TEST SITE REPORT

San Francisco State University

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San Francisco State University

During the 1991-92 academic year, students at San Francisco State University were introduced to the approach developed by the Calculus Consortium based at Harvard (CCH). On the whole, they found it more challenging but more rewarding than their previous math courses. In their evaluations, they called the course relevant, conceptual, and stimulating.

SFSU is a typical large urban university. The average age of the 27,000 students is 23.6 and the average course load is 10.6 units. Many students are self-supporting adults who attend school part-time. They are ethnically diverse, identifying themselves as African-American (6.7%), Asian (22.6%), European (51.5%), Filipino (6.7%) and Hispanic (8.2%). Fifty-eight percent are women.

In fall 1991, two of us (Meredith and Smith) used the CCH materials in three sections of Calculus 1 after attending the summer training session in Cambridge. A combination of our visible enthusiasm and their own dissatisfaction with the standard text led two colleagues, Diane Resek (see her notes below) and Alfred Tang, to use the materials in the spring. All of the four current instructors will continue to use the CCH text when they again teach the course, and three more instructors have decided to use it in fall 1992.

When discussing our experiment with faculty from other campuses, we are frequently asked, "How did you get your department to vote for it?" The answer is that we didn't. Meredith and Smith received permission from the Department Chair, Newman Fisher, to conduct a small experiment.

The experiment grew to include five additional instructors who listened to our reports at faculty meetings, visited our classes, read our materials and heard from our students. What they heard and saw led them to try the CCH approach for themselves.

We have encountered no difficulties teaching different calculus sections from different books. Both courses teach the same fundamental techniques of differentiation in the first semester and integration in the second semester. Both introduce the same basic definitions and similar applications. Although we feel that there are significant differences between the two approaches, we have found that students can move between them because the overall outlines of the two programs are similar.

The one important difference is the introduction of exponential and logarithmic functions. These are essential to the CCH program from the beginning, but they do not appear in the standard course until the second semester. The result has been to teach exponential and logarithmic functions in both semesters of the Harvard program.

Technology

Harvard calculus problems require calculating, graphing and algebraic analysis in approximately equal amounts. Because calculating and graphing can be so time consuming, students need easy access to graphing calculators or computers. We are divided about which to prefer, and so are our students.

We assigned lots of calculating and graphing problems; and we used class time to demonstrate computer or graphing calculator solutions. Then we left it to the students to choose the solution method they preferred.

Computer-literate students tended to use the software package that we recommended (*Calculus Calculator*), and they found it helpful and convenient. Even though the computer software was available in the computer labs, students without prior computer experience more often chose to purchase graphing calculators or just use ordinary scientific calculators.

Starting to use a computer program or graphing calculator, no matter how user friendly it seems to the experienced teacher, is not easy for unmotivated students. On the other hand, we have found that once they get started, students adapt fairly readily to either technology. We need to devote even more time and attention to getting students started with equipment.

Evaluation

When we started, each of us had an idea about how we wanted to teach calculus. We agreed that we wanted students to think more about the fundamental ideas of the course and gain more skill at analyzing problems. Compared to the standard course, the CCH approach makes it easier to focus on these issues. Both the text and the problems encourage students to think about mathematical ideas instead of recognizing problem types. Students also learn the standard manipulative skills that they need to use concepts efficiently.

We also found the text to be sufficiently flexible to adapt to our very different teaching styles and methods. It is, after all, only a book. It isn't a complete teaching program. We could use (or omit) lectures, discussions, problem groups, computer assignments or any other activities that we found useful. No matter what we did, we could be confident that our students had a text where they could read about mathematics in an understandable way. ▲

Techniques for Cooperative Group Work

Diane Resek, San Francisco State University

I've been working with students in cooperative learning groups since the late 60s and have found two major difficulties in setting up the process. The first difficulty is to find problems that interest and challenge students but that are not too difficult. The problems must engage the students or they will leave. If they are too easy and the way to solve them is too transparent, students won't need other students' help and will work on them alone. On the other hand, if the problems are too difficult, students will not be able to get started on the problem and, again, will not become engaged.

The Calculus Consortium text is ideal in this regard. There are problems in every section that are just right for my students. Not only was the difficulty level suitable, but the subject matter interested the students. Groups usually ended up discussing assumptions behind the application of the mathematics, without my suggesting it. The problems seemed real enough that this relationship interested them.

The second major difficulty with using cooperative groups is that one does not "cover" as much material as with the lecture discussion format. However, what the students do learn they learn at a deeper level. The CCH text is marginally helpful in this respect since it is easier for students to read with understanding than traditional texts are. Thus, I felt I didn't have to go over every idea in class, leaving more class time for students to work in small groups on prob-

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Cooperative Group Work

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lems. At the same time, almost none of the problems were routine so there was more discussion about homework than in a traditional class.

I feel the CCH text is certainly lively, but not lean. Following my department's syllabus, I was able to have students work in small groups for about 20 minutes a week out of a total of 150 minutes. I felt we had to sacrifice some depth for breadth. I certainly felt the time we spent in groups was worthwhile.

In what follows, I will describe the techniques I use that have evolved in my work with groups over the years.

Explaining the Rationale

At the beginning of the year, before I ask students to work in groups, I explain the benefits of group work. I repeat the adage: "Math is not a spectator sport," and try to convince them that they will only learn by doing. I explain that working in groups is a bridge between their following my work in front of the class and their working on their own at home. Even if I involve them in discussion during class, I am the director. When they work on their own, they must direct themselves. Working in groups is somewhere in between.

I also remind them that they can often learn better from a peer than from an expert. They have ample opportunity to learn from peers when they work in groups. I stress that they will gain more by explaining an idea to a peer than that other student will gain. That is, I try to convince them that the best way to learn something well is to teach it.

Finally, I explain that working in groups is how most people work in industry. Therefore, this type of classwork will help them develop useful skills. I also point out that their learning will have more depth, and they will enjoy it more. It shouldn't be ignored that having fun helps learning.

The Rules for Group Work

Before working in groups for the first time, I give students my rules for this work. I repeat those rules the next few times we use group work. Those rules are:

1. Introduce yourselves.
2. Work together.
3. Be responsible for yourself.
4. Be nice.

The meaning of the first one is clear. The second means that they are not supposed to work exclusively on their own. It is understood that they may want some time to think on their own, but this time is for collaboration. The third rule means that they are in control of their own learning. I can't make it happen for them. If they are not understanding what their group members mean, they must ask. The fourth rule means that the rest of the group must answer. They must do their best to help their fellow members understand, and those who are not understanding must provide appropriate feedback.

Setting Up Groups

There are a number of ways to set up the groups in class. The easiest and least embarrassing way for instructor and students is to let students work with others sitting near them. Unfortunately, the easy way is not the best. A better way is to randomly assign students to groups of four or five. One can either do this handing out playing cards, (where students who have the same rank work together), or by asking students to count off by an appropriate number.

When students work in random groups, they quickly get to know a lot of people. This familiarity breeds comfort. Students then ask more questions in class and volunteer more ideas. The familiarity helps them to see their own strengths in relation to the rest of the class, and most of them become more confident. Another benefit of random groupings is that students get to know more people and are more likely to work together outside of class on homework.

Problems With Group Work

After several weeks of group work, I begin to sense that some problems are occurring. For example, some students may be dominating, and others are freeloading. At that point, I ask students to spend a few minutes writing positive and negative aspects of group work. I then ask them to call out these points as I make two lists on the board. A positive list might include: "Helps you understand the material," or "Lets you make friends." A negative list might include: "Some people dominate," or "Often the group moves too slowly."

After generating the lists, we discuss the items on the "negative" list, to see whether students can think of things that they or I can do to mitigate these problems. This whole process takes about ten or fifteen minutes and is needed at most once a semester. It solves most problems for most students.

Teaching Assistants on the CCH Workshop

José Giraldo and Peter Springer, Michigan State University

Michigan State University has adopted the calculus materials developed by the Calculus Consortium based at Harvard (CCH) for use in forty sections of "non-technical calculus" for fall 1992. These sections will be staffed largely by teaching assistants (TAs), most of whom have had experience with the "traditional calculus." A primary concern among TAs is the notion that CCH requires a larger time investment than the usual course.

Attending the recent workshop at Harvard University, we were reassured that the CCH approach does require more time for preparation and test construction, at least on the first pass, but this is compensated by a more satisfying teaching experience. It was also clear that the issue of teaching calculus, making it more understandable and attractive for students not primarily concerned about mathematics, is bringing the whole mathematical community together. As a consequence, we left the workshop with a revitalized view of teaching as career training for a graduate assistant.

We are suggesting the following to our department to support the TAs' introduction to the CCH approach, so that they can succeed in the classroom under this program:

1. Prior to the first day of class, a workshop should be conducted, in the spirit of the one we attended, to familiarize the faculty and TAs with the CCH concept (Rule of Three), structure of the text, problems, and so on.
2. Rather than each instructor writing exams, exam construction should be a group activity to save time, reduce pressure, and increase the uniformity among sections.
3. All sections should follow the same syllabus and instructors should meet periodically to exchange their different experiences with content, ways of approaching certain topics, and students' reactions and progress.
4. We also feel it may be useful for each instructor to maintain a CCH diary (it should be a short and simple format) on a per class meeting basis.

This is an exciting period in mathematics education. We are privileged to be a part of the effort to improve the teaching of calculus and are enthusiastically looking forward to fall semester. ▲

A NEWSLETTER FOR THE CALCULUS CONSORTIUM BASED AT HARVARD UNIVERSITY

FOCUS ON CALCULUS

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CONFERENCE REPORT

The Calculus Conference at Harvard

Karen Thrash, University of Southern Mississippi

Cambridge and the Harvard Science Center provided the setting for the first calculus conference sponsored by John Wiley & Sons, Inc., the National Science Foundation, and the Calculus Consortium based at Harvard (CCH). Over 400 conference participants came from forty-five states (including Alaska and Hawaii) as well as the District of Columbia and Puerto Rico. Opening remarks were given by the "Father of Calculus Reform," Ron Douglas of SUNY at Stony Brook. Dr. Douglas and the morning's keynote speaker, Wayne Roberts of Macalester College, have been actively involved in calculus reform since the early rumblings began almost a decade ago. They traced the history and progress of the movement and set the stage for the rest of the conference.

The two-day conference was filled with opportunities to hear and meet people representing a wide variety of programs and ideas. From the project-related approach at New Mexico State, to the activities of the Five Colleges, to Jerry Uhl's clever and amusing demonstration of *Mathematica*, to the newly-released CCH video, attendees were given glimpses into the philosophical and technical aspects of calculus projects from around the country. In addition, experts from medicine, physics, engineering, and applied mathematics shared examples of some of the ways in which calculus is used. James Glimm, from the Department of Applied Mathematics and Statistics of SUNY at Stony Brook, stressed the increasingly important role of mathematics in today's world. He suggested that undergraduate mathematics should be viewed as a "soaker hose" feeding other disciplines—rather than as a "leaky pipeline," the symbol that has often been used to encourage mathematics reform.

Don Lewis reinforced the idea that mathematics departments must meet the challenge of demonstrating mathematical relevance to students from a wide variety of majors. Dr. Lewis, chair of mathematics at The University of Michigan, warned that if we do not meet the needs of students in other disciplines, the responsibility of teaching these students will be taken over by others. At the same time, Dr. Lewis recognized that faculty members must be given encouragement and support to make changes in undergraduate education. He has successfully struggled for reduced class sizes, tenure track positions based on undergraduate instruction, increased recognition and rewards for excellence in teaching, and a network to encourage interaction between faculty and students. With these requests, Dr. Lewis has sent a message to administration, faculty, and students that he believes in and is willing to support undergraduate education.

Conference participants were also reminded that calculus is but one of many areas receiving attention at the undergraduate and precollege levels. John Prados, from the University of Tennessee and current president of ABET (Accreditation Board for Engineering Technology), gave encouraging evidence that changes being made in the mathematics arena are consistent with those being made and considered by engineering accrediting agencies. Joan Ferrini-Mundy from the University of New Hampshire spoke

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Exploring Optimization

Millie J. Johnson, Western Washington University

"We can no longer teach kids about a subject; we can teach them what a subject is all about."
Elizabeth Hall Brady

A hands-on approach to min-max problems can motivate even the most fearful calculus student. The ideas that follow are extensions of bits and pieces of talks that I have heard at many conferences. Credit is due the originators of the ideas, but unfortunately, I do not know who they are!

Problem 1

A rectangle with fixed area k is rolled into a cylinder with radius r and height h. Determine the dimensions of the rectangle that will maximize the volume of the corresponding cylinder.

Most students use substitution to make the volume into a function of one variable. They often become confused when they find that the derivative cannot equal zero.

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