Project CALC: Calculus as a Laboratory Course

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Abstract

Calculus is the study of change. The concepts of calculus enable us to model processes that change and to describe properties of these processes that remain constant in the midst of change. Now change has come to the **learning** of calculus -- change driven by the need to respond to the revolution in technology and fueled by funds from the United States National Science Foundation. What should be changed? How and how fast? What should remain constant? In this paper we describe one answer to these questions: Project CALC, a new calculus course developed at Duke University. The key features of our approach are real-world problems, hands-on activities, discovery learning, writing and revision of writing, teamwork, and intelligent use of available tools.

Goals

As we discussed the nature of the new course and worked on materials, we gradually formulated a number of goals.

1. **We wanted the students to be able to use mathematics to structure their understanding of and investigate questions in the world around them.** This meant that the students should work on real-world problems with real data.

2. **We wanted the students to use calculus to formulate problems, to solve problems, and to communicate the solution of problems to others.** This meant that we needed to spend some time developing the physics setting, the economics background, or the biological models necessary to understanding the problem. It also meant that the students needed to write up their investigations in coherent readable English.

3. **We wanted the students to use technology as an integral part of this process of formulation, solution, and communication.** Computers and sophisticated calculators have changed they way we relate to the world. The students need to

concentrate on what they need to know to use these tools intelligently and with confidence; they should not engage in John Henry-like competition of pencil and paper versus technology.

4. We wanted the students to work and learn cooperatively. Talking to each other about mathematics is a strange new idea for most students. Once they get started and develop a learning community, they learn as much or more from their peers as they do from their instructors.

With these goals in mind, we developed a three-semester calculus program based on a laboratory science model. In our case, the laboratory is a computer laboratory. Here the students, working in pairs, explore real-world problems with real data, conjecture and test their conjectures, discuss their work with each other, and write up their results and conclusions on a technical word processor. This laboratory experience drives the rest of the course. It shapes the contents and the approach of the text and the format of the classroom activities.

In the classroom, we were struck by the difference between teaching and learning. For years we and our colleagues had concentrated on what the teacher was doing. What makes a good lecture? How can we cover all the topics packed into the syllabus in a logical manner? Now we began to concentrate on the student. What activities should students be doing to help them construct the mathematical knowledge needed? As we thought about this and experimented, we lectured less and less. More time was given to student activities in groups -- gathering data on the period of pendulums in terms of the length (for use later in the lab), balancing plywood cutouts to locate the experimental center of mass (to compare later with the theoretical center), calculating the rate of decrease of the distance between two planes approaching an air traffic control tower and deciding whether they will collide. We were more likely to be out among the class talking to the students than to be in front lecturing.