Calculus Reform: Catching the Wave?

By IVARS PETERSON

Calculus is big, important — and in trouble. This was one of the messages that came out of a recent conference at the National Academy of Sciences in Washington, D.C., on the future of calculus education. The meeting attracted more than 600 mathematicians, educators and other professionals worried about the state of calculus teaching. The large attendance reflected a growing feeling that something ought to be done to reform the way calculus is taught (SN:4/5/86,p.220).

"We are not doing a good job in teaching what we are teaching," says mathematician Ronald G. Douglas, physical sciences and mathematics dean at the State University of New York at Stony Brook. "We now have an opportunity to do something about the trouble and to make [calculus] even more important."

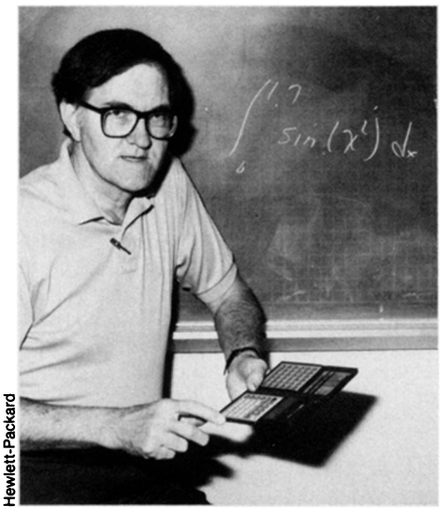
By almost any measure, the teaching of calculus is a huge enterprise. In any given semester, about 12,000 calculus instructors face more than 750,000 students in 7,500 high schools, colleges and universities. The number of students is double the figure of 20 years ago. These calculus courses represent almost $250 million in tuition and other fees, along with the millions invested by publishers in textbooks and other aids.

Furthermore, success in calculus is the gateway to professional careers, especially in the sciences and engineering. Some business schools and other college departments also require students to take a calculus course. For many students, calculus is the only college-level mathematics course they encounter. "A lot of people have a stake in calculus," says Douglas. "That makes it that much harder to change it."

But the need for changes is evident in the list of problems faced by current calculus programs: unwieldy textbooks, poor teaching, excessively large classes, low standards, simple-minded exams. Perhaps as many as a third of all students enrolled in calculus courses fail or withdraw, according to a recent survey by the Mathematical Association of America.

Although many mathematicians and educators agree that these problems exist, not everyone describes the situation as a crisis that clearly threatens the future viability of calculus courses. "There's no crisis in calculus," says Leonard Gillman of the University of Texas in Austin. "We have a solid program, and people are learning some mathematics." Two simple ways to improve the current state of calculus, he says, are by letting students use computers to practice routine problem-solving skills and by enforcing prerequisites so that students come into calculus classes properly prepared.

However, the poor quality of much calculus teaching, especially in university classes, is more difficult to deal with. "I have a lot of colleagues who are wedded to their research," says Gillman, "and they really don't care much about calculus [teaching]." He adds, "There's nothing wrong with sprucing up the curriculum. We've been doing that for many years, but the teaching is getting worse."



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John W. Kenelly of Clemson (S.C.) University demonstrates that a sophisticated calculator can now do many kinds of calculus problems.

Other mathematicians see a more direct threat to the present situation in which college and university mathematics departments teach calculus courses not only for students intending to major in mathematics but also for those planning to enter all other fields. "Calculus is our most important course," says Gail S. Young of the National Science Foundation (NSF), "and the future of our subject . . . depends on improving it."

For many students, calculus represents a significant barrier on the road to a professional career, says Robert M. White, president of the National Academy of Engineering. "It must become a pump instead of a filter in the pipeline," he says. "Calculus is really exciting stuff, and we're not presenting it as exciting stuff."

Says Douglas, "We've got to get back to the idea that teaching calculus is important. We have to devote time to it."

If changes aren't made, says Thomas W. Tucker of Colgate University in Hamilton, N.Y., then calculus could end up being taught largely in high schools. Another possibility is that client disciplines such as physics or engineering may begin to teach calculus classes better tailored to their needs.

Two recent developments may push forward attempts to reform calculus instruction. One is the increasing use of computers and the development of new calculators capable of manipulating algebraic symbols. Some calculator models now available allow students, just by pushing a few buttons, to do about 90 percent of the calculations required by typical calculus tests and exams or most textbook exercises.

At the same time, concerns about the state of all undergraduate education, the need for changes in mathematics and science programs from kindergarten to grade 12 (SN:1/31/87,p.72) and worries about cultural literacy, technological literacy (SN:2/22/86,p.118) and other knowledge gaps are generating a wave of interest in educational reform. Recently, NSF decided to focus on calculus education as one of two key areas for support and proposed a $2 million program for the development of calculus curriculum materials.

"It's a start," says Douglas, "and it indicates a national interest in calculus reform. It's a matter of catching the wave."

Nevertheless, the sheer size and inertia of the calculus establishment make it hard for reformers to introduce changes. The changes, says Douglas, must come by way of a large number of local efforts that gradually spread throughout the educational system. "We're planting seeds," he says. "We're not ready to harvest yet."

"Changing calculus may be a greater battle than we ever imagined, but it's a battle worth fighting," says Tucker. "I'm sure we can do better, but we can't do it alone." □