Local and Global Perspective: An Investigation of How Cultural Factors Contribute to Gender Balanced Participation in Computer Science

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I. Introduction

This project is concerned with the growing issue of participation in computer science in the United States as well as balancing participation in computer science. This is a growing issue and many people are starting to notice. From organizations dedicated to computer science research to industry leaders, people know the supply of computer scientists is not meeting the demand. This thesis intends to address this issue.

A. Problem

The Taulbee survey has been conducted since 1974 and is currently being facilitated by the CRA to measure the academic world of computer science. The Taulbee report collects data on Bachelor's and Ph.D. production as well as information on faculty in computer science. These statistics are nothing short of frightening as the most recent Taulbee report lists a decline of 10% in bachelor's production over the past year and reiterates this follows a decline of 20% of the previous year. The report notes we have seen a steady decline since 2004. There's been an upturn starting in 2006 but this is only in overall numbers as diversity remains stagnant. Additionally, the National Science Foundation reported that half of computer scientists working in industry were born abroad and Bill Gates testified to Congress a need to increase the number of H-1B visas to fulfill computer science jobs.[i] [ii] There is a serious demand for computer scientists which is not currently being met. Industry continues to look to other sources to fulfill the need for more jobs.

Additionally, the situation for women and minorities is even worse. The Taulbee survey reports the percentage of bachelors degrees in CS granted to women each year. For women the situation is dire. Most recently, the 2007-2008 Taulbee report identified that only 11.8% of the computer science degrees produced at Ph.D. granting universities were awarded to women. Even more threatening is the fact this figure is in decline. Master's and Ph.D. production is performing better as both are on the rise but still have reached only 21.2% and 20.6% respectively.

Carnegie Mellon's numbers have fluctuated similarly. The school of computer science went from 2,884 applicants in 2000 to 1734 in 2005 before rising up to 2627 in 2009.[iii] However, where Carnegie Mellon differs from the national trend is the number of women CMU enrolls. While national figures hover just over 10%, Carnegie Mellon enrolls almost double. The 2009 freshman class is made up of 23.7% women. As such Carnegie Mellon represents a local culture that is able to upend the enrollment of national trends in enrolling women.

B. Goals of this Project

This project is based on the hypothesis that gender differences do not provide a satisfactory explanation for the low representation of women in computer science. Instead, this project intends to investigate cultural factors that contribute to an

environment that is supportive to broader computer science participation. This is driven by the realization that globally, participation in computer science varies widely and as such, the differences in participation globally cannot be attributed to the "Men are from Mars, Women are from Venus" rhetoric wherein people believe women and men are fundamentally different. Since gender is a construct that varies widely, one cannot explain or examine the success of countries with broad participation through the lens of gender differences since if participation could be attributed to gender differences. Further, by looking at cultural factors that make an environment supportive, recommendations can also benefit ethnically underrepresented groups which aren't served by gender difference models. Through researching women and computing in other cultures and countries, and the usage of surveys, focus groups, and interviews this projects aims to better understand what makes students interested in computer science both locally at Carnegie Mellon as well as internationally.

II. Past Research

From 1995-1999, Jane Margolis and Alan Fisher investigated the undergraduate computer science community at Carnegie Mellon. Back in 1995, Margolis and Fisher were looking at a Carnegie Mellon department which had only 8% women.[iv] Margolis and Fisher identified that in this environment, women found themselves in a minority situation. They claimed that women and men related to computer science different and that while men loved programming women found programming uninteresting. Additionally, by not feeling like they fit into the CS department, many women at Carnegie Mellon were unable to build network and partnerships that many men in the CS department were able to take for granted. Margolis and Fisher, however, based their recommendations on the gender differences model. Margolis and Fisher encouraged altering computer science curriculum to be more female friendly. They cited the usage of sports metaphors in programming assignments and encouraged more feminine examples. Their conclusions arose out of childhood teachings and research at Carnegie Mellon that women and men enjoy different things and to increase enrollment computer science should be taught in a way that utilizes more female interests. Specifically, they targeted an altered high school curriculum to use examples that they thought better appealed to women.

In response to Margolis and Fisher, Carnegie Mellon shifted their admissions policies. However, this shift was *not* adapted to make it female-friendly as recommended by Margolis and Fisher. Instead, admissions focused on leadership ability and breadth, qualities not attributable to gender. With a more balanced computer science environment where women were enrolled at a high enough level to build stable networks and combat hostile attitudes Frieze et al. found drastic contrasts to the recommendations of Margolis and Fisher. One example being that while programming was initially perceived as a "masculine" activity, Frieze et al. showed that the majority of male and female students had mixed perceptions.[v] Further, Frieze et al. showed that in the more balanced environment, female students felt they fit in better both academically and socially. These two

studies show very different pictures of the same school. However, the change in the scenarios was not facilitated by a "female-friendly" approach. In the balanced environment female students were able to find a better fit.

III. Methodology

The beginning of our study focused on seeking out and reading relevant studies, research, and data that would help us understand the current state and perceptions of computer science. Part of this came from examining the references sections of various papers and following trails of research to get an idea of different results that investigators have found. Additionally, searching through the ACM, and papers on Google Scholar also turned up a few noteworthy results. Another source that was useful was annual reports such as the Taulbee report, and the AP testing reports. The data from these reports gave valuable insight into the rise and fall of computer science students and more specifically the gender breakdown of computer science studies from the university to the high school level. A final, noteworthy source for more information was reading relevant news articles. Computer science and diversity issues continue to appear frequently in news outlets and the articles content as well as the tone helped to shape a better understanding of the culture we were working with.[vi]

The second tool I used was a survey designed and issued with another computer science student, Elizabeth Kemp, to the non-freshman undergraduate class at Carnegie Mellon University. The thirty-two question one double sided page survey asked questions information on student's background, high school experience, computer science background, and how they felt they fit in at Carnegie Mellon. Students responses helped to develop a better understanding of how undergraduate CS students perceived computer science before Carnegie Mellon and what level of exposure they received to the field. Further, the survey attempted to gauge how students felt that the general population perceived computer science. Additionally, the freshman class was given a slightly modified survey that skipped over questions such as "have you ever TA'ed a course?" To target computer science students, the core classes required by all undergraduate computer science majors were targeted including, Algorithm Design and Analysis, Technical Communication for Computer Scientists, and the Freshman Immigration Course.

The final tool I utilized was focus groups targeted at female Carnegie Mellon graduate students in Computer Science who had done their high school in a country outside the United States. This helped to garner a more in depth understanding of how students and general populations outside of the United States perceived computer science. The focus groups centered around three central questions "What is the public perception of computer science in your home country?" "What are the striking differences between computer science in America and your home country?" and "Who encouraged you to participate in computer science?" Additionally, the focus groups were utilized to examine how the students felt about women's participation in computer science, both here and abroad. One final focus group was

conducted with a pair of students who had done their high school education in the United States to compare both the public perception of computer science in their home country, and what they perceived to be striking differences they encountered when working with colleagues from an international background.

IV. Results

The survey was given to 111 out of 131 total freshman and 170 out of 456 total upperclassmen. The survey's responses were broken down into several different groups. Significantly, over 80% of students listed knew a high school teacher as someone they knew in the field of computing, far outstripping fathers and mothers which were 2nd and 3rd respectively. It's unclear specifically what discipline the teacher taught in but teachers at their high school level were overwhelmingly important factors in student's journey to the computer science department at Carnegie Mellon.

One example internationally that highlights both the similarities and the differences between the United States and international computer science departments was a Trauth et al. 2002 paper about women in Australia. In their paper they explain that the environment for women in IT becomes more hostile as it becomes less balanced. The women in Australia industry find themselves in some situations where they are "1 in 30" and were surrounded by sexual jokes, "locker room behavior" and frequently questioning of their skill set or questioning of their position outside the home. Many of these women felt like they had been placed in a barrier where they had to "prove themselves" a burden not expected of men who are already assumed to be competent to perform the work. Additionally, two of the respondents from the study were not Australian natives and found stark differences between Australian departments and their home countries. One woman, originally, from Poland, stated "gender isn't an issue" when asked about IT participation while a woman originally from Yugoslavia said that there was nothing unusual about a woman choosing to become an engineer.

To investigate further globally I had a total of 6 focus groups with 20 graduate students from the United States, Romania, Ghana, India, Venezuela, China, Bulgaria, Iran, and Canada. The focus groups lasted from thirty minutes to an hour and students gave valuable insights that sometimes highlighted commonalities and isolated experiences. There were several common themes that students identified when describing the perceptions and their interests in computer science.

One common theme for many international students was the overwhelming presence of software companies who owned numerous buildings near their hometowns. The visual presence the industry had in their everyday lives were large contributors to the idea that computer science was the path to wealthy job prospects. One participant from South India, described the software industry's presence as the most significant factor in her decision to study computer science, ranking it higher than parents, teachers, and friends. Other participants described

the software industry as a means to elevate themselves to the middle class or live comfortably. Even in cases where computer science was conflated with IT support or working in call centers, some students identified the ability to work indoors with air conditioning as the sign of desirable jobs.

Another insight that came from Eastern European students included testing prior to high school where students had to apply to enter certain high schools where technology and science high schools were in high demand. At these schools computer science classes were offered and were in high demand as well as had better ratios of women to men than their American counterparts. Smart students wanted to go to smart high schools and smart high schools offered computer science. Additionally, students explained that they spent time "programming in our notebooks" and while students worked on computers for the class, many problem sets were not programming on computers.

This idea was brought up in the focus group with US students where one student explained that in her experience a lot of women "have had an AP program at their high school." This is in line with our survey results that showed over 75% of Carnegie Mellon students listed teachers as a major contributor to their college major decisions, the highest by far. Two of the focus groups got into an argument about the need to encourage women to participate in computer scientists and both arguments concluded with either making mandatory or expanding the teaching of computer science in high schools.

V. Recommendations

Positive trends seem to be on the horizon. NetworkWorld in a February article described rising enrollments out of the top 10 computer science schools.[vii] Similar to some of the focus groups, job prospects are as important in America as they are elsewhere and positive prospects turns into increased enrollment. However, extended statistics on applications for 2010 and, at least at Carnegie Mellon, increased enrollment does not turn into more balanced participation as the ratio of applications from men and women are equal to 2009. Additionally, while applications have increased nationwide since 2006, women are not enrolling at a higher rate and are in fact decreasing nationally.

One position for positive change is in the high school system. From our survey it's becoming clearer that Carnegie Mellon students have more opportunities to study computer science before college than students in past years. High school is a place for students to experiment and try new things and getting students into computer science classes at the high school level are critical. However, American students experience some roadblocks that students internationally don't. Many students internationally explained that they were "never discouraged from doing computer science," they were taught that nothing could stop them from being computer scientists. On the other side, the students in the United States focus group explained that they both initially ran up against students who utilized terminology and

attitudes that discouraged them from participating and with the help of encouraging teachers they were able to overcome these obstacles.

This factor is not one to be taken lightly. Computer science at the high school level is not a level playing field and the environment currently benefits no one. It is with this understanding of student's participation in mind that this study recommends increasing high school computer science classes and removing computers from classrooms. Currently, computer science is seen as an extracurricular activity and is taken mostly by students who already have prior experience using computers. By increasing the number of students able to take college level computer science courses in high school, students are more capable of experimenting. In addition, teachers can be encouraged through high school teacher computer science conferences such as CS4HS and ACTIVATE. These conferences encourage computer science lectures from a hands on perspective rather than a programming perspective. Prior programming experience has already been proven not to have an effect on student's success at the college level. Continuing to teach students programming as computer science is not the best path to future success. By removing students from computers and making high school computer science courses more paper-based, students will not get bogged down on debating computer knowledge and will instead be free to bolster their problem solving skills, something critical to future computer scientists.

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[i] *The Science and Engineering Workforce*. Rep. National Science Board, 14 Aug. 2003. Web. <http://www.nsf.gov/nsb/documents/2003/nsb0369/>.

[ii] "Bill Gates Targets Visa Rules for Tech Workers." *NPR*. 12 Mar. 2008. Web. <http://www.npr.org/templates/story/story.php?storyId=88154016>.

[iii] *Carnegie Mellon Factbook*. Rep. Carnegie Mellon University, Feb. 2010. Web. <http://www.cmu.edu/ira/factbook/index.html>.

[iv] Schackner, Bill. "CMU's Push to Put More Females in Computer Science Is Paying off." *Pittsburgh Post-Gazette*. 20 Aug. 1999. Web. <http://web.archive.org/web/20020803155352/www.post-gazette.com/regionstate/19990820compwomen4.asp>.

[v] Blum, Lenore, Carol Frieze, Orit Hazzan, and M. Bernardine Dias. *A Cultural Perspective on Gender Diversity in Computing*. Rep. Web. <http://www.cs.cmu.edu/%7Ecfrieze/CrossingCultures.pdf>.

[vi] "The Promise Of Diversity Is Yet To Be Fulfilled." *NPR*. 11 Jan. 2010. Web. <http://www.npr.org/templates/story/story.php?storyId=122370935>.

[vii] Marsan, Carolyn D. "Want a Job? Get a Computer Science Degree." *Network World*. 22 Feb. 2010. Web. <http://www.networkworld.com/news/2010/022210-computer-science.html>.