MATH CONNECTIONS IN COMPUTER SCIENCE
PANEL DISCUSSION

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ABSTRACT

This panel will lead a discussion about the role and relevance of mathematics in undergraduate Computer Science education. We will explore the major question pertaining to math connections in computer science: "How can we make the math that C.S. students take more meaningful to their major?" The panelists will describe the approaches they have taken toward achieving this goal. Ralph Bravaco will discuss his experience integrating math and computer science via learning communities at Stonehill College. Michael Gousie will describe a new Foundations of Computing Theory course that has been added to the C.S. curriculum at Wheaton College. Bo Kim will discuss the two particularly difficult challenges of (1) teaching discrete math to students with a wide range of mathematical abilities, and (2) students' lack of enthusiasm for mathematics. Linda Wilkens will discuss strategic problems

that are a consequence of recent trends in undergraduate enrollment including the rising numbers of undeclared students and the need to court students into the major.

PANELISTS' POSTION STATEMENTS

Ralph Bravaco

At Stonehill College, every sophomore must enroll in one interdisciplinary "learning community." A learning community consists of three courses: two courses in distinct disciplines and a third "integrative seminar" that links the two courses. Because every sophomore computer science major at Stonehill College takes Data Structures and Discrete Mathematics, a leaning community linking Data Structures and Discrete Mathematics seems a natural fit.

The goal of our current learning community is an appreciation of the symbiotic relationship between mathematics and computer science. The integrative seminar not only shows mathematics as indispensable to the computer scientist but also computer science as valuable to the mathematician.

The integrative seminar linking Data Structures and Discrete Mathematics consists of a series of closed lab experiments. For example, one lab explores fractal geometry and chaos. Here, students see some very modern mathematics that relies heavily on computers -- the computer scientist aids the mathematician. Another lab uses number theory to do cryptography. This lab uses some very old mathematics to do some interesting computer science – mathematics works for computer science.

Throughout the semester, we usually complete four or five such labs. Computer science majors who enroll in this learning community see not only the importance of mathematics in their discipline but also the relevance of computer science to mathematics.

Michael Gousie

With the rapid changes in the computing landscape, colleges and universities have been scrambling to keep up. These changes were recognized in the Computing Curricula 2001 report, in which the ACM proposed reducing the hours devoted to mathematics in favor of adding hours in newer computing topics. Following the guidelines, we at Wheaton College have also reduced the math requirements for the computer science major. While this change has made some students a bit happier, knowledge

of mathematics is still necessary to form a strong foundation upon which to build.

The one specific math course students cannot do without, according to the report, is Discrete Math. Our majors are required to take Discrete along with at least two other math courses. Because our students often struggle in this course, we now offer Comp 111 - Foundations of Computing Theory, which satisfies one of the math requirements and is meant to be taken before Discrete Math. In Foundations, discrete math concepts are combined with typical computer science problems, showing students clear connections between the two disciplines. The popular Computer Graphics is another course which uses many ideas from linear algebra: matrices, linear transformations, determinants, vectors, and so forth. Calculus is also brought in via a project where students have to render and compare linear, quadratic, and cubic splines. When students see these ideas leading to interesting graphical output, they suddenly understand the relevance of the math.

These are just two examples of courses in which we use mathematics as a tool to solve computer science problems. If the problems are interesting, students will put in the effort to learn or better understand the mathematics that are necessary for a good solution.

Bo Kim

After teaching Discrete Mathematics to CS freshmen and sophomore students, I felt challenged in two ways: First, freshmen students in Discrete Mathematics have wide range of mathematical abilities and to teach subject matter designed to accommodate all levels of mathematical abilities can be challenging. Second, some students do not see the importance of the linkage between mathematics and their major, computer science, which sometimes result in showing of lack of enthusiasm in the subject matter. These two factors are important in the teaching effectiveness in this course. Therefore, I am seeking suggestions and different methods that may have been effective in similar situations so that new teaching method can be introduced in an attempt to improve the challenges faced in the CS Discrete Mathematics curriculum at Daniel Webster College.

The DWC CS curriculum suggests that CS students take Calculus I and II. However, there are at least a half of CS freshmen students whose math level is below Calculus level. Math placement tests are given to all incoming students. For Discrete Mathematics, the prerequisite is College Algebra. Even though these requirements are quite reasonable for CS courses, some students demonstrated their unfamiliarity in basic math concepts and sometimes intimidated by mathematics. The challenge is that those students

need to keep up with the math requirement, but the advanced students may lose challenging learning environment. Presenting a material based on the students' wide range of ability can be difficult in any courses, but more so for the Mathematics course. Our current approach is to provide extra credit problem sets for the advanced students. On the other hand, additional tutoring opportunity is appropriate for the other student's.

The primary purpose of Discrete Mathematics is to provide a foundation for material that will be presented later in the curriculum. The consumer courses are separated from this preparatory mathematics by several semesters. Thus, the students do not see the importance of the linkage between Discrete Mathematics with the other advanced courses, or even computer science in general. Even though it is not the objective of this course to introduce all the applications of the material (nor it is feasible to do so in a limited time frame), the examples used to illustrate each topic can be based on the applications in computing – such as computer networking, sorting algorithms, etc to stimulate students interest. Also, most of the course material still utilizes presentation-oriented format such as powerpoint slides or blackboard/whiteboard. Rather experimental and empirical based approaches might need to be pursued.

Linda Wilkens

Having taught both C.S. and math, I fully appreciate math connections in C.S., both with respect to specific topics and also as a way to sharpen logical thinking and problem solving skills that are at the heart of computer science. However, with the rising number of students unsure of what they want to do and of which major(s) they should choose, it is difficult to get students to take their courses in the best order. Although our majors take 5 math courses including discrete math, two semesters of calculus, linear algebra, and calculus-based statistics, too frequently students take these math courses after their computer science courses, rather than before or concurrently with.

This unfortunate sequencing occurs for a variety of reasons. One of these reasons is the large number of undeclared freshmen. These students take a sampling of introductory courses in a variety of areas before they settle on a major, with some of them declaring as late as the second semester of their sophomore year. Thus, they are out of sequence to start with, often having taken the introductory C.S. course before any math whatsoever. Another obvious but still noteworthy reason for unfortunate sequencing is that the low number of students enrolling in C.S. results in required courses being offered less frequently than is optimal. A third but related reason is that, in competing for students, we sometimes make questionable concessions; e.g., allowing students to avoid much of the

required math so that they can have special customized majors. Furthermore, when students come to the major late, it often means they have time to complete only a minor rather than a major in the area.

These lamentable circumstances are hard to avoid, but there are some preemptive steps that can be taken. Undeclared advisors need to encourage students who are interested in C.S. to take the first course for the major, rather than the service course, and to take discrete math rather than a generic calculus for their math requirement. Faculty teaching the service course should incorporate both some programming concepts to pique the interest of potential majors or minors, and some mathematical concepts to connect the two areas in the minds of these students. At pre-registration advising time, all C.S. faculty should make it a point to encourage students in their classes to take their math requirements as early in their course sequence as possible, rather than as late as possible which is what many of them do currently.

ABOUT THE PANELISTS

Ralph Bravaco came to Stonehill College via graduate school at The University of Notre Dame, where he received his Ph.D. At Stonehill, where he instituted the computer science major, he has taught more than twenty-five different courses in both mathematics and computer science. He is a recipient of the Louise F. Hegarty Award for Excellence in Teaching as well as several grants from The National Science Foundation.

Michael B. Gousie is an Associate Professor of Computer Science at Wheaton College, where he has taught for ten years and is currently chair of his department. He has taught almost every course offered in the Department of Math and Computer Science. In general, he tries to incorporate rigor in all of his courses, and mathematical problems in many. He regularly teaches Theory of Computation and Computer Graphics, both of which have significant mathematical components. His main interests are in computer graphics, information visualization, and computational geometry, with an emphasis on three-dimensional applications in Geographic Information Systems (GIS).

Bo Kim is currently Assistant Professor of the Division of Computer Science, at Daniel Webster College in Nashua, NH. This is her 4^{th} year full time teaching at DWC and 6^{th} year at various institution of higher education. She has taught various undergraduate CS core courses including Discrete Mathematics I and II, Introduction to Programming, Data Structures and Algorithms I and II, Introduction to Software Engineering, Unix Programming, and Computer Networking. Prior to her teaching career in academy, she

worked for 5 years as a systems engineer for Optical Networking Group at Lucent Technologies

Linda Wilkens is a member of the Math and Computer Science Department at Providence College where she has taught the introductory C.S. course for 8 years. She also teaches a non-major C.S. course, Discrete Math, and Data Structures and Algorithms. She was previously at Bridgewater State College in Bridgewater MA for nine years and at Regis College in Weston MA for four years in the mathematics department.