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In this issue:

Developing an Equal Playing Field in the Information Systems Classroom

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Developing an Equal Playing Field in the Information Systems Classroom

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ABSTRACT

A mathematics component has consistently been included as criteria for accrediting information systems programs and many institutions satisfy that requirement with calculus. At the same time, the low enrollment and participation of female and minority students in computing fields is a nationwide concern. At The Richard Stockton College, it was felt that creating a female- and minority-friendly calculus class for Information Systems majors would help students succeed in this challenging course. This article discusses research concerning motivators for both women and men to major in computing fields and pedagogy that has a positive effect on women and minorities. Also, predictors of enrollment in computer courses are analyzed. These research findings and others were incorporated into a math course in order to create an equal playing field for our information systems majors. This article presents both objective and subjective assessment of the course.

Keywords: females and computing, gender issues, females and math, cooperative learning, self-esteem, minorities and math, minorities and computing, self-perception

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1. INTRODUCTION

The Computer Science and Information Systems (CSIS) faculty at The Richard Stockton College wanted to help their students, particularly the Information Systems (IS) students, to be successful in calculus. Since enrollments were already down in CSIS, they did not want to lose additional students to calculus. Not only did the students not do well in calculus, but they also did not understand its value to them.

In addition, the number of women and minorities in The Richard Stockton computing classes was approaching zero (sometimes it was zero).

Therefore, the CSIS faculty in cooperation with some Math faculty created a course that would be taken at the same time as calculus. The name of the course is "Bridges Connecting Computer Science and Calculus" (Bridges) and it is intended to help CSIS students succeed in calculus. It gives the students a review of the important concepts in calculus and demonstrates the usefulness of calculus to the CSIS major.

Other articles have described the course (Gerhardt, 2005, 2006) however this article will emphasize how the course was designed to provide an equal playing field for all of the students. Much of the research that was used to create a female- and minority-friendly course is applicable to any subject. The research is grouped into three main ingredients for creating a fair playing field.

2. NEED FOR THE NEW BRIDGES COURSE

The Richard Stockton College requires IS (Information Systems) majors to take one semester each of statistics, discrete math and calculus. Although The Richard Stockton College students seem to understand the value and applicability of statistics and discrete math in the real world, they generally do not understand why they have to take calculus. Moreover, at The Richard Stockton College the faculty are aware that many IS majors struggle with the one-semester calculus course. Students drop it, fail it, take it over, often more than once, and sometimes leave the major entirely because of it. They leave in spite of the fact that nine of the top ten fastest growing occupations in the United States that require bachelor's degrees are in the Information Technology area (US Department of Labor, Table One, 8). According to Barry Cipra, at some institutions as many as 50% of the students enrolling in calculus either fail or withdraw from the course (Cipra, 1988). At Stockton College the faculty felt the best support that they could give their IS students was to help them to succeed in calculus.

The Richard Stockton College Faculty also discussed the national problem concerning the lack of females and minorities in the computing majors. In fact, the number of female CS majors is at a historic low in spite of the fact that the majority of college students today are female (Patterson, 2005). The challenge for computer science programs is to retain women who enter the program as first-year students and to recruit other qualified women to the program (Margolis, 2000). The purpose of the new Bridges Course was to address each of these issues.

3. THREE KEY INGREDIENTS OF AN EQUAL PLAYING FIELD

The literature was searched for the topic of how to make an equal playing field for our Information Systems students. Some findings specifically mentioned computing or mathematics. Other research describes pedagogy that has a positive effect on women or minorities regardless of the subject matter. All of the attributes that were found in the literature, which contribute to promoting an equal playing field in our classrooms, were separated into three main categories called "three key ingredients of an equal playing field" which are described in this section. The three key ingredients are: 1-Present topics with real-world applications, 2-Build self-esteem, and 3-Emphasize cooperative learning.

1 - Present topics with real-world applications

Research has confirmed that interest is the strongest motivator for both women and men to major in computer science (Dryburgh, 2000). Pedagogical research shows that women are more attracted to topics and fields with real-world applications (Clarke, 1994). Therefore it is necessary to make real-world application based connections between calculus and Computer Science and Information Systems, particularly if we want to motivate women.

2 - Build self-esteem

Self-perception of skill proficiency has been shown to be a predictor of enrollment in computer courses for first and second-year students (Campbell, 1992). Treisman (1992) states that "Calculus {is} a major barrier for minority students seeking to enter careers that depend in an essential way on mathematics." We need to insure that females and minorities have high self-perceptions of their calculus skill proficiency and other skills that are necessary for a computer major if we want them to pursue a career in the computer field. Providing positive role models is another practice that can be used in order to build self-esteem.

3 - Emphasize cooperative learning (group study)

Many studies have pointed out the benefits of cooperative learning for females and minorities. Conciatore (1990) described a model for improving the calculus achievement of minority group college students that included group study; that model is currently used by 25 institutions. According to Clarke (1994) and Sandler (1996), women learn better in a cooperative environment than in the competitive or individualistic environment. Although men benefit from cooperative pedagogy too, they thrive better in a competitive environment than do women (Rosser, 1990).

Cooperative learning promotes positive peer interaction. This interaction can protect students against the feeling that they do not belong (Margolis, 2000). The social facilitation of cooperative learning is important to women because they are concerned with relationships (Gilligan, 1982; Rosser, 1990). Especially since there are few females and minorities in computer classes, it is important to help them to build relationships so that they feel that they belong.

In a meta-analysis comparing 305 research studies, Johnson (1998) found that cooperative learning promoted higher individual academic success than either competitive or individualistic learning. Since cooperative learning clearly benefits females and minorities and does not hurt males, cooperative learning should be used to equalize the playing field.

4. DESCRIPTION OF THE NEW COURSE THAT IMPLEMENTED THE THREE KEY INGREDIENTS OF AN EQUAL PLAYING FIELD

After delineating the three ingredients that promote an equal playing field, a new course was designed that highlighted those ingredients. Bridges Connecting Computer Science and Calculus (Bridges) is a one-credit course offered as a co-requisite with Calculus I designed to re-enforce the topics of calculus while discussing its application to CSIS. At the same time it was designed to be female and minority friendly. The material consists of real-life examples (i.e. 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 professionals. Examples would include Queuing Systems (i.e. using differential equations and the limiting process to analyze waiting lines) and Optimization Problems in Computing (i.e. how to store and transmit data efficiently). By demonstrating the usefulness of calculus with real-world problems, students become more interested in the subject and more motivated to learn it.

In order to build self esteem (i.e. ingredient #2) the Bridges course provides tutorials and discussions which increase the student's success rate in calculus. Success builds their confidence, and encourages them to continue to study in the Computing Field. Carnegie Mellon found a connection between women's confidence and their interest in continued study of computer science (Margolis, 2000).

Another technique used in the Bridges course to help build the self esteem of women and minorities was to highlight role models. One role model who was discussed in the course was Mina Rees. She was the first woman President of the American Association for the Advancement of Science. Her effort in World War II with the Applied Mathematics Panel in the Office of Scientific Research and Development brought together mathematicians from different disciplines to work on military based problems. The students also learn about Philip Emeagwali, the Nigerian American whose formula for using 65,000 separate computers to perform 3.1 billion calculations per second gives him credit as one of the fathers of the internet. Positive role models, who reflect who the students are, increase the students' own self-perceptions.

The cooperative learning structure (i.e. ingredient #3) of the course facilitates a network of Information Systems students who nurture and mentor one another. Social bonds also provide opportunities for informal peer group learning that contributes to persistence (Seymour, 1997). Team work is emphasized over individual work and grades are primarily based on class attendance and participation. This encourages students to take an active role in their education without the fear factor. See the Appendix for the Bridges Course Syllabus.

5. MATH REQUIREMENT OF ACCREDITING AGENCIES FOR INFORMATION SYSTEMS PROGRAMS

As of mid-2005, there are about 1000 IS programs in the U.S. They use a wide variety of names such as information systems, management information systems and computer information systems. Hundreds of IS programs exist other places in the world, also with a variety of names (Computing Curricula, 2005). Most IS programs look to accrediting agencies for guidance and possible accreditation. This section includes a recent sample of the Quantitative Analysis/Mathematics requirement for IS majors from two of the accrediting agencies.

ABET Accrediting Agency

ABET, Computing Accreditation Commission, accredits some 2,700 programs in engineering, technology and computer systems at more than 550 colleges and universities nationwide. In 2000 they adopted an innovative method of accreditation by looking at what is learned rather than what is taught. Each year they publish their criteria for accreditation.

2005-2006 cycle: ABET Criteria for Accrediting Information Systems Programs included the following details in the Quantitative Analysis area:

- The curriculum must include at least 9 semester-hours of quantitative analysis beyond pre-calculus.
- Statistics must be included.
- Calculus or discrete mathematics must be included.

Note: Thirty semester hours generally constitutes one year of full-time study, approx. 10 -3credit courses.

At that time, ABET Criteria for Accrediting Information Systems Programs included the following proposed changes (Lead Society: CSAB):

- Quantitative analysis or Methods: 6 semester hours that includes statistics.

2006-2007 cycle: During this timeframe, the ABET Criteria for Accrediting Information Systems Programs included the following details in the Quantitative Analysis area:

- The curriculum must include at least 9 semester-hours of quantitative analysis beyond pre-calculus.
- Statistics must be included.
- Calculus or discrete mathematics must be included.

During the 2006-2007 cycle, ABET Criteria for Accrediting Information Systems Programs included the following proposed changes (Lead Society: CSAB):

- Quantitative analysis or methods including statistics and mathematics beyond college level algebra.

It is interesting to note that in the 2005-2006 cycle less Quantitative Analysis was proposed for the future. However in the 2006-2007 cycle the Quantitative Analysis requirement did not change.

The Computing Curricula 2005

In 2005, a joint taskforce combining the Association for Computing Machinery (ACM), the Association for Information Systems (AIS) and The Computer Society (IEEE-CS) issued *The Computing Curricula 2005.*

Table 1 Selective data from Table 3.2: Comparative weight of non-computing topics across the five kinds of degree programs. (Joint Task Force, 2006, 25).

KA	CE	CS	IS	IT	SE
	Min/ Max	Min/ Max	Min/ Max	Min/ Max	Min/ Max
OT	0/0	0/0	1/4	1/2	0/0
OB	0/0	0/0	3/5	1/2	0/0
PM	2/4	1/2	3/5	2/3	4/5
BM	0/0	0/0	4/5	0/0	0/0
FB	0/0	0/0	4/5	0/0	0/0
EB	0/0	0/0	4/5	0/0	0/0
MF	4/5	4/5	2/4	2/4	3/5

KA = Knowledge Area

OT = Organizational Theory

OB = Organizational Behavior

PM = Project Management

BM = Business Models

FB = Functional Business Areas

EB = Evaluation of Business Performance

MF = Mathematical Foundations

The report covering undergraduate degree programs in Computer Engineering (CE), Computer Science (CS), Information Systems (IS), Information Technology (IT), and Software Engineering (SE) emphasizes the importance of mathematics in those fields.

Table 1 is part of a chart developed by the Joint Task Force, 2006 which shows the minimum and maximum emphasis placed on non-computing topics for each discipline. The numbers range from 0-5.

Notice IS has a minimum emphasis of 2 and a maximum emphasis of 4 when it comes to Mathematical Foundations.

As can be seen in this section, Information Systems accrediting boards continue to have a Quantitative Analysis/Mathematics requirement for the IS majors. Although the boards indirectly suggest calculus with expressions such as “beyond pre-calculus,” “beyond college–level algebra,” or “discrete math or calculus”; many educational institutions require that IS students take at least one semester of calculus. Whether we require calculus, discrete math, or statistics of our IS students we should always strive to create an equal playing field.

6. SUBJECTIVE RESULTS OF THE BRIDGES COURSE

Various subjective data was collected on the Bridges Course both in Spring 2004 and Spring 2005.

Spring 2004

In the spring of 2004, seven of the 30 students who took calculus also took the new one-credit Bridges course. A questionnaire was given to all of the calculus students (CSIS students and others) at the end of the semester. The responses from the students (i.e. 7) who took both calculus and the Bridges course were compared to the students (i.e. 23) who took calculus but did not take the Bridges course (Gerhardt, 2005). Although the sample size is small, all of the results favor the Bridges course.

Responses from the 30 calculus students:

Use Constantly

57% Bridges students felt they would use calculus often or constantly in their career

26% Non-Bridges students felt they would use calculus often or constantly in their career

Graduate School

43% Bridges Students felt they would use calculus a large or extreme amount in grad school

35% Non-Bridges Students felt they would use calculus a large or extreme amount in grad school

Connection to Computers

86% Bridges Students felt there was a large or extreme connection between calculus and computers

48% Non-Bridges Students felt there was a large or extreme connection between calculus and computers

Importance to the World

43% Bridges Students felt calculus was very or extremely important to the world around them

30% Non-Bridges Students felt calculus was very or extremely important to the world around them

Connection to Daily Work

86% Bridges Students felt there was a large or extreme connection between calculus and a Computer Scientist’s daily work

70% Non-Bridges Students felt there was a large or extreme connection between calculus and a Computer Scientist’s daily work

These percentages verify that those students who took the Bridges course, whether CSIS majors or others, understood the usefulness of calculus and its connection with computers more than the students that did not take it. By presenting topics with real-world applications, students were able to see the value of calculus to their own life. Thus the playing field was equalized.

Spring 2005 - Attitudes

In the spring of 2005, six students took the Bridges course (Gerhardt, 2006). They were given a questionnaire on the first day of the class and the last day of the class. The responses to the questions were assigned a numerical rating from one to five (i.e. strongly disagree=1, disagree=2, neutral=3, agree=4, strongly agree=5). The rate of change in the students’ attitudes was calculated for each student.

Rate of change =

last day's rating – first day's rating

first day's rating

Only five students completed both the first and last day questionnaires. Therefore, there are only results from five students.

The first statement on the questionnaire was:

"I know specific examples where calculus is used in Computer Science."

The students were asked to circle one of the following:

Strongly Disagree Disagree Neutral Agree Strongly Agree

On the first day of the course most students chose disagree. On the last day most students chose agree. The rate of change was 69%.

The second statement was:

"I know specific examples where Computers are useful in calculus."

On the first day two students chose disagree, two chose agree and one chose neutral. On the last day everyone chose agree or strongly agree. The students had a 46% increase on this statement.

The third statement was:

"I am aware of the historical involvement of females in CSIS and Math."

Most students chose disagree on the first day and strongly agree on the last day. This was a rate of change of 92%.

The fourth statement was:

"I am aware of the historical involvement of minorities in CSIS and Math."

Most students chose disagree on the first day and agree on the last. Once again there was a dramatic rate of change from the first class to the last. It was 83%.

Although the sample was small, the rate of change in the student's attitudes from the first day of class until the last day of class was dramatic. Being aware of the connections between calculus and computers and learning about role models are great motivators for students to continue to study in the Computing Field.

Spring 2005 - Opinions

The Bridges students were also asked to respond to the following statements:

"The Bridges course has helped to improve my grade in calculus."

80% of the students agreed or strongly agreed with that statement.

"The Bridges course gave me a better understanding of concepts in calculus."

100% of the students agreed or strongly agreed.

"The Bridges course has given me a better understanding of how calculus relates to Computer Science."

Once again, 100% of the students agreed or strongly agreed.

The students' responses to these statements demonstrate an improved self-perception of their calculus proficiency. This increases their chances for future enrollment in computing courses.

6. OBJECTIVE ASSESSMENT OF THE BRIDGES COURSE

After studying subjective data from Spring 2004 and 2005 separately, the objective data for both courses was combined for an overall assessment of the Bridges course. The 10 calculus grades from the CSIS students who took the Bridges courses (Spring 2004 and Spring 2005) were compared to the calculus grades from all of the 30 CSIS students during that time period, who did not take the Bridges course (Gerhardt, 2006).

When one looks at the success rate in calculus for the CSIS students, the value of the Bridges course is apparent in Table 2. Fifty percent of the CSIS students who took the Bridges course received a grade of C or better in their calculus course compared to thirty-three percent of the CSIS students who did not take the Bridges course. That means that the success rate (i.e. a grade of C or better) was 53% higher for the CSIS students who took the Bridges course.

Only two female CSIS majors took the Bridges course along with their calculus course. One received a C in calculus and the other received a D. Five female CSIS majors took calculus without the Bridges course. Their grades were one A-, one D and three Ws. Although the sample is small, 100% of the Bridges female CSIS students passed calculus but only 40% of the non-Bridges female CSIS students passed calculus.

Table 2 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	

7. CONCLUSION

Bridges Connecting Computer Science and Calculus (Bridges) is a one-credit course offered as a co-requisite with Calculus I designed to re-enforce the topics of calculus while discussing its application to CSIS. At the same time, this course was designed to be female- and minority-friendly by creating an equal playing field in the classroom. Three key ingredients that were used are: 1-Present topics with real-world applications, 2-Build self-esteem, and 3-Emphasize cooperative learning.

Subjective and objective data have been provided to demonstrate the success of this course. Students' self-perceptions, attitudes, and opinions improved concerning themselves and their viewpoint of calculus. The students perceived that their calculus grades were higher because of the Bridges course and they were correct. Their success rate (i.e. a grade of C or better) in calculus was 53% higher than the success rate of CSIS students who did not take the Bridges course.

Much of the research data that was used to create the new Bridges course was subject and major neutral (e.g. "women are more attracted to topics and fields with real-world applications", Clarke, 1994). Therefore, although the focus of this study was a math class, the "three key ingredients" would help to make any classroom an equal playing field.

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APPENDIX

CSIS 2215 – Bridges Connecting Computer Science and Calculus

Course Syllabus

Credit: 1 credit.

Co-requisite: Calculus I – Math 2215.

Audience: This course is highly recommended for all Computer Science majors and is open to all students with an interest in Computational Sciences. This course must be taken concurrently with Calculus I.

Motivation: Calculus is known as a challenging course which is required for most science majors. Computer Science majors are required to take one semester of Calculus and are encouraged to take additional semesters of Calculus. The successful passing rate of Computer Science students in this course is not as high as in other service courses. Furthermore, student feedback suggests that Computer Science students do not see the relevance and future applications of Calculus to their chosen field. In addition, the enrollment and participation of female and minority students in the Computer Science program is a nationwide focal point, and creating a female and minority friendly class environment is considered highly desirable. This course is designed to address each of these concerns.

Objective: This one credit course is intended to offer students, who are majoring in Computer Science and Mathematics, insight into the connection between the study of Calculus and the field of Computer Science. It is designed to increase the passing rate of the Computer Science major by emphasizing the importance of the subject to their field, and by creating an environment where topics in Calculus will be re-examined as they are used to address topics in Computer Science. In addition, the structure of the course will help create a network of Computer Science students designed to nurture and mentor one another. The further purpose of this course will be to encourage the participation and retention of female and minority Computer Science students. It will aid in their success in the Calculus course and will motivate their future study in the area of Computer Science.

Structure: This is an activity based course which emphasizes collaborative learning. The structure of the classroom will include: group work, discussions, tutorials, and projects designed to implement concepts in Calculus using computer software. Students are expected to take an active part in the learning process. A student's final grade is primarily based on class attendance and participation.

Content: This course will include subjects covered in the regular Calculus course together with their applications to Computer Science. Emphasis will be placed on real-life applications of Calculus concepts and the importance of Calculus topics to upper-level Computer Science courses. The course will highlight the historical contributions of females and minorities to the disciplines of Computer Science and Mathematics.

Topics:

Involvement of Females and Minorities in Computer Science.

- Mina Rees – First woman President of the American Association for the advancement of Science. Her effort in World War II with the Applied Mathematics Panel in the Office of Scientific Research and Development brought together mathematicians from different disciplines to work on military based problems.

- Annie Easley – NASA research. Her work focuses on computer applications used to identify energy conversion systems.
- Clarence Ellis – First African American to receive a Ph.D. in Computer Science. Director of the Collaborative Technology Research Group at the University of Colorado.
- Philip Emeagwali – Nigerian American whose formula for using 65,000 separate computers to perform 3.1 billion calculations per seconds gives him the recognition as being one of the fathers of the Internet.

Topics in Calculus with Computer Science Applications.

- Queueing Systems. Using differential equations and the limiting process to analyze waiting lines.
- Optimization problems in computing. How to store and transmit data efficiently.
- Comparison of the speed of sorting algorithms using integrals, limits and l'Hopital's rule.
- Integration's relation to Stocastic process.

Tutorial Sessions.

- Recitations on Calculus homework and questions on material from the formal Calculus class.
- Teaching Computer Algebra syntax: Maple, Matlab.

