AC 2007-2865: RECRUITMENT AND RETENTION OF WOMEN IN THE COMPUTING SCIENCES: TACKLING THE UNDERLYING PROBLEMS

Sheryl Duggins, Southern Polytechnic State University

Sheryl Duggins is a professor of Software Engineering at Southern Polytechnic State University in Marietta, Georgia. She received her Ph.D. degree from the University of Florida, and her M.S. and B.A. degrees from the University of Missouri.

Recruitment and Retention of Women in the Computing Sciences: Tackling the Underlying Problems

Abstract

This paper explores the issues surrounding recruitment and retention of women in computer science and software engineering. It examines why so few women enter computing sciences, why so many women leave computing sciences, and what can be done to improve the situation? This paper explores the social barriers and stereotypes that bias girls and women from entering the computing sciences as well as biases in the educational system that contribute to the problem. This paper will give a current overview of gender related issues in the computing sciences, as well as examine social factors that may affect the deficiency. Specific techniques that have proven effective in changing the recruitment and retention of women in computer science in the last decade will be presented. The latest research in the role that culture plays in gender diversity in computing will also be examined and the idea that cultural influences rather than gender differences account for the differences in female participation in computing related fields will be explored. Finally, it will examine historical data at my university and try to identify what elements may have contributed to the fact that our programs exceed the national average of women students in computing sciences. The findings show that while our graduate programs have more females than the national average, this is probably attributable more to our high numbers of international female graduate students than to our "female friendly" environment.

Introduction

This paper explores the issues surrounding recruitment and retention of women in the computing sciences. It examines why so few women enter computing sciences, why so many women leave computing sciences, and what can be done to improve the situation? This paper explores the social barriers and stereotypes that bias girls and women from entering the computing sciences. Whether or not the stereotypes are accurate is irrelevant: if women believe the stereotype, whether true or false, it may influence their decision of whether to study in a computing related field. There are also biases in the educational system as well as differences in the types of experiences between incoming freshman males and females that contribute to the problem. Because of these difficult social issues, specific techniques are needed to improve the situation. This paper will give a current overview of gender related issues in the computing sciences, as well as examine social factors that may affect the deficiency. Specific techniques that have proven effective in changing the recruitment and retention of women in computer science in the last decade will be discussed and current views on those findings will be explored. This will lead to a discussion of the latest research in the role that culture plays in gender diversity in computing. Finally, historical data at my university will be examined and analyzed to discover what elements may have contributed to the fact that our programs exceed the national average of women students in computing sciences.

Any paper addressing the shortage of women in the computing sciences must begin with an examination of the underlying issues surrounding the recruitment and retention of women in computing related fields. To understand the depth of the problem, one need only examine the data. Whereas the number of women in the sciences has increased over the last two decades, especially in medicine and biological sciences, the number of women in computer science (CS) has dramatically decreased over the last two decades.[1] Women in biological and agricultural sciences currently earn half the Bachelor's degrees, while the number of women graduating with Bachelor's degrees in computer science from United States Universities reached the highest point of 37.1% in 1984 and has continued declining since, with a national low of 17% in 2004. This disparity continues in graduate education where in 2004 women earned 25% of Master's degrees in CS and only 18% of PhDs. In academia, in 2005 just 16% of assistant professors, 12% of associate professors, and only 10% of full professors in CS faculties are women.[2] This has lead some to question whether there is an inherent gender-based inability in women's intellect to be able to succeed in CS. Recent studies have shown that is absolutely not the case; it has long been believed that men do better at math and CS, but a review of math and cognitive test data has revealed that any differences that exist between boys' and girls' cognitive skills are insignificantly small.[3] Similar results were found by Hyde, who also pointed to the fact that test results "fluctuate with age" and the variance between men and women's abilities create or erase "gender differences in math performance."[4] But in spite of the equivalent playing field, there are more insidious factors that seem to be contributing to the problem. To understand why there are so few girls majoring in CS, it is notable that in high school, only 29% of girls compared to 52% of boys indicated they would enjoy being scientists. And in 1999, females were 56% of Advanced Placement test takers, but only 10% of CS AP test takers were female.[5]

Why Are There So Few Women in CS?

Most of the reasons why women stay away from computer science are due to long-standing social barriers including: stereotypes, biased educational systems, experience gaps, lack of confidence, and the traditional concept of 'women's role.'[6] Aided by the ubiquitous media stereotype as epitomized by the Saturday Night Live character 'The Computer Guy', the stereotype of the computer science "hacker" is seen as one whom: is socially inept, has antipathy toward women, has poor hygiene, talks strangely, has bizarre hours, and spends all their time thinking about computers.[7] Whether or not the stereotype is accurate is irrelevant: if women *believe* that to study or work in a computing related field requires social encounters with socially incompetent nerds, the stereotype, whether true or false, may influence their decision.

Biased educational systems and experience gaps also contribute to the problem. In preschool, males dominate the school computers and studies show an inherent sex bias in educational software.[8] At the university level, most introductory CS1 classes assume a level of computer experience and knowledge that girls don't have. Most females start college with little or no experience in CS, while males enter with years of experience in both programming and exploring hardware. Even the way introductory courses are presented (consisting primarily of lectures on coding) appeals more to men. The first two years in CS are very technical with a heavy programming component, and females see males as having more experience and able to get better scores effortlessly.[9]

Another persistent factor is that females generally have a lack of self-confidence in mathematics and CS. Studies show that at every level, from middle school to the doctorate, women are

generally less confident in their mathematical and computer science abilities than men.[10,11] Even females with grades equal to or better than those of their male peers still have less confidence.

Since programming seems to be easier for men, women doubt their ability to learn computer science. Women begin to think learning CS takes "innate talent" and no amount of hard work will pay off, and so female attrition from a CS major is more than twice the rate of male attrition.[12]

An even deeper issue is the traditional concept of the 'women's role' in society. Women engineers (and computer scientists) are considered unfeminine. There is a strong cultural bias in the US against women pursuing careers in CS. Girls don't see computer scientists as having lives outside their work; with the perception that working in computing related fields requires 24/7/365 commitment.[13] Women are ill at ease in a field that encourages highly focused, almost obsessive behavior as the key to success, and believe it will be difficult to balance CS with a family life. The image of a CS student as someone (usually male) who has played with computers since early childhood is widespread and pervasive, and for a large percentage of male CS students, it also happens to be accurate.

Can Anything Be Done To Improve the Situation?

Studies have shown that there are effective techniques to increase the number of women in computing related fields.[14] Most of these techniques focus on gender differences and try to utilize those factors to make a female-friendly CS environment. For example, women excel in environments that encourage cooperative, hands-on learning. Both mentoring programs and role modeling have shown to be effective. They typically pair female students with female faculty members or working professionals, but successful mentoring is not restricted only to female mentors: involved male mentors are also effective—what is important is the social factor. Inter-disciplinary programs which link CS to real-world applications in areas like health, environment, politics, history, literature and art also are beneficial because initial studies showed women are interested in using computers to solve problems rather than studying computers "as toys."[15]

But to really make an effective difference, systemic change and commitment by leaders at all levels to advancing women in CS, beginning in kindergarten and continuing throughout women's careers is needed. This includes replacing the "gate-keeping" weed-out first-year CS courses with courses that invite students into the discipline and emphasize the various application areas rather than just focusing on programming. Universities should examine what they expect students to know coming into a CS1 course, and how they expect students to get this knowledge. Get the message out that no prior programming experience is necessary and provide bridging courses that fill in the gender gaps. CS departments need to make it known that they want women and value their presence. Organize activities to help create a community of women in CS by enhancing educational and social experiences including: speakers, workshops, outreach activities, and community-building activities like dinners, socials, and group outings.[16]

In 1995, Carnegie Mellon University began an effort to increase females in CS. At that time, 7% of CS freshmen were women. They utilized the techniques identified in the previous two paragraphs and were able to change the face of computing at their institution. In just five years, they were able to increase the number of freshmen women from 7% to 42%.[17] This had a significant impact on the efficacy of gender-based recruitment and retention and was seen as a

possible solution to the "alarming decline of women's participation in CS" as discussed in the seminal article, "The Incredible Shrinking Pipeline."[18]

Women in Computing

The work done at CMU and their success in increasing both recruitment and retention of females in CS led to a number of other similar programs and quite a few studies on gender differences in CS.[19,20] In 2002, there was a special issue SIGSCE Bulletin entitled, "Women and Computing" dedicated to "understand and change the plight of women in the computing field."[21] "Unlocking the Clubhouse", by Allan fisher and Jane Margolis, in this journal, described the research study at CMU as well as the findings.[22] The research suggested institutional change in the areas of culture, curriculum, and support for women students. The changes in culture they suggested were to remove prior experience in programming as a requirement for entering students, and to broaden the perceptions of the field of CS by addressing the fact that success in CS is more than the one-dimensional view of the "boy hacker", and by stressing the idea that there are multiple valid ways to be a computer scientist. The curriculum change allowed for "multiple points of entry into the Carnegie Mellon computer science curriculum that allow students with widely varying levels of experience to enter courses with appropriate prerequisites, and to end up 'in the same place.'"[23] But the most significant and persistent change in the culture was in terms of support for women students. They found that "the lack of faculty relationships and mentoring relationships is one of the most common causes of women's drop in confidence"; and to enhance the social and educational experiences of women in CS, they established the Women in Computer Science Advisory Committee (Women@SCS) that holds a variety of events for women in CS "to encourage cohesion and lessen social isolation."[24]

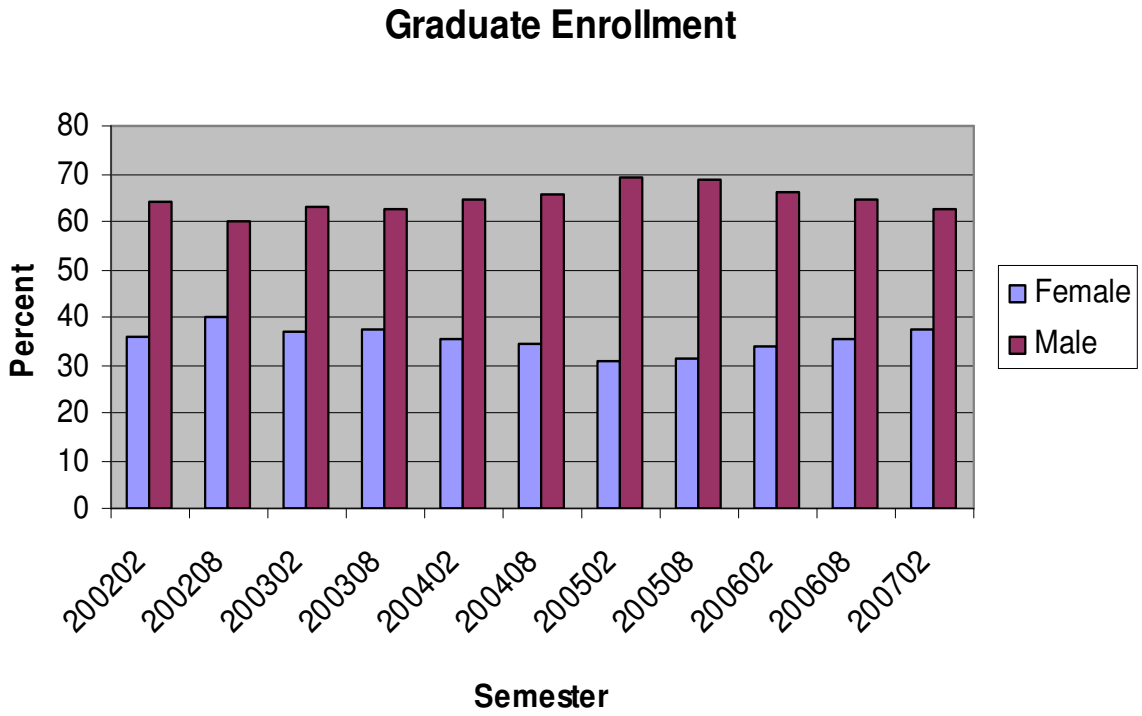
In June of 2000, the Computing Research Association's Committee on the Status of Women in Computing Research help a workshop entitled, "Recruitment and Retention of Women Graduate Students in Computer Science and Engineering" with the goal to "provide departments with practical advice on recruitment and retention in the form of a set of specific recommendations."[25] The workshop produced 20 recommendations including the following: provide bridging opportunities, review departmental publications for subtle messages that might discourage women applicants, give individual encouragement to women, actively counter negative stereotypes, provide women role models, be diligent at mentoring women students, create a peer community for women students, broaden the institutional culture of the department, and change the departmental infrastructure to promote equal participation of women.

Women in Computing at Southern Polytechnic State University

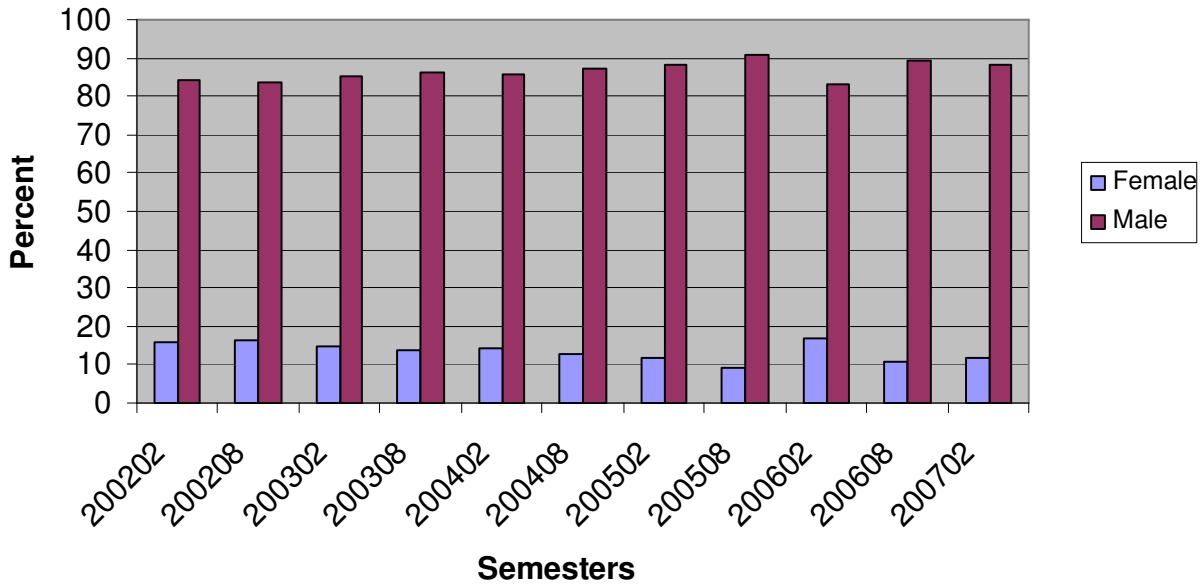
In preparation for a panel discussion I participated in at ASEE SE 2002 on underrepresented groups in computing and engineering,[26] I located the report from the CRA-W workshop identified above. Of the 20 suggestions the report identified, the 9 specific recommendations listed in the preceding paragraph were all implemented at my institution. Having seen cumulative data on females in computing in our School of Computing and Engineering, when I began research for this paper, I intended to espouse the successful results we had obtained during the last five years of recruitment and retention of women in the computing related disciplines after following the recommendations of the workshop. We have a female presence on our

campus with a female university president, 33% of the faculties in our School of CSE are women, and over the last five years in the School of CSE three women have been department heads and four women have had leadership roles in recruiting and advising as departmental Coordinators. We have these female leaders pictured on all of our department literature and they participate in recruiting events like open houses. We also have a Computing Women ACM group; the President sponsors mentoring events for women students; our School culture offers many different opportunities for different paths of study in computing related fields; we have several different bridging possibilities for entrance into our graduate programs; and we actively encourage our women students. As the Graduate Coordinator, my focus is predominately on graduate education, where our female student rates are higher than the national average.

According to the Taulbee study,[27] the average rates for female Master's graduate students in 2002 was 25%, in 2003 was 26%, and in 2004 was 25%. During the same time period, our female Master's students rates were well above the national average varying from 30.77% to 40.18%. Our female graduate rates can be seen in the following table.



But our undergraduate female rates are not so high, actually falling below the national averages. According to the Taulbee study,[28] the average percentages of Bachelor's degrees in computer sciences was granted in 2002 and 2003 was 18%, and in 2004 was 17%. During the same time period our lowest percentage was 12.93% in fall of 2004, and the highest was 16.31% in the fall of 2002. Our undergraduate female rates are noted in the table below.



In the course of locating this data, calculating it, graphing it, and comparing the graduate and undergraduate rates for this paper, it became clear to me that our efforts in recruiting and retaining women students in computing were not successful at the undergraduate level, which indicates that something else is going on to affect the graduate female rates. The fact that our efforts at making a female friendly computing environment seemed only to affect the graduate women, and did little to attract or retain undergraduate women, made me question my interpretation of the data. This uncertainty led me to do more research into both the literature and our enrollment data. What I found was that there is a current trend in the literature that paralleled my reservations.[29]

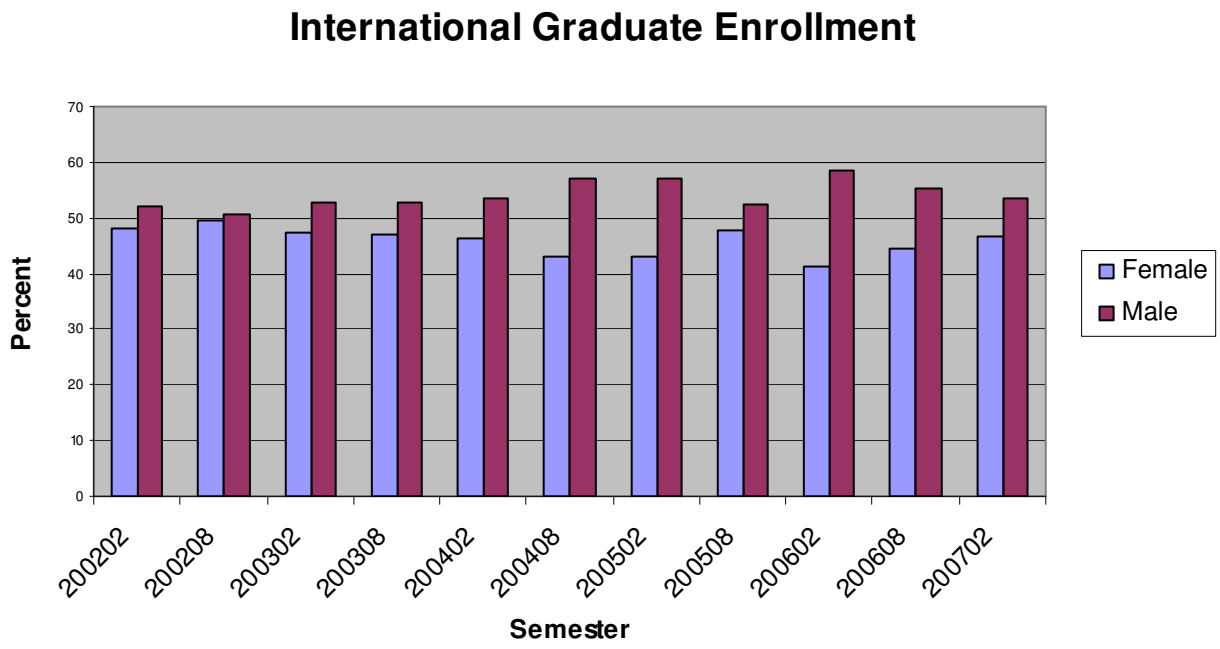
While the study done at CMU and the resulting changes did in fact, increase the number of females in computing, their contemporary work has led them also to question their earlier interpretation of the data as well as the efficacy of some of their implemented changes. Instead of focusing on gender differences, they now posit that the data about women's preferences and biases were actually based on the fact that there were so few women, resulting in a minority, which had more to do with the cultural differences than any actual gender differences.[30] This led to a general focus on gender differences, which in and of itself, by focusing on differences, was "self-limiting, self-sustaining, and self-fulfilling."[31] Now that there is more equity between the sexes, the initial supposed gender differences "tend to dissolve and gender similarities emerge when the environment becomes more balanced."[32] For example, the females in their initial study wanted to study computer science to be able to use the computer as a problem solving tool in other disciplines, whereas the males were more interested in programming and viewing the computer as a toy. Current data shows that both males and females view computer science as a problem solving tool to be used in other application areas and males and females in almost equal numbers enjoy programming and have high levels of confidence in their programming skills.[33]

So rather than focusing on the divisive question of gender differences, now the emphasis is on gender similarities.

This brings us to the role that culture, or even micro-culture plays on the decision to study in computing related fields. New studies show that it is actually cultural influences that account for the differences in female participation in computing.[34] Specifically, the actual improvements in the climate for women in their program were the result of the new "micro-culture" due to the increase of women at CMU and the socialization aspects of Women@SCS. Contrary to earlier assumptions that the increase in enrollment was a result of institutional changes including the forced curricular changes, which they now realize brought about an unplanned antagonism between the sexes, because the males thought the females were being given unfair advantages. Other studies show that the stereotypes of the "Computer Guy" as mentioned earlier, are localized to US culture and are not at all a global perception. Rather, in other cultures females are encouraged to study computer science by their families and their friends and computer science is viewed as a positive field for females to study.[35]

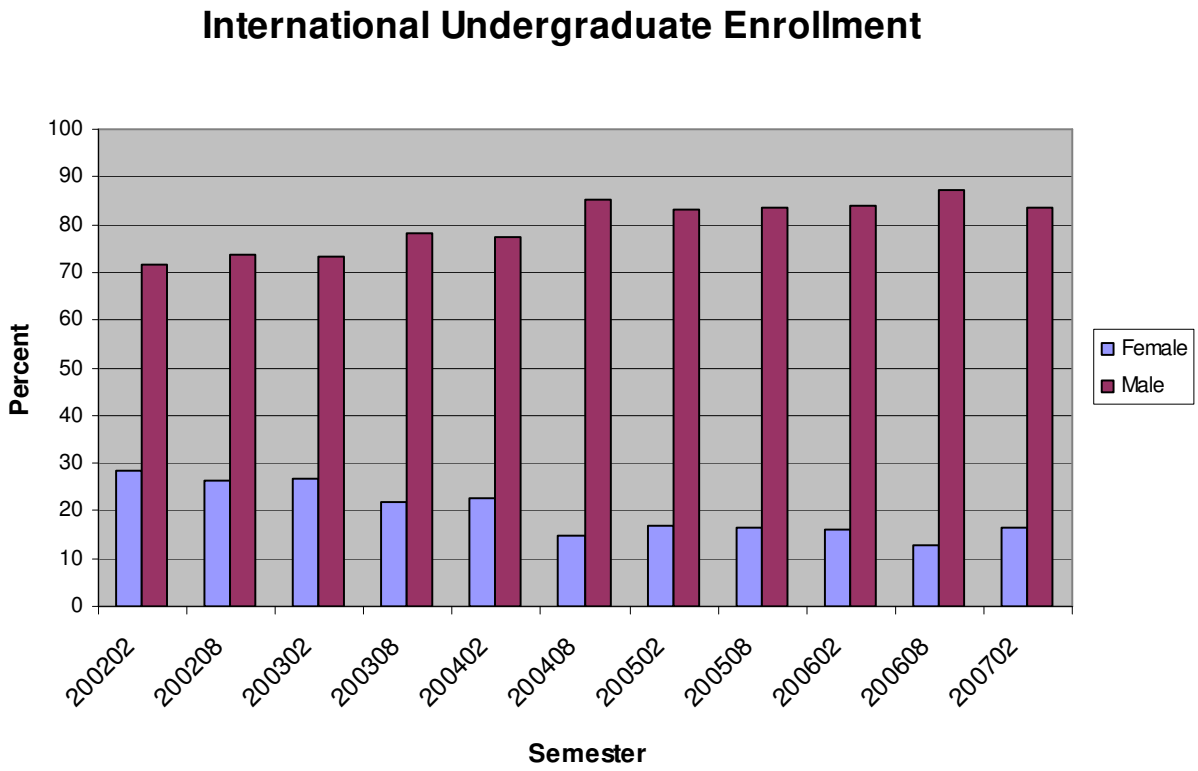
Finding this new research was the impetus for me to dig deeper into our enrollment data to see what role culture might have played in our high female rates. We have observed that a large percentage of our Master's students are international, predominately from India, but with China also being a fair contributor. As our university is in a large metropolitan area, we typically accounted for the females as being "trailing spouses" of their husbands who worked in the computing industry. Identifying this new research into the different cultural influences has made me doubt our earlier assumptions.

In studying the data on the ethnicity of our graduate students, an interesting finding appeared. The table below shows that we have had almost as many females as males during the last 11



semesters, with the highest percentage of females being 49.48% ranging down to a low of 41.38%. Comparing these rates to our overall graduate female rates, there are significantly more international females, which appears to indicate that there are cultural factors affecting women's decisions to study in computing related fields.

This led me to examine the rates of international females studying computing at the undergraduate level. My initial assumption was that if culture played such an important role, then there should be similar findings at the undergraduate level. This contradicted observational data, which was that we have fewer international women undergraduates. The actual data is displayed in the following table.



This table shows that over the last 11 semesters, the number of international females ranged from a high of 28.28% to a low of 12.7% of the undergraduate international students. Comparing that to the previous table of our undergraduate students, the number of international females is clearly higher than the overall rate of females, which over the 11 semesters, ranged from a high of 16.31 to a low of 9.23%. Thus the cultural influence does factor in, but that raises the question of why are there fewer international undergraduate females than their graduate counterparts? This question was tentatively answered in Adams et. al.[36] who studied Eastern cultures and found that in general, families are less inclined to allow their younger daughters to study internationally, whereas that is not the case with their male children. By the time those women have reached graduate school eligibility, the families are willing to let their daughters go abroad to study computing in American schools. My own findings support this research.

Directions for Future Study

While doing this research, I was surprised by my findings and ended up in a very different place than I imagined at the onset. However, these answers have left me with many questions. Specifically, I want to do an ethnographic study to confirm my assumptions that the differences in culture account for the higher number of female graduate students. Questions arise about how these female students were influenced to study computing, how their friends and family view their decision, whether there is a CS stereotype in their culture and if so, what it consists of, whether they are concerned about balancing family and career, and if they feel part of a female-CS culture. I also want to include the male international students in the study to see how they view CS and what their perceptions of females who study in computing related fields are. Finally, it will be interesting to compare the results from the different international cultures to find the similarities that are shared around the globe and those that conflict with American perceptions. The results of this type of study have widespread potential for recruitment as well as for affecting change in our own culture.

Summary

This paper examined the myriad issues surrounding recruitment and retention of women in computing sciences. It explored early studies in gender-related differences contributing to the under-representation of women in CS and considered a range of social factors that may affect the deficiency. Specific techniques that have proven effective in changing the recruitment and retention of women in computer science in the last decade were presented and a hind-sight analysis of their findings was explored. The latest research in the role that culture plays on one's decision to study in computing related fields was examined. It was posited that cultural influences rather than gender differences account for the differences in female participation in computing related fields. Finally, historical enrollment data from my university was presented and analyzed to try to identify what elements may have contributed to the fact that our programs exceed the national average of women students in computing sciences. The findings show that while our graduate programs have more females than the national average, this is probably attributable more to our high numbers of international female graduate students than to our "female friendly" environment.

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