AC 2010-1838: RECRUITMENT AND RETENTION OF WOMEN IN COMPUTER SCIENCE & ENGINEERING

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Recruitment and Retention of Women in Computer Science & Engineering

Abstract

Today, an important issue in academics is the need to increase the participation of women in engineering and science. It is well known that women are significantly underrepresented in the scientific fields of the world, and computer science is no exception. The percentage of female graduates in our Computer Science and Engineering (CSE) department is 2.2% while the national average percentage of Bachelor's degrees in computer science which was granted to females in 2007-2008 is 11.8%[28]. Clearly, the representation of women in our Computer Science program is far lower than the national average.

There are several reasons for attracting women to computer science, including the fact that more than 50% of consumers are women. If those designing products are able to relate to the female section of the population, there is a better chance of selling the products. Industry needs women designers. In addition, female perspectives can be very useful in improving the work environment. Women excel in verbal and interpersonal skills and are very good collaborators[29].

This paper presents the study of different approaches that are used by different colleges and universities for recruiting and retaining women in computing. This paper also addresses the low enrollment in our computer science department and the reason that our female enrollment is lower than the national average and how we should go about fixing this issue.

Introduction

There are many studies spanning decades related to the issue of gender in engineering and computer science. Social influences, family influences, peer influences, fundamental psychological differences, and motivational issues have all been broken down, dissected, and researched on numerous occasions. Typically, solutions call for [8, 9, 10]:

- Improved mentoring.
- Increasing student exposure to professional women in computer science and engineering.
- Providing a better sense of opportunities in computer science and engineering to young women.
- Big sister programs.
- Attempts to promote a larger feeling of belonging among the community of women involved in computer science and engineering.

Studies have suggested the implementation of new improvements to curriculums, yet enrollments of women in computer science have continued to decline[12, 13]. More recent studies have begun to outline fundamental differences in the ways young women think versus the thinking process of young men with regard to their careers, contributions to society, fundamental views of technology, and motivations behind choices and education [8, 11].

A young woman's view of computers and their usage is much different from that of a young man's. Experience also differs significantly between young women and men entering college[5, 10]. Usage of computers in areas such as word processing is similar for boys and girls entering college[5]. However, a higher percentage of boys entering college have been exposed to programming and are more proficient at tasks such as moving files back and forth[5].

Girls are far more hesitant to enter computer science programs because of their inherent feelings for potential success in the field[4, 13], their view that computer science is masculine in nature, and that the culture associated with computer science is not one that they want to be associated with[11]. They also have a very difficult time seeing the applicability of what they learn in computer science to their long-term goals and interests[15].

While comparing computer science programs to biology programs it was noted that academic rigor requirements between both disciplines are similar as they both require mathematics lab-based science works such as physics and chemistry, and are closely tied to particular careers. Both disciplines are evolving rapidly and require students to stay on top of new technologies. In the schools studied, biology enrollments by females were equal to or higher than male enrollments while enrollments of females in computer science in these schools continued to drop[7, 9].

Reports from the National Science Foundation (NSF) indicates that there is a "troubling decline in the number of US citizens who are training to become scientists and engineers, whereas the number of jobs requiring science and engineering training continues to grow"[1]. It is crucial that more students are attracted to science and engineering fields in order to prevent creating a significant shortage of qualified workers in these areas. In 2004, the U.S. graduated 70,000 undergraduate engineers, while China and India graduated 600,000 and 350,000, respectively (U.S. Department of Education, 2006). Women make up 46% of the available workforce [2], but less than 20% of computer scientists are women[28]. Increasing the number of women computer scientists' and engineering graduates is a way of increasing the total number of qualified workers.

There are two techniques for increasing the number of graduates in computer science and engineering:

1. Increasing the number of students entering into the programs.
2. Decreasing the number of students who leave the programs.

The number of students entering a program can be increased by applying effective recruitment activities while the number of students leaving a program can be decreased by employing retention techniques. The following is a study of different retention and recruitment activities that is employed by different institutions of higher education to retain and recruit computer science and engineering students.

Retention Activities at Michigan State University & Lansing Community College

The College of Engineering at Michigan State University (MSU) and Lansing Community College have received grants from NSF to ease the transition of high school students into engineering undergraduate programs. Their Engaging Early Engineering Students (EEES) project consists of four content subprograms[22]:

1. "A program to provide formative assessments in the key courses with follow-on 'bootstrapping' tutorials.

2. A supplemental instruction program which is called the PAL (Peer-Assisted Learning) subproject.

3. A program to directly engage engineering faculty with early engineering students.

4. A program to develop and exploit course material from one key course in another."[22]

Over the last three years they have initiated an aggressive recruitment program that has been successful in recruiting more students to their program. A review of their enrollment and graduation statistics over the last decade indicates that their most vulnerable period of loss is the interval between the time a student enters their program and the time the student completes the second calculus course[22]. Thus, their goal is to increase retention of early students.

Another goal of this program is to increase the number of women who graduate with baccalaureate degree in engineering, with a specific focus on the two largest engineering disciplines with the lowest women enrollments, electrical and mechanical[25]. In order to achieve their goal, they are working with 14 engineering departments (4 electrical, 10 Mechanical). They have provided them access to experts in gender equity research as well as small grants for project development. Many have chosen to reach out to high school girls to encourage them to enter into engineering fields, while others have provided faculty training in gender equitable teaching[25].

The EEES project at MSU is six months into a five-year project and they have not published any results yet. The goal of this project is to increase retention and consequently graduation rates in their university[22]. It will be interesting to see how successful this project is.

Recruitment & Retention Activities at Texas A & M University – Corpus Christi

At Texas A & M University, they have put together a team of recruiters consisting of undergraduate students and a graduate student who serve as the supervisor of the recruiters (undergraduate students)[19]. This program, which was supported by an NSF grant, was successful, and their enrollment increased by 14%[19].

At Texas A & M University, the percentage of female students has ranged between 18% to 30%. In order to retain their students, they have put in place two programs[19]:

1. "Undergraduate research fellowship – 15 fellowships awarded each semester, each paying $1000.00. The result of this program has been positive in several aspects. First, it helps students financially so that students don't drop out of the program because of financial problems. Additionally, this program increases student involvement in real, hands-on research.
2. The second program involves using students as peer-tutors for students who are struggling in their program."

Implementation of these programs at Texas A& M University has been successful in recruiting and retaining students in their program.

Recruitment and Retention Activities for the Rio South Texas Region:

The Rio South Texas Region, composed of seven counties in South Texas, has traditionally experienced unemployment rates significantly higher than state and national averages[16]. The University of Texas -Pan American (UTPA) and South Texas College (STC) have received funding from the Department of Education to facilitate student engagement and success in STEM (Science, Technology, Engineering, and Math) areas. Their initiative focuses on four activities which are[17]:

1. "Enhanced Student Service – STEM Orientation and Mentoring Program and STEM Calculus I Student Assistant Program.
2. Curriculum Reform – Curriculum development based on Challenge- Based Instruction (CBI) in selected key courses.
3. Faculty Development – Faculty development seminars and workshops on CBI
4. STEM Pathways Growth and Support – Dual enrollment programs at STC."[17]

Recruitment and Retention Activity at Georgia Institute of Technology

In one insightful experiment conducted at Georgia Institute of Technology[15], the computer science department created an introductory course parallel to the traditional CS1 (a standard designator for the very first class in computer science) course that had at its core topical material naturally of interest to women: introduction to media computation. Coursework involved using computers to manipulate and create media. Although the course and assignments focused on media, instructional objectives of assignments were similar to those in the traditional CS1 course. Enrollment by females was high, retention of females during the course was high, and 89% of the students (two thirds female) completed with a grade of C or better.

Young women do not want to be part of, or associated with, the perceived culture of computer science. Their views of computer science are very narrow, and they do not see how it applies to their interests and what they hope to accomplish in life. However, when properly introduced, these same young women compete favorably with their male counterparts in upper division computer science courses.

Success in CS1 is critical to retention of females in computer science. Currently, females fail at a higher rate in CS1 than that of males[14]. However, the same research has shown that once females get through the coursework their success rate in upper division CS courses is equivalent to that of males[9].

Recruitment Activities in Northern Arizona University:

Northern Arizona University (NAU) has developed and implemented a Summer Technology and Engineering Program in addition to a University Preview (STEP UP) camp for high school age female students. According to their paper, this camp was very successful in helping young women make their decision about entering engineering fields.

Retention Activities at Rochester Institute of Technology:

The Rochester Institute of Technology has started a Woman in Technology (WIT) program in 2003 to help retain female Engineering Technology students with the goal of increasing the number of female graduates of their Technology programs[20]. Their program consisted of four supportive activities for the first three years:

1. "Study groups facilitated by adjunct faculty
2. Peer tutoring by juniors and seniors
3. Purchase of academic laboratory kits for the first and second year students
4. Support for students attendance at the Society of Women Engineers (SWE) national conference."[20]

Since 2003, retention of their first-year women students has increased from 84% to 96%. In 2007, they developed a new program that consists of a mentoring network, quarterly socials for faculty and students, tours of local companies and a Girl Scout Badge workshop[20].

Recruitment and Retention Activities at the University of North Texas

The University of Texas has designed a three-part plan to achieve their recruitment and retention goals[23]:

1. "Sponsorship of portable and mobile summer computer engineering robotics camps for middle and high-school women students, coordinating with regional Girl Scouts councils and other organizations to help with recruitment.
2. Creation of an Ambassador program using young women currently enrolled in the upper division of current computer science and computer engineering programs as a form of outreach to area high schools and junior colleges.
3. Expansion of their successful undergraduate mentoring program by using the Ambassador cohort mentioned above as mentors for incoming freshman and first-year transfer women entering their programs."[23]

The university has developed a mobile laboratory so that the summer camp can be held at several locations. Their ambassador and mentoring programs are derived from the fact that recruitment

and retention can be improved by providing opportunities to develop student-to-student relationships. Their camp enrollment was limited to young women in the ninth, tenth, and eleventh grades. Their department has experienced a steady growth in the number of women and minorities after putting in place these programs. In three years, the number of their female students increased by 61.04%. The percentage of women students increased from 11.5% to 16.39%[23].

Recruitment Activities at University of Texas, Arlington

The University of Texas at Arlington has created recruitment program where the recruiters are their own students[24]. The majority of their recruiters are female. Their goal for having peer recruiters is to connect better with their prospective student population. They have two peer recruiters per undergraduate engineering department for a total of 10 student ambassadors each semester. Part of the impact of female engineering peer recruiters is to break down stereotypes about engineering and who can be an engineer[24]. Research has shown that stereotypes about engineering and computer science turns women away from those careers[24], so by having female recruiters as role models they are encouraging women to consider engineering as a viable career choice. Their data does not show enrollment growth; however, their student recruiters can benefit from this program by broadening their knowledge of engineering and practicing on their communication skills.

Women in Computing at Southern Polytechnic State University

At Southern Polytechnic State University, their female Master's student's rate in 2002 to 2004 ranged from 30.77% to 40.18%, which is well above the national average[21]. On the other hand, their undergraduate female rates are falling below national average. In a study done by Duggins on the ethnicity of their graduate students, she found that they have a significant amount of international female students. She is contributing their high rate of females in their graduate program to the participation of international female students in their program and is not because of a campus atmosphere that is necessarily attractive to females. From her findings it appears that culture plays an important role in one's decision to study computing related fields. It seems that culture rather than gender differences accounts for the differences in female participation in computing fields.

Universities are using different techniques for recruitment and retention of their female students. Efforts at recruitment and retention should be part of any comprehensive education program.

Background Information:

Utah Valley University (UVU) is a state institution with 23,840 students of which 13,606 are males and 10,234 are females. UVU is located in Utah County which has a population of over 430,000 residents, 78% of which are members of the Church of Jesus Christ of Latter Day Saints. Figure 1 indicates the female enrollment trends at UVU. From this figure, it can be seen that the percentage of female students in the university is around 43% since 2002. Nationally, more women (57%) than men enroll in college[28]. In our university, 43% of students are female which is lower than the state of Utah's average, which is 49%[30].

Enrollment Trend at UVU

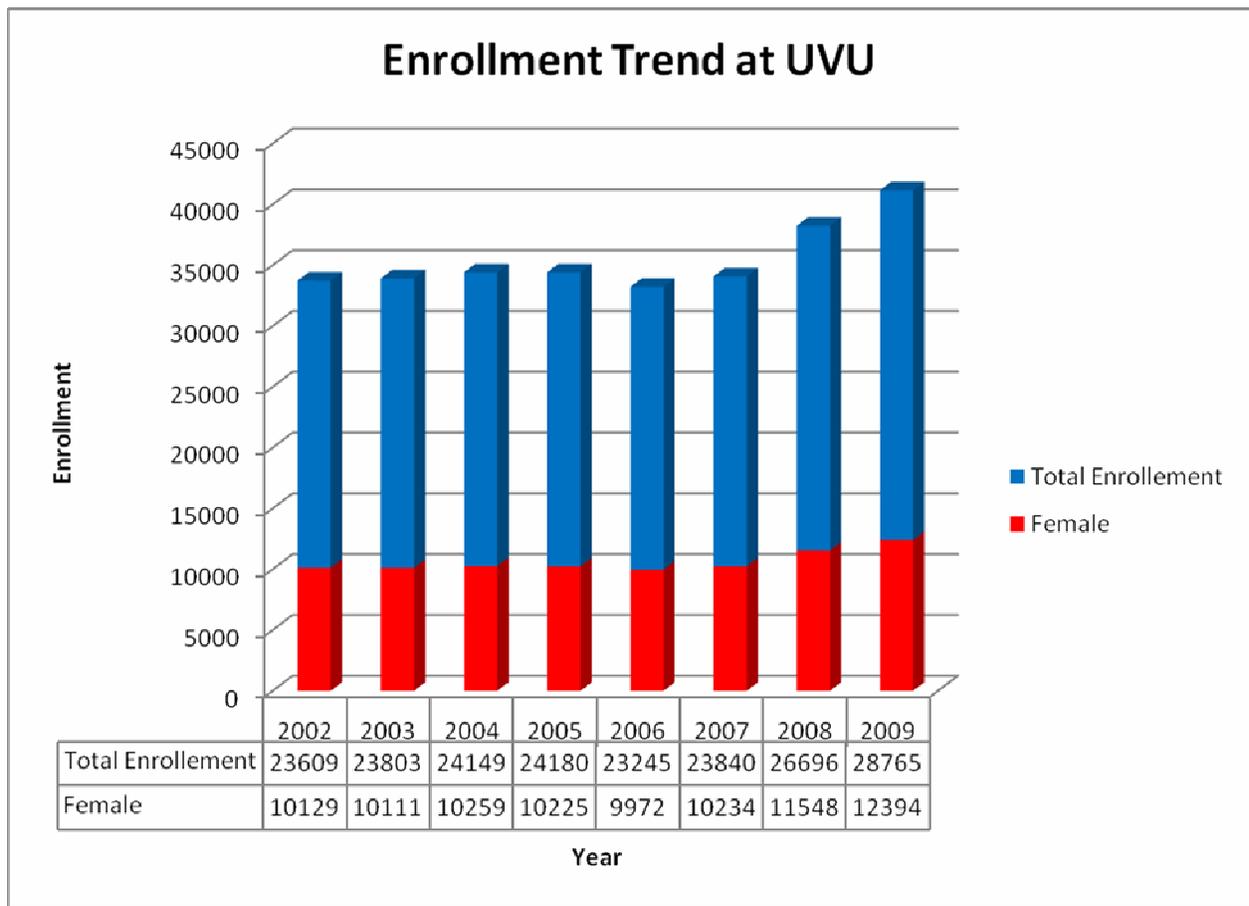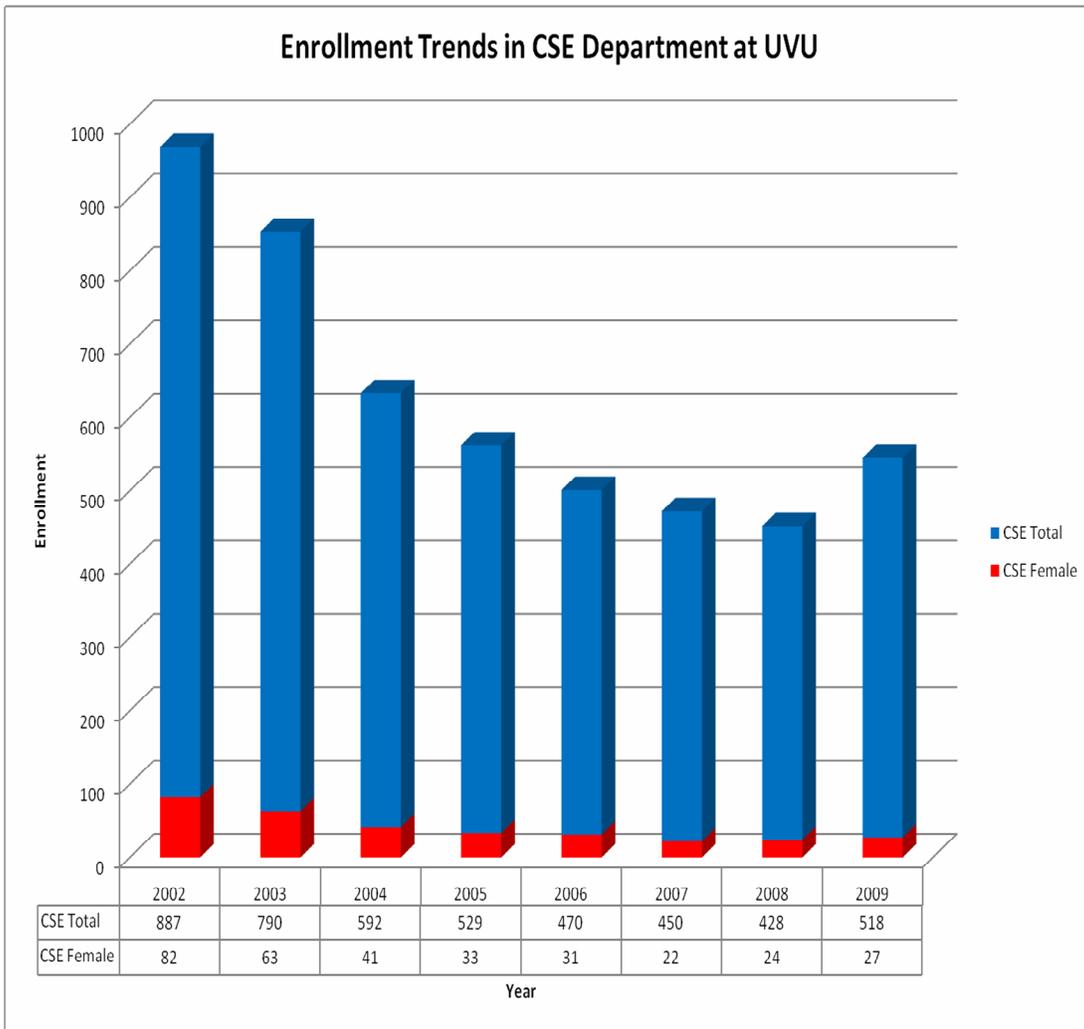|	2002	2003	2004	2005	2006	2007	2008	2009
Total Enrollement	23609	23803	24149	24180	23245	23840	26696	28765
Female	10129	10111	10259	10225	9972	10234	11548	12394

Figure 1. Enrollment trends at UVU.

The Computer Science department at UVU offers a Bachelor's Degree in Computer Science with four areas of specialization: Computer Science (traditional), Computer Engineering, Database Engineering and Computer Networking. The Bachelor of Science in Computer Science program was one of the first Bachelor of Science programs implemented at UVU in 1993. The program's goal has been to provide a quality program that meets accreditation standards while providing the students with a skill set that allows them to succeed in computing careers. The curriculum content for the Computer Science degree is based on the 2001 ACM Curriculum Report. The Computer Science degree at UVU was accredited by Accreditation Board for Engineering and Technology (ABET) in 2002 and currently has more than 500 students. The female enrollment trends of the Computer Science and Engineering department are given in Figure 2. The percentage of female students in the department was more than 9% in 2002 and has a decreasing trend, and in 2009, has been reduced to 5%. Figure 3 summarizes the number of female students who have been graduated from the CSE department. From that figure it can be seen that the number of female graduates in the CSE department has been decreased from more than 5% in 2002 to 2.2% in 2009.

Enrollment Trends in CSE Department at UVU

Year	2002	2003	2004	2005	2006	2007	2008	2009
CSE Total	887	790	592	529	470	450	428	518
CSE Female	82	63	41	33	31	22	24	27

Figure 2. Enrollment trends in CSE Department at UVU
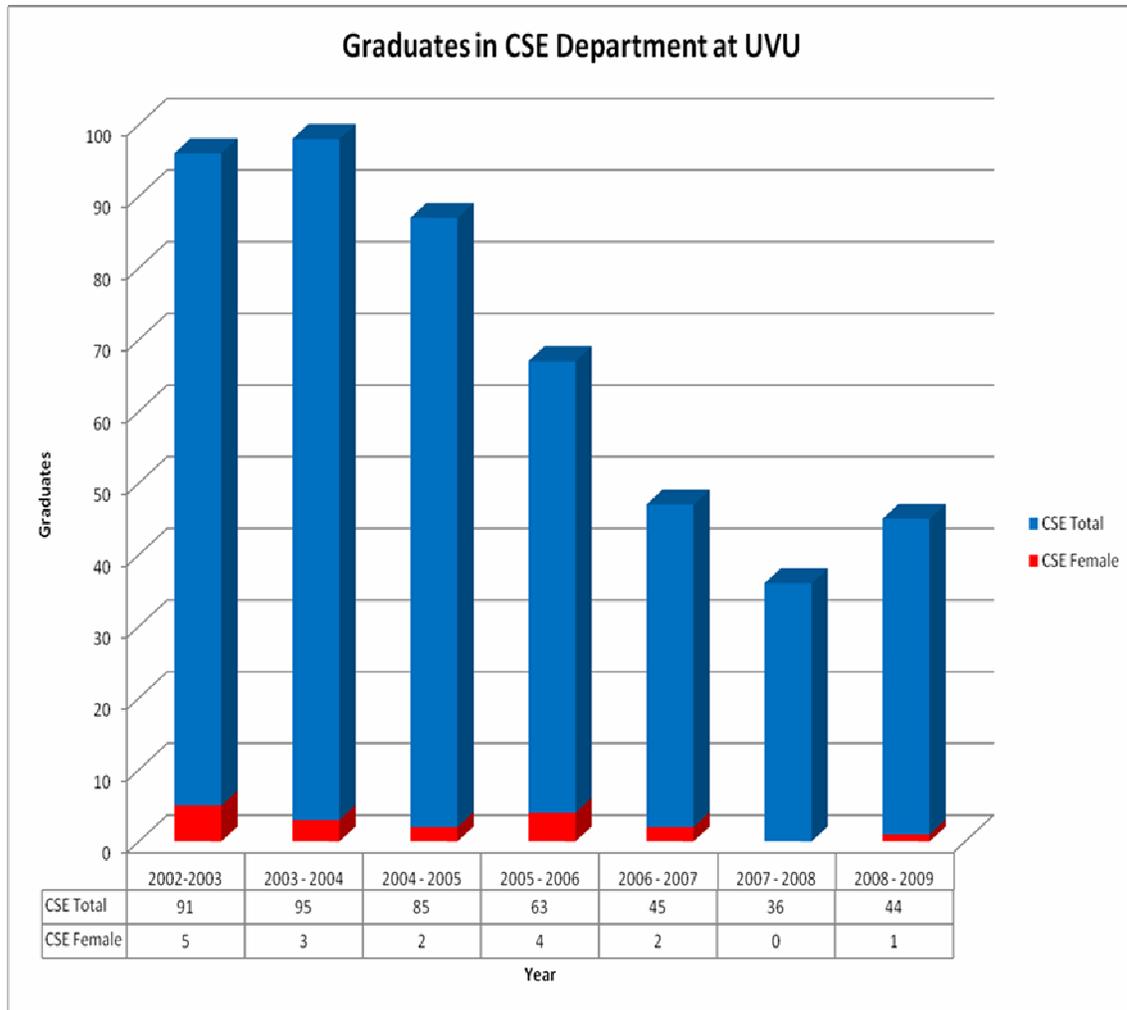
Figure 3. Graduates in CSE department at UVU.

The chart shows the following data:

	2002-2003	2003 - 2004	2004 - 2005	2005 - 2006	2006 - 2007	2007 - 2008	2008 - 2009
CSE Total	91	95	85	63	45	36	44
CSE Female	5	3	2	4	2	0	1

Recruitment and Retention Activities at Utah Valley University

The percentage of female graduates in our CSE (Computer Science & Engineering) department is 2.2% while the national average percentage of Bachelor's degrees in computer science granted to females in 2007-2008 was 11.8%[28]. Clearly, the underrepresentation of women in our computer science program is worse than the national average. In our computer engineering area of specialization we don't have any female students and we have never graduated a single female student in this track. This under-enrollment of females in our computer science program is of great concern to our department faculty and administration. Many efforts have been made to recruit young women into computer science through organizations and events such as Expanding Your Horizons annual conference, Women in Technology, high school visits, literature, scholarships, and more active mentoring of female students. However, all of these efforts have failed to achieve significant results.

At a time that 57 percent of B.S. graduates are women in the United States[29], only 11.8 percent of graduates are women in the computer science field[29]. In a paper by Adams[26], it is indicated that the percentage of female graduates in Mauritius, a developing country is 48 percent in computer science and engineering. In Greece, approximately 50 percent of computer science graduates are women. Statistics from Iran, which is also a developing country, show that the number of female graduates in engineering in 2000 - 2001 was about 30 percent, and the percentage of graduates in computer engineering in 2000 – 2001 was about 40 percent[27]. Studying these numbers makes one wonder if culture is the cause of interest or lack of interest in computer science and engineering by women? More studies are needed to identify these cultural differences. Understanding why women in those countries are choosing computer science or engineering is going to help us understand why United States women are not choosing computer science as a major.

One of the authors has conducted a study for two consecutive years at our annual Expanding Your Horizons (EYH) conference. Every year UVU sponsors an EYH event where young women from high school and junior high come up to the University and attend various workshops oriented towards expanding their views of available careers and education paths. He has developed a workshop for high school and middle school female students. In 2009, he designed an exercise for these students called button-button. In this game, an image of sewing buttons is hidden under one of six boxes. These boxes briefly (20 ms) flash pink in a random sequence ending with the box that has the button image hidden under it. If the player relaxed and watched the sequence of flashes, they are accurately able to select the box with the button hidden under it. If they consciously try to follow the sequence, they lose track of it and fail to find the button. When he presented this exercise to 30 young women that attended they were much more interested in redesigning his game board layout (e.g., box size, background color, box location, etc.) than what was going on underneath. They did enjoy playing the game but as a positive experience in programming he was not very successful.

So, for this year's workshop he got help from two mature female college students from majors other than computer science to help him redesign the exercise. The exercise that these female college students come up with was involved matching optimal clothing colors to a person's natural appearance. When presented to the young women attending the EYH that chose to participate, they had a very positive experience. They also really liked the program and related immediately to what the program did and how it worked. This second attempt was much more successful than the first attempt.

In the next phase of this study an attitude survey will be developed and administered before the exercise and again after the exercise to measure the extent that their views were improved of computer science as a potential major. As soon as an IRB approval is obtained, we will be taking our exercises out directly to high schools each semester so that we can have more participation and cover more materials.

The motivation for this research was to find a solution to our serious problem by reviewing the literature. Authors believe that our low enrollment in computer science and engineering has to do with the culture of the area. In order to increase the participation of women in our program the following actions are recommended:

- Create an ambassador program using students currently enrolled in our program to recruit high school students.
- Develop summer camp activities for high school and middle school students.
- Provide scholarships to women.
- Using students as tutors for students who are struggling in our program.
- To retain our female students design a CS1 course especially for women. This course should be free of what has been masculine in its perception and addresses interests and entry skill levels of young women.
- Place strong teachers in introductory and preparatory courses.
- Integrate students into research culture as soon as possible.
- Build peer communities and foster a sense of belonging.
- Provide relevant role models.
- Be aware of gender-based perceptions.
- Understand own biases and unconscious preferences.

The author's are going to continue with their recruitment activities and try to integrate as many as the above recommendations into their program.

Summary and Future Research

This paper explored the issue surrounding recruitment and retention of women in the computing sciences and suggested recommendations that might improve recruitment and retention of female students in the computer science programs. Women are significantly underrepresented in computer science programs. Studies show that cultural influences are the cause of differences of female participation in computing[31]. The authors believe that culture might be the cause of the problem and more studies are needed to confirm this fact. Under-representation translates into loss of individual opportunity, talent to the workforce, and creativity in shaping the future of society. If the United States is to remain competitive and continue to thrive in the competitive global market, it must draw on all of the talents in its population.

The underrepresentation of women at UVU's CSE department is worse than the national average. In order to increase the participation of females in their program, the authors are going to integrate recommendations suggested in the previous section in their program and then report on success or lack of success of this integration. They are going to develop a recruitment and retention plan for their department. This will require prioritization of the activities suggested in the previous section and a commitment by the department and the university.

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