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

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Abstract

This thesis is based on the premise that cultural factors play an important role in the representation of women in computer science. I argue that gender differences, usually noted as a primary source of women's low representation, do not provide a satisfactory explanation for the low participation of women in computer science (CS) and that we need to look at factors other than gender differences. This thesis will begin by exploring research which shows that the underrepresentation of women in computer science (well documented in the United States) is not a universal phenomenon. Some countries such as Guyana are graduating women in computer science degrees in numbers equal to those of men. I investigate the cultural factors that make this possible. Additionally, I investigate the local culture at Carnegie Mellon where we enroll women in computer science at twice the national average compared to other Ph. D. universities. Finally I make recommendations to engage a more diversified population in computer science in the United States.

Introduction

This project is concerned with the problem of computer science participation in the United States. This is an issue of great concern and many people have taken notice. From organizations dedicated to computer science research to industry leaders to universities, people know the supply of computer scientists is not meeting the demand and falling enrollments stifles innovation. Further, the computer science community is sorely lacking in diversity. While solutions have been proposed they often fit into the position of making a more "female-friendly" approach that plays off gender stereotypes. However, the predominantly male culture of the US computer science community does hold globally and many countries do not have issues of needing to balance participation. I intend to investigate these countries as well as local communities that are upsetting the trend to investigate what cultural factors contribute to participation.

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 regularly examines Bachelor's, Master's and Ph.D. production as well as information on faculty in computer science. These statistics are a valuable look at the turmoil Ph.D. granting departments in the United States have gone through. In particular, they note the substantial decline that computer science departments experienced after 2001 with enrollment dropping 1/3 over the next decade. Despite this, there is some positive trends experienced over the past two years. Most recently, the 2009 class has increased 5.5% over last year. Additionally, 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. 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 [1][2]. Further, computer science classes at the high school level are in decline. The Computer Science Teachers Association showed in their 2009 survey, 27% of surveyed high schools offered AP Computer Science, down from 40% surveyed in 2005 [3].

Additionally, the situation for women and minorities is even worse. The Taulbee report explains that the percentage of degrees being earned by women every year is a dire situation. Most recently, the 2009-2010 Taulbee report identified that only 11.3% of the computer science degrees produced at Ph.D. granting universities were granted to women [4]. Even more threatening is the fact this figure is in decline as in 2001 18.8% of bachelor's degrees in CS were granted to women. Master's and Ph.D. production is performing slightly better at 22.1% and 20.8% respectively, although this is still a ways off from balanced.

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 investigates cultural factors that contribute to an environment that is supportive of 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. Many people look at women's underrepresentation and assign the difference to something in their biological or genetic makeup. These arguments explain that men are programmers while women are more concerned with helping people and ignore the many communities where the participation in computer science is more balanced and ultimately encourage more division than inclusion. 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. 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 the usage of surveys, focus groups, and interviews this projects aims to better understand what makes a supportive environment for students 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 [5]. Margolis and Fisher identified that in this environment, women found themselves in a minority situation where they didn't find themselves fitting in. 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 [6]. Margolis and Fisher, however, based their recommendations on the gender differences model. Their conclusions arose out of childhood teachings and the need to alter computer science classrooms to become more female friendly. To Margolis and Fisher, the computer was a boy's toy and is encouraged so from childhood. By the time these students get older, Margolis and Fisher believed they had evolved into the computer science hackers that were prevalent in computer science departments while girls had pursued more ethically caring disciplines. As such, they targeted an altered high school curriculum to use examples and word problems that they thought better appealed to women. In response to some of the findings, Carnegie Mellon modified their admissions policies. One of the positive findings that did come out of the Margolis and Fisher study was that prior programming experience was not an indicator of future success in computer science. As such, admissions focused on leadership ability and breadth, qualities not attributable to gender.

With a more balanced computer science environment, Frieze et. al. found drastic contrasts to the findings of Margolis and Fisher. For example, while programming was initially perceived as a "masculine" activity, Frieze et. al. showed that the majority of male and female students had mixed perceptions on programming. There were both male and female students expressed a love to code while there were also male and female students who didn't enjoy it [7]. Further, Frieze et. al. showed that in the more gender balanced environment where female students did not find themselves in a minority situation, 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 without having to fall into stereotypes about female behavior that can result in falling further behind.

Further, the issue of male dominated computing environments is not a uniquely-American phenomenon. Many computer science departments and workplaces globally have the same problem of inadequate balance. Additionally, the environment becomes more hostile because of the lack of balance. Trauth et al. in their 2000 paper identify scenarios for Australian women similar to those encountered by Margolis and Fisher when computer science areas lack an appropriate supply of women, although Trauth et. al. did not argue from a gender differences perspective. The women in Australian industry who find themselves in some situations "1 in 30" were surrounded by sexual jokes, "locker room behavior" and frequent~~ly~~ questioning of their skill set or questioning of their position outside the home [8]. 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 "computer science is a masculine field" 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 [8].

Frieze et al. found evidence that gender balanced participation in computer science creates a more socially beneficial environment for students and Paloheimo and Stenman showed the argument held in Finish classrooms. In an investigation at Helsinki State University, Paloheimo and Stenman investigated different gender arrangements in computer science classrooms. In the mixed classrooms they found a significant difference in the status of computer science compared to the all-male and all-female classrooms. In the mixed classrooms, students were found to ask more questions, interact more with the instructor, and devote more time in group work to the success of assignments [9]. Following Frieze et. al.'s work that balanced environments correct for a lot of the issues isolated in Margolis and Fisher concerning women not feeling like they "fit" into the department, Paloheimo and Stenman identify that balanced environments also produce more fruitful classrooms

which benefit all students. As such this can be identified not as an issue of underrepresentation but a need to increase the quality of education for all students.

While all of this research has formed a better understanding of how computer science education functions in western nations, Vashti Galpin in 2002 presented a more global picture. Her paper, “Women in Computing Around the World” identifies little seen statistics that are more than a little shocking to many computer scientists today. Not many people are surprised by the fact that computer science has a problem with balanced participation. However, Galpin's research identifying the breakdown of gender participation in computer science in a variety of nations is capable of raising more than a few eyebrows. From the most recent Taulbee report, it's known that female's receive 11.3% of Bachelor’s computer science degrees in the United States. This is a figure in line with many western nations that Galpin identifies including Germany (10.5%), the United Kingdom (19%) and Denmark (6%). In contrast, the biggest outliers tend to come from developing countries such as Malaysia (51.4%), Thailand (55%) and Guyana (54.5%) [10]. There’s a clear difference between the participation in these two sets of nations that cannot be attributed merely to gender differences. This distinction encouraged further investigation into the cultures of various countries around the world to better understand what cultural factors contribute to participation in computer science.

In 2006 two researchers found an interesting contrast to the male-dominated computer science departments of many western nations. Gharibyan and Gunsaulus investigated Yeversan State University in Aremenia where from 1980 to 2000, 75% of the computer science department was female. This image is interesting and aligns with Galpin’s paper that the countries with the most gender balanced participation in computer science aren’t the ones people would suspect. Gharibyan and Gunsaulus identify that Armenia represents a "traditionally male dominated culture"[11]. As such, one doesn’t expect them to be a leader in diversity, but despite this they still enrolled women at much higher women to men ratios than the United States. In identifying some of the factors that drew Armenian students to computer science, Gharibyan and Gunsaulus touched on many topics such as a general interest in computer science, career possibilities, and parental encouragement. One factor, however, stands out in particular. Gharibyan and Gunsaulus in their surveys identified that "83% of surveyed think of CS as a mathematical field" while engineering disciplines continued to be male dominated. This is in stark contrast to the United States where computer science is not always distinguished from engineering and many computer science departments are merely extensions of the electrical engineering schools. This position is one worth further investigation to identify what makes computer science popular as according to the National Center for Education Statistics while many engineering fields still have a wide discrepancy in male-female ratios, in 2008 women received 45% of bachelor's degrees granted in math [12]. Math departments have already made large strides in gender equality and may provide an adequate avenue to explore further methods to broaden participation.

III. Methodology

Our methodology is based on the investigation of both local and global cultures to assess students' perceptions of, and attitudes to, computing.

A. Seeking Relevant Studies

As evidenced by the past research on the subject, the perspective of computer science varies widely around the world. Thus, 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 identified 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, 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 as some articles were very supportive of diversity efforts, some considered efforts misguided, and some contained useful information but misappropriated points [13]. By examining a wide array of different sources we were able to gleam perspectives from academia as well as broader culture through news reports. This allowed us to create a better understanding of the cultures we were investigating as well as paint a stronger picture of what kind of outside factors would be affecting our research.

B. Survey of Undergraduate Local Culture at Carnegie Mellon

Carnegie Mellon's undergraduate computer science program continues to b~~e~~ a leader in diversity efforts in computer science. In 2009, Carnegie Mellon's computer science department enrolled 131 students, 31 or 23.7% of which were women [14]. This figure is well over the national average. As such, Carnegie Mellon is a worthy site of investigation in the United States to find what makes a site where women can achieve a women-CS fit; one in which they feel they can actively contribute. Additionally, the computer science department has a history of investigations to examine the local culture (see papers by Frieze et. al.). These surveys will offer a continuing perspective on these studies and to determine if the computer science department still creates a women-CS fit.

The survey was designed, issued, and analyzed with a junior in SCS, Elizabeth Kemp. The one page, front-and-back, survey was designed such that it could be completed in 5 to 10 minutes while still asking all the questions we desired. The survey covered several major categories including the student's background, high school experience, perception of computer science, and their experience so far at Carnegie Mellon. Additionally, since some questions assumed predicated experience at

Carnegie Mellon (e.g. "Name one thing that you know about CS that you didn't know when you entered as a freshman?") a separate survey with similar design was created for freshman. These surveys gave us valuable information about what encouraged students to pursue computer science, their perception of computer science as well as the public's perception of computer science, and how they feel they fit in at Carnegie Mellon.

To issue the survey, core classes in the computer science curriculum were targeted at Carnegie Mellon. Only undergraduate students with computer science listed as their primary major were allowed to take the survey and students were told to only take the survey once.

C. Focus Groups of International Students at Carnegie Mellon

At Carnegie Mellon, the graduate departments in the School of Computer Science have students from a wide variety of backgrounds. Additionally, the School of Computer Science hosts faculty from a large number of countries. As such within Carnegie Mellon's graduate programs are a significant number of different histories and perspectives on computer science. In order to investigate some of the factors that contributed to their interests in computer science, focus groups provide a way to both garner their perspectives as well as push back on any questions their responses may provoke.

The focus groups were one-hour long and focus on a small set of questions that would provoke larger discussion. Specifically, the focus groups targeted the public perception of computer science in their home country, their first impressions about computer science in America, and who encouraged their participation in computer science. Through these questions, the intention was to uncover the~~ir~~ motivations of those who participated and how computer science is taught and perceived differently and/or similarly internationally.

Graduate students were targeted through the graduate Women@SCS program as well as recommendations from other students and faculty. The focus groups were performed confidentially and all participants were informed that quotes from the focus group might be utilized in a paper, names withheld.

IV. Results

A. Relevant Studies

The political turmoil Afghanistan has endured since 2001 has been well documented through the media. The war caused extensive damage to many educational institutions that are only now beginning to recover. In this environment, Eva Maria Hoffmann analyzed the growing presence of female computer science students in Afghan Universities. In particular she noted that at the University of Herat 33% of computer science students were female and at the University of Kabul 40% of computer science students were female and "CS is the most favorite subject

within the natural sciences"[15]. However, Hoffmann also notes that women are not taking CS for job prospects as while the prospects are theoretically great, in actuality many companies in the region are hesitant to hire women. Despite this, women continue to enroll at significant numbers and cite education as a means of entrance into society.

There's also a wealth of studies from countries where enrollment of women in computer science programs remains a problem. Pöpper and Altenhoff analyze a Swiss computer science department that had an average of 8% enrollment of female students in computer science over a decade. In their analysis, Pöpper and Altenhoff found that the 1/3 of incoming students listed "relevance of computers for everyday life" and "curiosity of how programs are written" as their reasons for studying computer science, reasons which are more often associated with male brains in gender difference analyses which assume men to be "tinkerers"[16]. Further, Boschetto and Cortesi, in their article Women and Informatics: The ADA Web Portal, describe the need to change the image of IT professions in Italy where women represent 15% of the female student body [17]. By increasing the presence of women within computing both in the historical and in the current professional sense they attempted to move away from old stereotypes.

Further, work on the image of people in the field of computing shows a vastly different picture in South India. Joyojeet Pal analyzes a number of popular films and how computer users are perceived. While in the United States and many western nations computer scientists and individuals in the field of computing tend to always be cast in supporting roles and often take on anti-social or "geeky" appearances, it is notably different in many South Indian films [18]. Pal notes that Bollywood has followed the teenager hacker stereotype while South India has moved to making their computer-users "aspirational heroes." Rather, users in fields like software engineering are seen as desirable characters. These characters are heroic figures who looked up to by many and represent symbols of success. Further, entrance to a computing field allows the heroes to cross class boundaries as their skills in computing often give the heroes to pull themselves out of poverty. Further, the hero as computer science is not male-exclusive as Pal cites films where females use careers in software engineering to pull their families out of poverty. However, while in some films the move from rural villager to urban life comes at a cost of morality, in the films Pal notices that many female software engineers are outliers as not being corrupted, and includes films where "the female lead plays an accomplished technologist of some form, and the male lead is portrayed as professionally subservient." Pal's analyses of the film industry is notably different to the one familiar in the United States and shows a picture where technology is not only a heroic skill but allows the heroes to move beyond class and gender barriers.

B. Survey of Undergraduate Local Culture at Carnegie Mellon

The survey was given to 110 out of 131 total freshman and 148 out of 456 total upperclassmen. The survey's responses were broken down into several different groups.

Table 1: Survey Participants by Gender and Class Standing

	Males	Females	Total
Freshman	79	31	110
Sophomores	42	7	49
Juniors	48	11	59
Seniors	32	8	40
Total	201	57	258

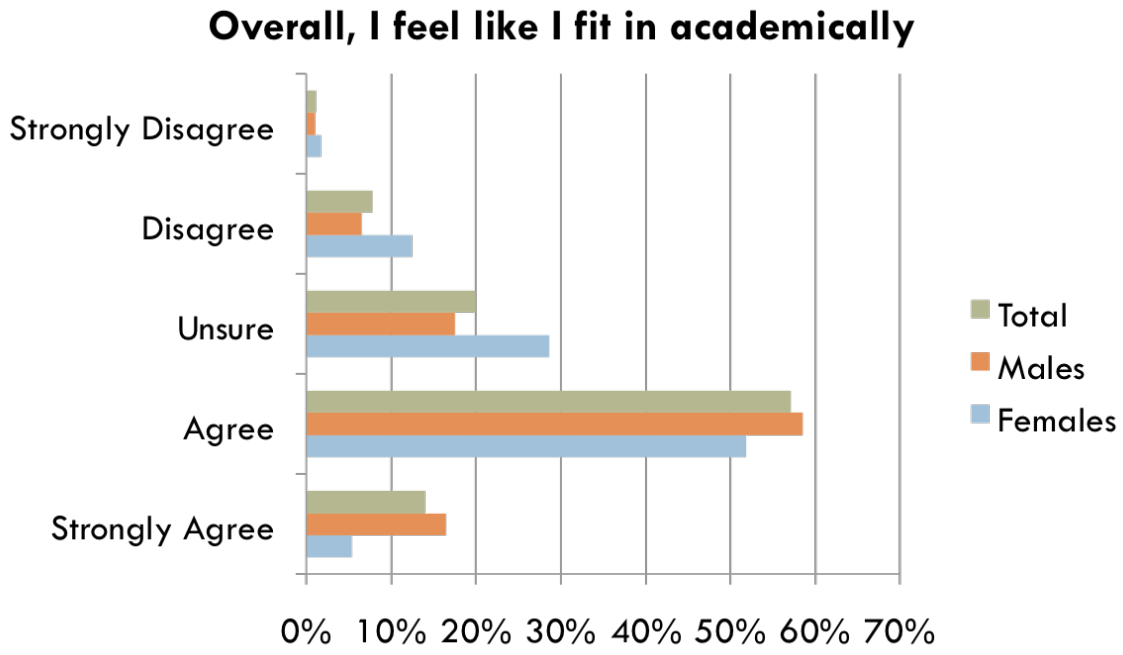


Figure 1: Students academic fit

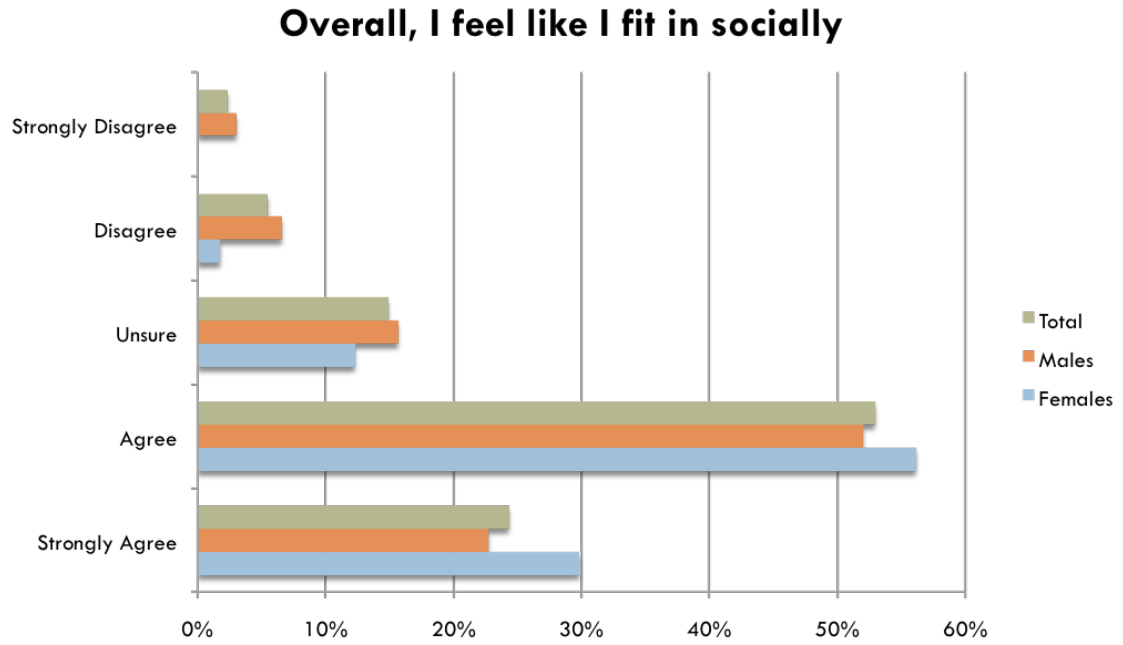


Figure 2: Students social fit

One of the primary reasons for conducting this survey was to see if Carnegie Mellon was able to sustain the Women-CS fit described by Frieze et. al. From the charts we

can see that both male and female students still strongly feel like they fit in well at Carnegie Mellon. Over half the women and over three-quarters of the men either agree or strongly agree that they fit in academically. Additionally, 86% of the women and 75% of the men either agree or strongly agree that they fit in socially. These figures are close to the figures found in Frieze, Chang, and Fan's 2005 survey of the undergraduate CS community suggesting that the Women-CS fit hasn't changed [19].

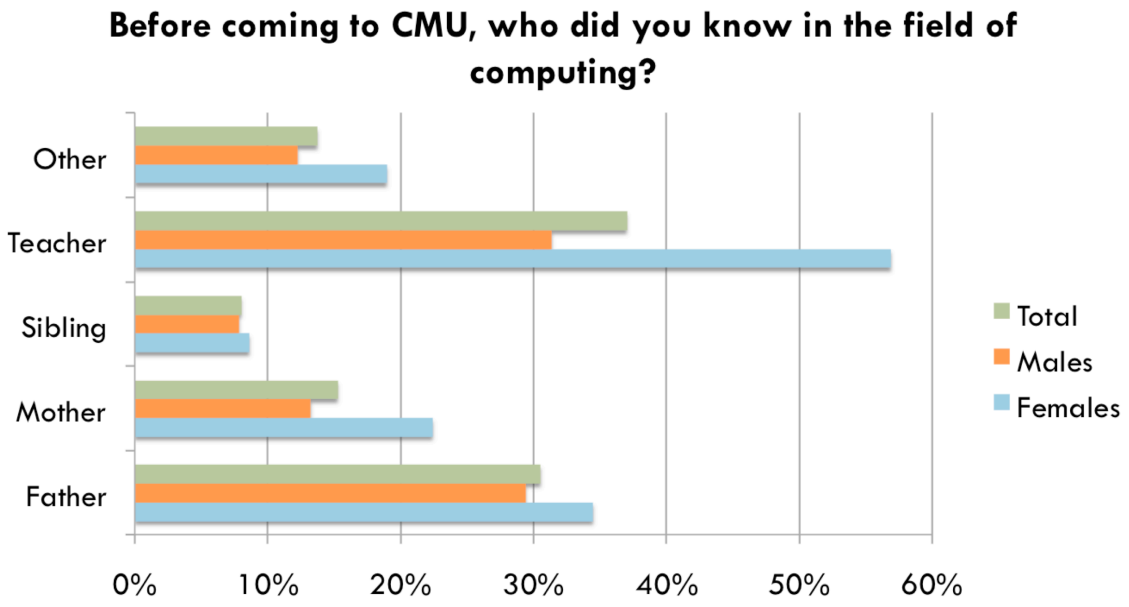


Figure 3: Students Computing Contacts

Another significant result, the person most often listed as a contact in computing for students was a teacher, 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, especially for women as half of our female survey takers listed teachers while a third of the males listed a teacher.

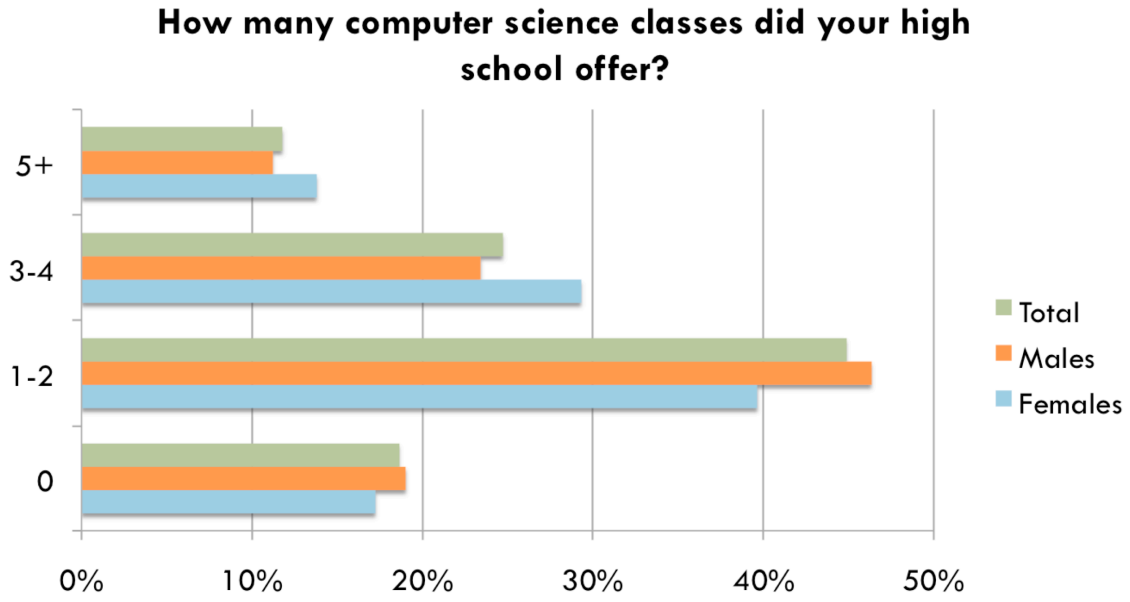


Figure 4: Computer Science Classes Offered at High School

Further, the survey takers had a very high number of computer science classes available at their high school. 80% of incoming students had at least 1 computer science course with 10% having 5 or more classes available to them. This was separated from computer applications courses on the survey (e.g. keyboarding, using word processing) but not purely from programming courses. However, this shows Carnegie Mellon's undergraduate population to be vastly different from national averages where the number of high schools offering computer science hovers around 10% and the number of students taking the AP CS exam is declining. For Carnegie Mellon's population at least, high school is more important than ever.

Given the overwhelming presence of high school teachers and courses in computing for our survey takers, we see just how important high school is for these students. These initial experiences for computer science students before moving to the collegiate level are critical for producing future computer science students. CS's low presence along the other major high school sciences such as biology or chemistry give it a lower presence in high school student's lives. However, it's rare to find a biology or chemistry college student who wasn't exposed to the subject in high school. This experience is a significant cultural factor that contributes to how Carnegie Mellon's students begin participation in computer science.

C. Focus Groups with International Students

To investigate globally I had a total of 6 focus groups with 18 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.

Table 2: Survey Participants by Gender and Class Standing

Country	# of participating students
United States	2
Romania	4
Ghana	1
India	4
Venezuela	1
China	3
Bulgaria	1
Iran	1
Canada	1

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. This directly complements Pal's work, investigating South Asian film were software engineers were heroic figures. Some participants put computer scientists next to doctors in level of prestige with one Indian student acknowledging, "becoming a computer scientist is as good as becoming a medical doctor." Other participants described the software industry as a means to elevate themselves to the middle class or live comfortably, one student stated "there's like some kind of status when you're working for software, there's a status symbol [. . .] because you [. . .] luxury" 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. This relates back to Pal's description of the class-crossing software engineering hero/heroine. By pursuing a job in the software engineering field they were able to pull themselves out of poverty or overcome various hardships due to the strength of the software engineering field.

Another insight that came from Eastern European students involving testing prior to high school where students had to apply to enter certain high schools where technology and science 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 notebook" and while students worked occasionally on computers for the class, many problem sets were not programming on computers. In this we can see Gharbiyan and Gunsaulus's work in Armenia. There they associated the large presence of women in computer science with the fact that it was seen as a mathematic discipline. By getting students off of computers, classes will focus more on the mathematical and algorithmic side than learning to program.

Additionally, some students identified that their home countries had established programs to encourage more women to participate in computer science. One student who performed her undergraduate education in computer science in China explained how professors from the university spoke to strong female math students to encourage participation in computer science when she realized "that it's because there's too few, [. . .] girls choosing computer science. So, they encouraged girls to choose computer science." In contrast, a couple of students from countries with more balanced participation found programs that encouraged balanced participation in computer science odd and were confused when told that some American girls were actively discouraged from participating in computing fields. A Bulgarian student explained, "they didn't encourage and they didn't discourage," painting a very different picture from female United States students who are sometimes actively discouraged from pursuing careers in fields like computer science. From this it's clear that there's a stark difference in cultural difference between the United States and other countries in how students come to participate in computer science. While in the United States, a common argument is the belief that girls are better at reading and writing while boys are better at math, this quote from a Bulgarian student suggests this is a cultural phenomenon as in her home country such a preference is non-existent.

Further, the question of access to high school computer science courses was also addressed 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. The US students also explained the "wide range of job opportunities." To these students, the ability to fulfill many roles or different jobs was an appealing part of their studies in computer science. This also aligns with international students who spoke about the difference between the number of jobs in other fields in the United States versus the possibilities beyond a small number of jobs in their home countries. As one of the United States students said "we're getting to a point now

where every field is finding a way to use computer science," and showing that there are possibilities to combine other academic interests with computer science.

V. Conclusions

Positive trends seem to be on the horizon. NetworkWorld in a February article described rising enrollments out of the top 10 computer science schools [20]. 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. Despite this, Carnegie Mellon's Women-CS fit has helped Carnegie Mellon to not suffer this decline. Applications from women remained steady and the 2009 freshman class had 31 women out of 131 total students, still almost twice the national average.

Within Carnegie Mellon's student body, our survey takers showed that the Women-CS fit still holds and both men and women feel they are fitting in socially as well as academically. Given that Carnegie Mellon has not changed its curriculum to be more "female friendly," Carnegie Mellon's above average female enrollment relies on something cultural rather than something biological.

One example of cultural factors that encourage students to participate is computer science classes at the high school level. 80% of our survey takers had access to a computer science class in high school when computer science classes at the high school level are at a decline nationally. Having this experience is a specifically cultural factor that contributes to our student's participation. From the focus groups we also encountered more cultural factors that contribute to computer science participation. Specifically, the image of prestige of computer science in many countries is vastly different than one that is present in the United States. The geeky pale nerd is a cultural representation of computer scientists in the United States while a software engineer is a hero in Indian cinema, while focus group contributors aligned software engineers with medical doctors in factors of prestige. The difference in cultural images is one that cannot be tied to biological differences and is a specifically cultural factor that affects computer science participation.

One position for positive change in the United States 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 may not experience. Many students internationally explained that they were "never

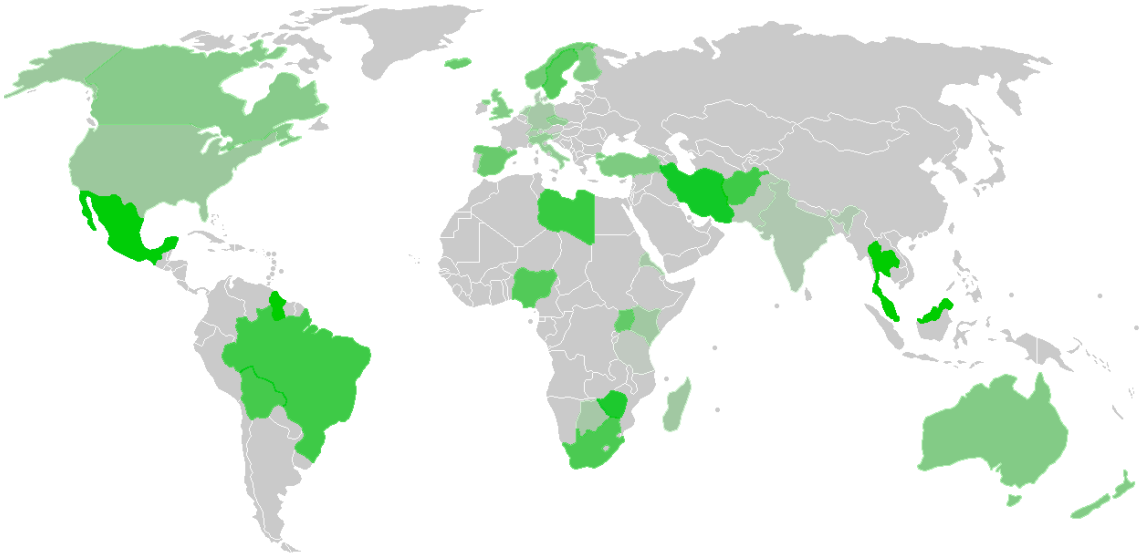
discouraged from doing computer science," they were taught that nothing could stop them from being computer scientists. On the other side, the students in the United States focus group explained that they both initially ran up against students who utilized terminology and attitudes that discouraged them 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. CS4HS is a conference hosted annually at Carnegie Mellon for high school, and if possible even before, computer science teachers to promote teaching computer science concepts in novel ways as well as encouraging teachers to promote the broad range of opportunities available with a computer science degree. 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.

A. Web Application of Global Statistics

There's little doubt from students that in computer science communities across the United States, there is a huge gender imbalance. However, what comes as a big shock, not just to students but to faculty as well is the fact that there this imbalance does not hold globally. However, these statistics are not easy to access by any means. Some statistics can be found through research papers or conference proceedings on the state of computer science. However, some statistics involve pushing through international government census information that often isn't in English or through contacts at foreign universities. Vashti Galpin's 2002 paper, Women in Computing Around the World is a testament to the difficulty and amount of resources necessary to accumulate some of this information. However this information also is shocking and was a significant reason this study was possible, From Denmark's 6% to Thailand's 55%, there's a huge diversity in the numbers around the world.

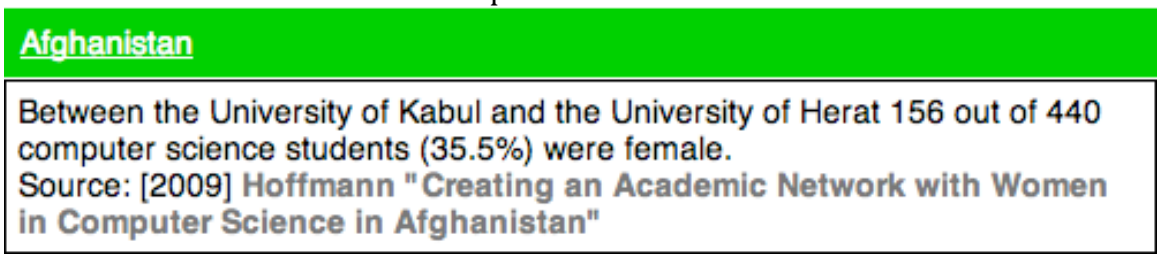
The information is still far from accessible but I have developed a web application for people to investigate computing enrollment around the world.



The application, available at http://www.womenincomputingglobally.com is a visual representation of the percentage of women currently in rolling in computing fields around the world. Users can compare individual countries to each other by how green they appear on the map. Countries' percentage of female enrollment is directly related to their green opacity up to 50% where all countries with women enrolling at 50% or higher come to the same full green color.

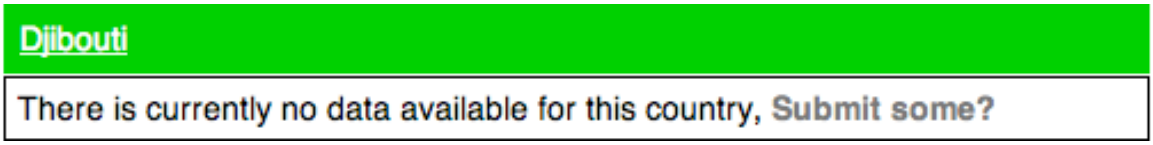
Additionally, statistics are available by rolling over the countries in the map. When a user rests their mouse pointer over any country, a tool tip will pop up describing the country's name, percentage of women involved in computing in that country, and the year the data was taken.

To give these further statistics further context, users can scroll below the map. There they will find an alphabetical listing of all of the countries. Clicking on any of the names will cause a drawer to expand with more detailed information.



In the drawer is a more detailed description of what exactly the statistics compose. As in the figure above, the Afghanistan data is composed of two universities' computer science programs. This is necessary because of the wide diversity of

computer science education. For example, the Mexico data currently lists "Licenciatures in Informática," which while not exactly computer science does provide a helpful point of explanation.



However, the data still has a wide amount of missing information. Users of the site are invited to submit data that they may have access. The issue of balanced participation in computer science around the world is an issue for countries well beyond the United States, as documented in the Pöpper and Altenhoff, and Boschetto and Cortesi papers. By keeping submissions, we can promote increased discussion and create a resource that benefits further studies internationally.

The application is written in JavaScript, taking advantage the jQuery library. The tooltips were designed with Drew Wilson's TipTip jQuery plugin and the sliding drawers functionality came with the help of Marco van Hylckama Vileg's Simple jQuery Accordion Menu plugin [21][22]. The map of the world was taken off of WikiCommons with a Creative Commons License [23].

References

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

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

[3] *Comparison Results for the 2005, 2007, and 2009 CSTA National Secondary Computer Science Surveys*. Rep. Computer Science Teachers Association. Web. <http://www.csta.acm.org/Research/sub/Projects/ResearchFiles/CSTASurvey05-07_09Comp_DCarter.pdf>.

[4] Zweben, Stuart. *CRA Taulbee Survey*. Rep. Computing Research Association. Web. <http://archive.cra.org/statistics/survey/0708.pdf>.

[5] 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>.

[6] Margolis, Jane, and Allan Fisher. Unlocking the Clubhouse: Women in Computing. London: The Mit Press, 2001.

[7] Blum, Lenore, Carol Frieze, Orit Hazzan, and M. Bernardine Dias. *A Cultural Perspective on Gender Diversity in Computing*. Rep. Web.

[8] Trauth, Eileen M., Susan H. Nielsen, and Liisa A. Von Hellens. *Explaining the IT Gender Gap: Australian Stories for the New Millennium*. Rep. Australian Computer Society Inc., Dec. 2000. Web.

[9] Paloheimo, Aura, and Jenni Stenman. *Gender, Communication and Comfort Level in Higher Level Computer Science Education – Case Study*. Rep. 2006. Web.

[10] Galpin, Vasthi. "Women in Computing around the world", ACM Press, SIGCSE Bulletin Volume 34, Issue 2, 2002.

[11] Gharibyan, Hasmik, and Stephan Gunsaulus. "Gender Gap in Computer Science Does Not Exist in One Former Soviet Republic: Results of a Study." *ACM SIGCSE Bulletin* 38.3 (2006): 222-26. Web.

[12] "Bachelor's, Master's, and Doctor's Degrees Conferred by Degree-granting Institutions, by Sex of Student and Discipline Division: 2007-08." *National Center for Education Statistics (NCES) Home Page, a Part of the U.S. Department of Education*. Web. 29 Apr. 2010. <http://nces.ed.gov/programs/digest/d09/tables/dt09_275.asp>.

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

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

[15] Hoffmann, Eva M. *Creating an Academic Network with Women in Computer Science in Afghanistan*. Rep. Web.

[16] Pöpper, Christina, and Adrian Altenhoff. *What Drives Young Women to Study Computer Science in Switzerland? – Experiences on Promoting Computer Science Studies for Female High School Graduates*. Rep. Web.

[17] Boschetto, Emanuela, and Agostino Cortesi. *Women And Informatics: The Ada Web Portal*. Rep. Web.
[18] Pal, Joyojeet. Of Mouse and Men: Computers and Geeks as Cinematic Icons in the Age of ICTD. Rep. Web. <www.ischool.berkeley.edu/files/joyojeet_pal_of_mouse_and_men.pdf>.
[19] Frieze, C., Chang, B. and Fan, C. (2005), Final report to CREU: Collaborative Research Experience for Undergraduates in Computer Science and Engineering.
[20] 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>.
[21] "JQuery: The Write Less, Do More, JavaScript Library." JQuery: The Write Less, Do More, JavaScript Library. Web. 18 Apr. 2010. <http://jquery.com/>.
[22] Van Hylckama Vlieg, Marco. "Yup, Yet Another JQuery Accordion Plugin - The Net Is Dead."Marco Van Hylckama Vlieg - Design / Web Development / Photography. 27 Feb. 2010. Web. 18 Apr. 2010. <http://www.i-marco.nl/weblog/archive/2010/02/27/yup_yet_another_jquery_accordi>.
[23] "File:BlankMap-World-v2.png - Wikimedia Commons." Main Page - Wikimedia Commons. 3 May 2008. Web. 18 Apr. 2010. <http://commons.wikimedia.org/wiki/File:BlankMap-World-v2.png>.

Appendix: Survey Given to Undergraduates

Your Background

1. When was your first experience with computing or computer science?
2. Before coming to Carnegie Mellon, did you know anybody in the field of computing personally?
3. How likely are you to talk about CS in your general conversations with non-CS friends?
4. Besides Computer Science, what are your academic interests? Why didn't you choose a major in these fields?
5. What about social interests? When not in class what do you like to do?
6. List some clubs or organizations you participate in.

High School

7. Did you participate in any academic competitions in high school/middle school?
8. How many computer science classes did your high school have?
    a. 0
    b. 1-2
    c. 3-4
    d. 5+
9. How many computer applications courses did your high school have?
    a. 0
    b. 1-2
    c. 3-4
    d. 5+
10. How helpful were your high school teachers and counselors in your college/career decisions.

CS General

11. Define computer science.
12. Enrollment in computer science has declined by 2/3 since 2000. Why do you think this is?
13. Describe the public's perception of computer science.
14. Is this perception valid at CMU? What is a CMU CS student like?
15. What is one thing about computer science incoming students aren't aware of?
16. Name three famous computer scientists.
17. Name a fictional computer scientist

Carnegie Mellon

18. Why Carnegie Mellon? Give your CMU sales pitch.
19. What was your first programming course at Carnegie Mellon? _____
20. How difficult was it?

a. Too Hard
b. Too Easy
c. Just Right

21. How much programming do you do per week?
    a. 0-3 hours
    b. 3-9 hours
    c. 9-18 hours
    d. 18+ hours
22. How do you feel this value conveys the CMU CS experience?
    a. Very Typical
    b. Typical
    c. Abnormal
    d. Very abnormal
23. Have your career goals changed since you came to Carnegie Mellon?
24. Name a skill the CS core courses don't cover well enough.

How true are the following statements?

25. The environment at CMU provides me with everything I need to succeed
    a. Very true
    b. True
    c. In between
    d. False
    e. Very False
26. I regret majoring in computer science
    a. Very True
    b. True
    c. In between
    d. False
    e. Very False
27. I know people I can ask for help if I'm struggling with an assignment
    a. Very True
    b. True
    c. In between
    d. False
    e. Very False
28. I feel like everyone I know performs better than I do.
    a. Very True
    b. True
    c. In between
    d. False
    e. Very False
29. Carnegie Mellon encourages innovative thinking
    a. Very True
    b. True

c. In between
d. False
e. Very False

30. Teamwork makes me nervous
    a. Very True
    b. True
    c. In between
    d. False
    e. Very False
31. I feel comfortable taking a leadership role
    a. Very True
    b. True
    c. In between
    d. False
    e. Very False
32. The professors at Carnegie Mellon are not approachable
    a. Very True
    b. True
    c. In between
    d. False
    e. Very False