong subjects, and many chose computer science as a major because it is "a practical application of math." Still, as they begin their first year, many of these students feel inadequate, especially as they compare their own knowledge to

those of their mostly male peers. From our first two years of interviews we did note that self-confidence rises as they move up in the program. Female students describe the playing field as becoming more level as the courses get more difficult and male students are faced with learning new material as well. But, we continue to hear of women's underestimation of their abilities -- a ghost that haunts our subject.

For instance, one of the female students who made the Dean's List still feels inadequate because she believes she has to work harder than most other students to even begin to understand the material. And we question why an undergraduate class (formerly titled "How to Think Like a Computer Scientist") taken by second semester first year students, that brings together theoretical math with computer science, and has a reputation as one of the most difficult classes, attracts a disproportionate number of male students and a very low number of women. One of the top women students, who did not enroll in the class, described it as the class for "brainy" students. This year 90 male (out of 120) and 3 female (out of 20) students are enrolled. Researchers Astin and Sax of UCLA studied seventh grades and found that male and female students performed comparably in math and science courses, but the females consistently underestimated their abilities. Because of their lack of confidence the females begin to take fewer courses, a trend that accelerates as they move to the more advanced levels.[5] Is a similar dynamic at work here? Are the CMU CS women students underestimating their ability? What can be done institutionally to rectify, rather than compound, this societally pervasive phenomenon?

## VII. From Mystery to Mastery

**Question: What are the critical factors that change the perceptions of female students, who were previously fearful of computing, so that they now experience intellectual pleasure in the field?**

Interviews this year with non-CS students who have taken an Introduction to Programming class are filled with descriptions of how "scared" and "frightened" they were at the beginning of the computer science class. We have heard of how their intellectual curiosity and sense of satisfaction is awakened after they begin to master the material. Students who were computer aversive describe their elation when they get their program to run. They speak of loving the fact that they "got the computer to do what I wanted it to do." Over the next two years we need to conduct more interviews to closely monitor this process. We surmise that good teaching, time and exposure are critical factors for this to occur. A sense of mastery appears to be a critical factor in encouraging females' interest in CS.

## VIII. Interventions

To date, the key intervention we have instituted at CMU, has been to use our observations on the life-cycle of women's attachment to computer science in the redesign of the entry level of our curriculum. Recognizing that women tend to have later and lesser experience with computers and programming, and that the proportion of students overall with significant programming experience has increased over the years, we have developed a total of four different points of entry to the curriculum, depending on prior experience. We also made it an explicit feature of our recruiting (in the Spring of 1996, for students already

having applied to the university) that no prior experience is required to enter the program. This fall, we offered the "novice" class for the first time, to a class whose enrollment was approximately 40% female. While it is too early to judge their subsequent integration and success in the main line of the curriculum, we can at least report that the levels of stress that similar students experienced while taking the "standard" programming course were not evident. We believe that our programs specifically designed to address the gender imbalance will also benefit students--both male and female-- from underrepresented minority groups.

During the continuation of our research, in addition to evaluating and fine-tuning this mechanism, we plan to carry out and evaluate further interventions on two main fronts. One has to do with perceptions and social construction, and the other with pedagogical practice. In the area of perceptions, we need to continue to work to portray more accurately both the nature of computer science and the personal dimension of those engaged in its study and practice. In the first instance, we have had success, via our Immigration Course (in which students are introduced to the faculty's range of research interests), in helping first-year students to see the broad potential of the field beyond programming; we need to extend this success to non-majors and to prospective students. In regard to the personal dimension, we need to unravel the "geek mythology" paradox. Building on the recognition of most CS students that they themselves are multi-faceted individuals, we can use that information to give their peers and potential peers a clearer understanding that a commitment to computer science does not preclude an one-way path.

While computers and their applications play an ever more critical role in society, the demographics of the field of computer science remain heavily skewed. Especially since computers and information technology play an increasingly pervasive role in education, and the practice of many disciplines, this underrepresentation is critical, not only for the students whose potential may go unrealized, but also for the institutions responsible for providing equal education.

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