THREE KEY INGREDIENTS OF SUCCESSFUL INTERVENTION PROGRAMS DESIGNED TO ENCOURAGE GIRLS TO STUDY AND SUCCEED IN COMPUTING: MAKE IT REAL, MAKE IT COOPERATIVE, MAKE THEM CONFIDENT

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Abstract: This paper describes intervention programs that were designed to encourage girls to study computing and to succeed in computing. The programs include a course called "Bridges" to be taken concurrently with calculus that helps computing students with the subject matter and also demonstrates the relationship between calculus and computing. The second intervention is a freshman seminar designed to recruit women computing majors and to help interested women build computer skills and confidence. The third intervention is a tutoring in programming project. All of these interventions put into practice three key ingredients that help women succeed in computing: 1- Use real-world applications, 2- Implement cooperative learning and 3- Build student-confidence.

Keywords: *Female intervention programs, Cooperative learning, female retention, female self-confidence, recruiting females, female success in computing*

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INTRODUCTION

We at Stockton College have been fighting the same battle that Computing Departments have been fighting across the United States, which is an overall decrease in enrollments with a bigger percent decrease in particular for women. In fact, the number of female CS (Computer Science) majors is at a historic low in spite of the fact that the majority of college students today are female (Patterson, 2005). In 2003, Stockton College had 384 CSIS (Computer Science and Information Systems) majors. Now we have 137 majors and only 12% are female.

Powell (2008) said that all science and engineering majors have experienced a steady increase in female participation over the past twenty years except for computer science. In Powell's study she investigated what Penn could do to support women's persistence in the computing areas. That challenge remains the same for every computing department in every college. This article describes several intervention programs introduced by Stockton College designed to encourage women to study computing and to remain and succeed in computing.

Generally speaking, interventions that help females also help minorities. And research shows that these special interventions do not hurt white males and may sometimes even help them. Therefore, we have a win - win situation. Interventions to help women do not hurt anyone and usually help everyone. Powell (2008) found this to be true, that some of the same problems that deter males also deter females and the solutions that help females also help males.

Two of Stockton's interventions have been in the form of special courses: "Bridges Connecting Computer Science and Calculus" and "Women in Computing." The third intervention implemented at Stockton was Peer Tutoring in Programming. All three interventions include three key ingredients that encourage female success: 1- Present topics with real-world applications, 2- Emphasize cooperative learning and 3- Build self-confidence.

REVIEW OF THE LITERATURE

As of 2008, more women work in professional and related occupations than men. However, only 9 percent of female professionals work in the high-paying jobs in the computer and engineering fields compared to 45% of the male professionals (Bureau of Labor Statistics, 2008). Educationally the percentage of women earning a bachelor's degree in computer science has dropped from 19% in 2001 to 11.8% in 2006-2007 (CRA, 2008).

At the same time the need for computer professionals is increasing. The U.S. Bureau of Labor Statistics (2008) released projections of the fastest growing jobs. It predicts the following growth by 2016: Database Administrators- 29%, Computer Systems Software Engineers- 28%, Network Administrators- 27%, Computer Applications Engineers- 45% and Network Systems Analysts-53%.

Intention of women freshmen to major in computer science was 0.4% in 2006 compared to 3.0 % of the males (NSF, 2007). 15% of all students who took the AP computer science exam were female which was the smallest percent of females for any AP exam (NCWIT, 2007). Female Associates Degrees went from 35,789 in 2003 to 24,345 in 2006, and 15,190 females graduated with a Bachelor's degree in Computer Science in 2003 compared to 8,852 in 2006 (NSF, 2007). Therefore, the supply of female computing majors is going down and appears will continue to go down, while the demand is going up.

Numbers is not the only reason why the computer fields need females. If there is not diversity of thought when developing computer products, all users' needs will not be met. Products designed by one group of people may not be as appealing or useful to multiple groups of people (Peckham, 2007). In order to develop products that are favorable to all people, it is necessary to have all people represented on the design team.

So what can be done to embed diversity of thought into our computer products? Why are we losing females from the computer field? And what can we do to change this? The answer lies below the surface. What makes females tick? What motivates them? What makes them feel comfortable? What do they care about?

MAKE IT REAL

Many studies have indicated that females prefer real-world applications as opposed to abstract ideas.

Women care more about how they can use a computer to accomplish something rather than what goes on inside the computer (NCWIT, 2007). Barker (2009) pointed out that concepts presented in pleasing contexts, related to a student's interest is a positive force for female retention. Carter (2006) tells us that freshmen are attracted to Computer Science when they are properly introduced to it. A proper introduction for females includes making computers relevant to society and their own lives as opposed to studying computers in isolation which males are more likely to prefer (Treu, 2002).

It is important to women that assignments have social relevance (Barker, 2009). They want to help themselves, help society, and help the world. Altruistic people are good for the world. That is another important reason to increase the number of women in computing. A healthy society needs them. Therefore it is necessary to make real-world application based connections if we want to motivate women to major in computing.

MAKE IT COOPERATIVE

Shimazoe and Aldrich (2010) point out that despite success at the K–12 level, cooperative learning has struggled to catch on at the college level. They (Shimazoe and Aldrich) are surprised by this because of the many benefits, which they list, provided by cooperative learning such as social skills, critical thinking skills and deep learning of materials. Other benefits of collaborative learning that are extolled in literature include the development of peer networks, greater retention in the major and improved learning (Barker, 2009).

In Barker's study (2009) of factors that influence Computer Science students in introductory courses to persist in the major, student-student interaction was the strongest predictor. Cooperative learning promotes positive peer interaction. And this in turn contributes to a feeling of belonging that can help overcome stereotypes and develop support groups (Barker, 2009). This is especially important for females because there are so few of them in most computer classes.

Beck (2005) found that students in a cooperative learning group performed much better on exams than a control group and it was particularly beneficial for women and non-white students.

Powell's study (2008) confirms the benefits for students exposed to frequent interaction with other students.

Klawe (2009) and many others point out the benefits of pair programming which is a form of collaborative learning. The benefits include that a woman is more likely to complete the course, obtain a better grade, and take another CS course. Men can also benefit from pair programming as well as other forms of cooperative learning. Since cooperative learning clearly benefits females and minorities and does not hurt males, cooperative learning should be used to equalize the playing field.

MAKE THEM CONFIDENT

Previous programming experience obviously benefits students in an introductory programming class. Those students without experience quite often perform poorly, lose their confidence and drop the CS major (Barker, 2009). And more often than not, those with less experience are female. According to Carter (2006) who surveyed 836 high school students, 40% of the men had at least one formal computing class compared to 27% of the women. When the students were asked if they took more than one class the results were yes for 13% of the men and only 3% of the women.

What can be done to retain the less experienced students (mostly female) in the computer major? One answer is obvious, design a kinder, gentler, first programming course. At Penn a new course was designed for students with little previous programming experience. It is a slower paced course which gives students time to gain skills and build their confidence (Powell, 2008) before they join the other students in more rigorous programming courses.

If one is not able to introduce a new gentler programming course then update the school's present course to make it more female friendly. As it has been said, "The devil is in the details." Carefully go over items such as the details of the operating system, file management and organization, and the use of peripheral devices (Treu, 2002). This will help to build confidence in the less experienced students. When students are properly introduced to computing, they become attracted to it and may even change their major (Carter, 2006).

Self-perception of skill proficiency is a predictor of success and retention in the computer major (Powell, 2008). However, if a student is a part of an underrepresented group which has a stereotype that predicts members of that group will do poorly, it tends to become true (Peckman, 07; Barker, 2009; Powell, 2008). These stereotypes decimate their self-confidence. Therefore, it is necessary for faculty to reverse this decimation if we are going to build up these underrepresented groups. We need to insure that females have high self-perceptions of their skills that are necessary for a computer major if we want them to pursue a career in the computer field.

Providing positive role models for our female students is another practice that can be used in order to build self-esteem. At Penn (Powell, 2008) mentoring was implemented by both faculty and peers. MentorNet (2008) surveyed approximately 2,500 science, technology, engineering, and mathematics (STEM) undergraduates, graduate students, and postdoctoral scholars to find out how they felt about mentors. All STEM students considered mentoring important but almost 40% of the respondents reported that they were not encouraged by anyone to find a mentor. More females compared to males rated mentoring important to them. Females were also more likely to report an absence of mentoring and they cared more about same-gender mentoring. It is interesting that in this same study females were significantly more likely to report a lack of confidence in their choice of major.

In a previous article (Gerhardt, 2008) the author listed the attributes that were found in the literature that contributed to success for women in computing courses. These attributes were categorized into three key ingredients which were described above: 1- Present topics with real-world applications, 2- Emphasize cooperative learning and 3- Build self-confidence. The following sections will describe intervention programs that were applied at Stockton which implemented those key ingredients.

INTERVENTION STRATEGY- "BRIDGES CONNECTING COMPUTER SCIENCE AND CALCULUS"

Barry Cipra stated that "at some institutions as many as 50% of the students enrolling in Calculus either fail or withdraw from the course (Cipra, 1988)." Walsh (Walsh, 1987) agreed that in some institutions, particularly large ones, the proportion of students who do not satisfactorily complete the course can be 50% or more. Professors at Fresno State estimate that 66% of the students fail calculus (Borba, 2005).

Why is the success rate so low for Calculus? What makes it difficult? Douglas (Douglas, 1986) wrote that, "Calculus is difficult because Calculus is difficult." Unwieldy textbooks that have continued to place the emphasis on rote and repetition, unmanageable class sizes, and unmotivated students and faculty are also listed by the literature as some of the problems with Calculus instruction (Cipra, 1988). At Fresno the reasons stated for low scores were lack of preparation from high school, poor study habits and the rapid pace of the course (Borba, 2005). A senior at Fresno majoring in economics said that many students are afraid of calculus.

Stockton was no different than other colleges, many of our students, particularly the Information Systems majors struggled with Calculus. As an advisor, as well as a professor at Stockton, the author had many opportunities to speak with students concerning why they failed calculus. While no hard statistics were collected, this is only anecdotal information, males generally would say that they failed because something was wrong with the professor, their car was acting up that semester, their mother had a health problem, or something else not directly related to them. However, more often than not, when a female failed the course she generally blamed herself. She would say I was never good in math, I cannot do it, and I want to change my major. I saw males fail calculus two and three times but they did not give up. Quite often if a female failed it once, she ran, did not look back, to another major.

Since many of our students struggled with Calculus, we designed an intervention program with the three key ingredients mentioned above: 1- Present topics with real-world applications, 2- Emphasize cooperative learning and 3- Build self-confidence. "Bridges Connecting Computer Science and Calculus" (Bridges) is a course designed to re-enforce the topics of Calculus while discussing its application to CSIS. It is a 1-credit course designed to take concurrently with Calculus.

The material consists of real-life examples (Ingredient-1) in which students can see the importance of the topics in Calculus to the world around them and the connection of these topics to the daily work of computer scientists. Students engage in group projects (Ingredient-2), which illustrate the strong interrelation of these two fields. Zakaria (2010) found that cooperative learning methods improve students' achievement in mathematics and their attitude toward it. Students also study the historical involvement of females (Ingredient-3) in CSIS and Mathematics. Focus is placed on individuals (i.e. role models), who have made notable contributions to their field such as Mina Rees, the first woman President of the American Association for the Advancement of Science (Gerhardt, 2005).

When possible we try to have a female professor for this course (Ingredient-3). In addition, the class size is limited in order that the students will have an opportunity to develop a relationship with the faculty member (Ingredient-3).

When one looks at the success rate in Calculus for the CSIS students, the value of the Bridges course is apparent. Fifty percent of the CSIS students who took the Bridges course received a grade of C or better in Calculus compared to thirty-three percent of the CSIS students who did not take the Bridges course (Table 1). The success rate in Calculus was 20% better for the CSIS students who took the Bridges course (Gerhardt, 2006). This is in line with what Shimazoe (2010) said that benefits of cooperative learning include deep learning and better grades.

Table 1 Calculus Grades of CSIS Students with and without Bridges Course

Combined Spring 2004 and 2005 data

CSIS Students Without Bridges Course			CSIS Students With Bridges Course		
	# of Students	% of Total		# of Students	% of Total
A	3	10	A	0	0
B	3	10	B	2	20
C	4	13	C	3	30
D	6	20	D	2	20
F	2	7	F	1	10
W	12	40	W	2	20
Total	30		Total	10	

INTERVENTION STRATEGY– "WOMEN IN COMPUTING"

Females graduating with a CS degree have decreased from 37% in 1985 to 22% in 2005 (NSF, 2007). In order to help correct this situation, a new freshman seminar was introduced at Stockton called, "Women in Computing." As observed by Carter (2006), an interesting introductory computer science course could attract freshmen to the field and motivate them to change their majors. That is precisely what this course attempted to do.

This intervention program also included the three key ingredients mentioned above: 1- Present topics with real-world applications, 2- Emphasize cooperative learning and 3- Build self-confidence. This introductory course was designed to recruit women CSIS majors and to help interested women build computer skills and confidence (Ingredient-3).

In addition to spending a great deal of time honing their computer skills, students researched articles concerning women and computing. At the end of the course students wrote a research paper on that same topic. There were female guest speakers who spoke about their own varied careers in computing.

There were 186 (31 female) first-time, full-time CSIS majors at Stockton from Fall 2000 to Fall 2005 that were followed through Spring 2007. Among the women who intended to major in CSIS, 100% of those who attended the introductory course were still CSIS majors until the end of the second year and beyond vs. 33.3% for non-course females; males also benefited, 66.7% vs. 49.7% (Mathis, 2008). The course was a success and once again, an intervention created to assist females, benefitted males as well.

INTERVENTION STRATEGY– "PEER TUTORING IN PROGRAMMING"

Stockton has a wonderful tutoring program in writing and basic mathematics. Our computing students certainly benefit from these services. However tutoring in computer programming was nonexistent at our school in spite of the fact that programming and problem solving is often considered as the heart and soul of computing (Denning and McGettrick 2005).

Programming in JAVA was a challenging course for many of our students, particularly female, who generally had less programming courses in high school. Consequently, female students usually enter computing classes with less confidence than male students (Treu and Skinner 2002).

Therefore, a third intervention strategy implemented at Stockton was to provide peer tutoring in programming. This intervention program, along with the manner in which we teach JAVA programming at Stockton, also embraces the three key ingredients mentioned above: 1- Present topics with real-world applications, 2- Emphasize co-operative learning and 3- Build self-confidence. By providing tutoring in programming we are helping the students to build relationships with other students (Ingredient–2) and confidence in their programming skill (Ingredient–3). Their assignments are done in pairs (Ingredient–2) using real-world problems (Ingredient–1).

The average percentage of students using the service has been 16.2% of Programming I respondents and 22.8% of Programming II respondents (Gerhardt, 2009). The highest ranking reason for using the service has been: "Needed help completing homework programming projects." Programming I students tend to use the tutoring service more often. A significant majority of the respondents said that the tutoring service was very valuable, and that the tutors were very competent and helpful.

Tutoring in programming filled a significant void at Stockton College and led to better retention in the computing areas. Ninety-seven per cent of the respondents who used the tutoring service said that it helped in their understanding of course material, and 91% thought that it improved their grade in the course (Gerhardt, 2009).

CONCLUSION

By designing intervention programs with the three key ingredients: 1- Present topics with real-world applications, 2- Emphasize cooperative learning and 3- Build self-confidence, we were able to encourage girls to study computing and to remain and succeed in computing. For example the success rate in Calculus was 20% better for the CSIS students who took the Bridges course.

Among the women who intended to major in CSIS, 100% of those who attended the Women in Computing course were still CSIS majors to the end of the second year and beyond vs. 33.3% for non-course females; males also benefited, 66.7% vs. 49.7%. Ninety-seven per cent of the respondents who used the tutoring service said that it helped in their understanding of the course material, and 91% thought that it improved their grade in the course.

Some of the results of the interventions in this article are positive facts and some are positive student perceptions and we know that positive perceptions can lead to positive facts. Further, we know from the literature that self-perception of skill proficiency has been shown to be a predictor of enrollment in computer courses. Therefore, if we want to encourage girls to study computing and to remain and succeed in computing we should make it real, make it cooperative and make them confident. Implementing those ingredients into courses and other interventions will result in positive perceptions, positive facts and positive girls when it comes to computing. And the bonus is that those three ingredients will probably help minorities and white males as well.

ACKNOWLEDGEMENTS

The author would like to acknowledge the work done by Dr. Mathis in the Women in Computing course, the work done by Drs. Vogel and Wu in the Bridges course and the work done by Dr. Olan in the Peer Tutoring in Programming project.

This material is based upon work supported by the National Science Foundation's Computer Science, Engineering, and Mathematics Program under grant DUE-0323917. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

BIOGRAPHY

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