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In this issue:

Why Do I Have to Take Calculus?

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Why Do I Have to Take Calculus?

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Abstract

The merits of Calculus for the Computer Science and Information Systems curriculum are discussed, and the under-representation of females and minorities in Computer Science and Mathematics is examined. An experimental course is highlighted which helps to bridge the material between Computer Science and Calculus. The course showcases female and minority involvement in Computer Science and Information Systems and Mathematics. In addition, the course acts as a tutorial for topics in Calculus. Data is presented which supports the success of this course and its objectives.

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1. INTRODUCTION

In the fall of 2003, a team of faculty from the Computer Science and Information Systems (CSIS) and Mathematics programs of The Richard Stockton College of New Jersey was awarded an NSF grant entitled, *Computer Science and Mathematics Scholarships* (CSAMS). The grant funds a program which provides scholarship money to deserving Computer Science and Mathematics majors. The program has several objectives in providing these scholarships, at the heart of which is the desire to guide our students through a successful academic career. The scholarships are intended for good students with financial need, and particular focus is placed on attracting and retaining female and minority students to these fields of study. As part of the implementation of the grant, special courses were created, a mentoring program was instituted for scholarship recipients, and additional tutoring was made available (Gerhardt, 2004). At the center of the initiatives set out by the grant was the concept that some Computer Science and Information Systems students need help with Calculus. Calculus I has become a roadblock course to many students in CSIS. Thus, one of the program's main objectives

is to help students understand and appreciate Calculus.

2. THE IMPORTANCE OF CALCULUS

Calculus is an important component in the education of our CSIS majors. At Stockton, the CSIS majors must choose a track in either Computer Science or Information Systems. Information Systems majors must complete at least one semester of Calculus. The Computer Science majors must complete at least two semesters of Calculus. The topics in Calculus supply a strong foundation of computational skills, which are essential tools in many upper level computer courses. In addition, the mathematical thinking skills, developed by the concepts presented in Calculus, provide the computer major with the training necessary for such an algorithmic and logic based field. Despite these clear indications of the importance of Calculus, many CSIS students are not able to see the relevance of Calculus to their major.

Ronald Douglas wrote that Calculus "is the key to understanding systems that change in the social, the biological, or the physical sciences (Douglas, 1986)." He went on to say that "Computer Scientists will need to learn Calculus if they are to understand many of the most exciting applications of large-scale computing (Douglas, 1986)."

3. THE DIFFICULTY OF CALCULUS

If Calculus is such an important core course for the computer major why is its value and need questioned? One answer is that the computer major too often does not see the relevance of Calculus. A second reason is that Calculus is a challenging course requiring strong analytical skills.

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.

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).

4. FEMALE AND MINORITY FRIENDLY CALCULUS ENVIRONMENT

The enrollment and participation of female and minority students in computer fields is a nationwide focal point, and creating a female and minority friendly class environment is considered highly desirable. In 1998-1999, women earned only 16.7% of all bachelor's degrees in computer science (Davis, 2000).

Since Calculus is a core course for the computer major in many institutions, it is important to make Calculus female and minority friendly. Treisman states that "Calculus [is] a major barrier for minority students seeking to enter careers that depend in an essential way on mathematics" (Treisman, 1992). Research has confirmed that interest is the strongest motivator for both women and men to major in computer science (Dryburgh, 2000). Therefore, it is important to capture students' interest in Calculus by demonstrating that Calculus is relevant to the computer field. More specifically, pedagogical research shows that women are more attracted to topics and fields with real-world applications (Clarke, 1994). As a result, in order to promote a higher level of interest and involvement from our female Computer Science majors, it is necessary to make application based connections between Calculus and Computer Science.

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). We need to insure that female and minorities have high self-perceptions of their Calculus skill proficiency. Tutorials and extra practice sessions are an important part of insuring increased proficiency in Calculus I and thus are an important part of attracting and retaining female and minority Computer Science majors.

Finally, it is important for students to have role models in their field of interest. In Computer Science and Mathematics there are many noteworthy individuals, past and present, who can act as role models to fe-

male and minority students. The historical involvement of females and minorities in these fields helps insure a strong future of continued involvement.

5. BRIDGES CONNECTING COMPUTER SCIENCE AND CALCULUS COURSE (BRIDGES)

The Richard Stockton College CSIS faculty felt that Calculus was important for their majors, but many of the CSIS students were not able to see the relevance of Calculus. As a result, many majors delay taking Calculus until the end of their academic career. In addition, there was a concern that CSIS majors were not successfully passing Calculus at a rate consistent with other required courses. Therefore, there was a need for a course which supplemented the material taught in Calculus and which specifically addressed the needs of the CSIS student. In creating the course, focus was placed on those students from underrepresented groups in the CSIS program including females and minorities.

"Bridges Connecting Computer Science and Calculus" (Bridges) is a course designed to re-enforce the topics of Calculus while discussing its application to CSIS. The material consists of real-life examples 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 projects, which illustrate the strong interrelation of these two fields. Students use computer algebra systems (e.g. MAPLE, MATLAB) to develop computer code, which performs basic Calculus computational skills. For example, while studying the definition of the definite integral, students create computer programs which implement the steps involved in the Riemann Sum.

Students study the historical involvement of females and minorities in CSIS and Mathematics. Focus is placed on individuals, who have made notable contributions to their field. Some examples include the following:

- Mina Rees – First woman President of the American Association for the Advancement of Science.
- Philip Emeagwali – Nigerian American whose formula for using 65,000 separate computers to perform 3.1 billion calculations per seconds gives him credit as one of the fathers of the internet.
- Clarence Ellis – First African American to receive a Ph.D. in Computer Science.
- Annie Easley – NASA researcher.

Emphasis is also placed on the current research of faculty members at Richard Stockton College. Part of each class is spent as a tutorial session. Student questions and classroom discussions are encouraged and students spend time in group learning in order to use each other as resources in the learning process. Conciatore (1990) described a model for improving the Calculus achievement of minority group college students that included the use of group study. Also, positive peer interaction can protect students against the feeling that they do not belong (Margolis, 2000).

Bridges is a one-credit course offered as a co-requisite with Calculus I. This is an activity-based course that emphasizes collaborative learning. 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.

6. BRIDGES INAUGURATION SPRING 2004

In the spring of 2004, eight of 31 Calculus I students also took the new one-credit Bridges course. A questionnaire was given to all of the students at the end of the semester. One of the Bridges students did not complete the questionnaire. Therefore, there is data for 30 students, seven of whom took the Bridges course. Ten percent (six) of the 30 students were CSIS majors.

Responses from the 30 students:

33% felt they would use Calculus often or constantly in their career

17% felt they would use Calculus a large or extreme amount in grad school

50% felt there was a large or extreme connection between Calculus and computers.

33% felt Calculus was very or extremely important to the world around them

50% felt there was a large or extreme connection between Calculus and a Computer Scientist's daily work

As one can see from the above statistics the majority of the 30 students surveyed did not see the importance or the need of Calculus to their career, grad school, or the world around them. Also, they did not feel that there was a large or extreme connection between Calculus and computers or Calculus and a Computer Scientist's daily work. The above statistics included CSIS Majors and Non-Majors.

7. A COMPARISON OF THE CSIS MAJORS WHO TOOK THE BRIDGES COURSE AND THOSE WHO DID NOT TAKE THE COURSE

The Calculus class of 30 students had six CSIS majors. The remaining majors were Science, Math, Business, and Other. 67% (four) of the six CSIS majors took the Bridges course.

Responses from the six CSIS majors:

50% Bridges students felt they would use Calculus often or constantly in their Career

0% Non-Bridges students felt they would use Calculus often or constantly in their career

25% Bridges Students felt they would use Calculus a large or extreme amount in grad school

0% Non-Bridges Students felt they would use Calculus a large or extreme amount in grade school

75% Bridges Students felt there was a large or extreme connection between Calculus and computers

0% Non-Bridges Students felt there was a large or extreme connection between Calculus and computers

75% Bridges Students felt there was a large or extreme connection between Calculus and a Computer Scientist's daily work.

0% Non-Bridges Students felt there was a large or extreme connection between Calculus and a Computer Scientist's daily work.

Although the sample size was small, there is a clear difference in attitude between the CSIS majors who took the Bridges course and those that did not. Those students that took the Bridges Course understood the usefulness of Calculus and its connection with computers more than the students that did not take it.

8. A COMPARISON OF ALL MAJORS WHO TOOK THE BRIDGES COURSE AND THOSE WHO DID NOT TAKE THE COURSE

The calculus class of 30 students had seven students (23%) who took the Bridges class.

Responses from the 30 students:

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

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

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

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

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

Once again, these percentages verify that those students who took the Bridges course understood the usefulness of Calculus and its connection with computers more than the students that did not take it.

9. STUDENT RESPONSES TO THE BRIDGES COURSE

At the end of the semester, a second questionnaire was given to the students taking the Bridges course. Six students filled out the questionnaire, and their responses provide additional insight into the success of the course. All six students felt that the Bridges course gave them a better understanding of Calculus and a better understanding of how Calculus relates to Computer Science. Four of the six rated this better understanding at a large or extreme amount. In addition, every student who took the bridges course felt that the course helped to improve their grade in Calculus I, and four out of six rated this improvement at a large or extreme amount. Student comments support these findings:

- "I like the extra help with problems from Calculus class, and the option and understanding of how computers can help."
- "[This] class helped me a lot."
- "I enjoyed the tutorial sessions. It really helped!"
- "[It gave me] a better understanding of Calculus I."
- "It helped me understand Calculus."

Students also commented favorably on the use of computer algebras in the classroom, including the use of Maple as a problem solving tool. In addition, students enjoyed the collaborative approach to the classroom, including group work, board work, and student presentations. The student feedback concerning the Bridges course has been overwhelmingly positive. All the students who took the course thought it was a beneficial and worthwhile experience. There was no negative feedback to report.

10. CONCLUSION

If we in the computer field believe that Calculus is an important course for our majors, we should strive to look for ways to demonstrate its usefulness and relevancy. The Bridges course described by this article has endeavored to meet that goal. The course was carefully planned and organized to satisfy several objectives: (1) show the interrelations of Calculus and Computer Science, (2) showcase the involvement of females and minorities in the fields of Computer Science and Mathematics, and (3) act as a tutorial for topics in Calculus I. In teaching this course, the professors have achieved these goals while also giving the students hands-on experience with programming skills and computer algebras.

The Bridges course is proving itself to be a successful experiment. Although the sample size is small, the data shows that the Bridges course did change the attitudes of CSIS Majors and Non-Majors as well. The seven (four CSIS) students who took the Bridges course compared to the 23 students who did not take the course felt that they would use Calculus more in their future and that there was a connection between computers and Calculus. In addition, all of the students taking the Bridges course felt the course improved their understanding of the relationship between Calculus and Computer Science, and they felt that the course helped improve their grade in Calculus I.

11. REFERENCES

Campbell, N. J. (1992). "Enrollment in Computer Courses by College Students: Computer Proficiency, Attitudes, and Attributions." Journal of Research on Computing in Education, v25, n1, pp.61-74.

Cipra, Barry (1988) "Crisis Looms in Mathematics' Future." Science, March 25, 1988, pp. 1491-1492.

Clarke, V.A. and G.J. Teague (1994), "En couraging Girls to Study Computer Sci ence Should We Even Try?" Australian Educational Computing, May 1994, pp. 17-22.

Conciatore, Jacqueline (1990) "From Flunking to Mastering Calculus" Black Issues in Higher Education, February 1, 1990, v6, n22, pp.5-6.

Davies, V., and T. Camp (2000, winter). "Where Have Women Gone and Will They be Returning" [6 paragraphs]. The Computer Professionals for Social Responsibility Newsletter, v18, n1.

Douglas, Ronald G. (1986) "The Importance of Calculus in Core Mathematics.'' Journal of College Science Teaching, February 1986, v15, pp.250-251.

Dryburgh, H. (2000). "Underrepresentation of Girls and Women in Computer Science: Classification of 1990s Research." Journal of Educational Computing Research, v23, n2, pp.181-202.

Gerhardt, Jill and Beth Olsen (2004) "Small Colleges Can Get Big NSF Grants." Proceedings of the 21st Annual Information Systems Education Conference, Newport, Rhode Island, November 2004.

Margolis, J., A. Fisher, and F. Miller (2000). The Anatomy of Interest: Women in UnderGraduate Computer Science. *Women's Studies Quarterly.* v28, n1/2, pp.104-127.

Treisman, Uri (1992) "Studying Students Studying Calculus: A Look at the Lives of Minority Mathematics Students in College" College Math Journal, v23, n5, pp.362-373.

Walsh, John (1987) "Why is Calculus Such a Hurdle?" Science, November 6, 1987, pp.749.