Taking Anxiety Out of the Equation

Some professors say colleges should make mathematics more student-friendly

By ELIZABETH F. FARRELL

Rob Fiorillo always liked mathematics. In high school, he got an A- in calculus, and unlike many of his peers, he understood the material. When he arrived at the University of Michigan at Ann Arbor this fall, he eagerly enrolled in an introductory calculus course.

A varsity runner and a member of the Reserve Officer Training Corps, Mr. Fiorillo figured the course would give him the easy A he needed to balance out his hectic schedule, which included a 16-credit course load. Yet halfway through the semester, he became confused. His math professor had little time for questions during class. His textbook baffled him.

After he scored a 48 percent on his midterm exam, Mr. Fiorillo dropped the course. "I came in very confident in math, and I'm not a quitter," says Mr. Fiorillo. "But this experience has definitely shaken me."

Math, with its abstract concepts and obscure terminology, has humbled many students. Educators have even coined a phrase for the stress their subject can cause: math anxiety. Instructors say the affliction causes many intelligent students to believe — mistakenly — that they lack the ability to master the subject.

Until recently, math anxiety received little attention from mathematicians. But professors are starting to question their teaching tactics in hopes of making the field more accessible. Some are looking at ways to make their classes more interactive, while others are considering alternative grading methods for exams and problem sets.

Twelve years ago, the Mathematical Association of America started Project NExT (New Experiences in Teaching), a program that has recruited some 800 mathematics professors who are interested in experimenting with new ways of teaching math.

Meanwhile, the number of doctoral programs in collegiate math education, unheard of a decade ago, has grown to more than a dozen amid an increasing demand for math instructors with those degrees.
"They're a hot commodity right now," says Domenico Grasso, dean of the College of Engineering and Mathematical Sciences at the University of Vermont. "The whole concept of how we teach has to play a more central role in our process."

Mathematicians, he believes, must become better teachers.

'Chalk and Talk'

Math anxiety has been extensively researched. Most of the explanations for the phenomenon have focused on problems with math instruction at elementary and secondary schools.

Some students sour on math at an early age. Yet the bigger losses to math departments are the students who, like Mr. Fiorillo at Michigan, come to college liking math, only to have an abrupt change of heart. Attrition rates in mathematics and engineering programs average about 60 percent nationwide. And only about 2 percent of undergraduates major in math.

"The very committed and math-oriented student is doing just fine," says Sheila Tobias, a consultant in science-and-math education based in Tuscon, Ariz. "It's the second tier, the group of students who have the cognitive equipment and the motivation and discipline for math but less natural ability, that we are losing at the college level."

But is college math really that much harder than high-school math?

Generally, yes. Professors teach the subject differently than high-school teachers do. Most college students take math classes in large lecture halls, where they watch instructors solve equations on a blackboard. That passive, "chalk and talk" method, Mr. Grasso says, makes it difficult for some students to learn.

Mr. Grasso and other professors who share his concerns agree that colleges should make math courses more interactive, by shrinking the class sizes and letting students help solve equations at the blackboard. In the large lectures, they say, instructors often go too fast for students to ask questions.

Still, many mathematicians cite tradition in defending large lectures, says Tabitha Mingus, an associate professor of collegiate-mathematics education at Western Michigan University, in Kalamazoo, Mich.

"We basically teach the way we were taught, and the system essentially replicates itself," says Ms. Mingus, who earned her Ph.D. in collegiate-math education at the University of Northern Colorado. "I understand clearly the mathematician's desire to protect the field and to make sure the content is taught to the students, but on the other hand, I know that lecturing the students does not mean that they learn it."
Zachary E. Kenitzer is a textbook example of a student who got lost in math lectures. Mr. Kenitzer, a freshman at the University of Louisville, enrolled in the Speed School of Engineering this fall but quickly switched to a political-science major one month into his introductory calculus course. The class was taught by Larry D. Tyler, a professor of mechanical engineering and Patricia A. Stark Ralston, a professor of chemical engineering.

According to Mr. Kenitzer, one professor would do a problem on the blackboard while the other erased completed equations.

"The speed they would go at was incredible," says Mr. Kenitzer. "Dr. Ralston was a complete math dork. She would do things in one step that take a normal person four steps to complete, and that made it extremely hard to follow."

Mr. Tyler says he tries to make his classes as interactive as possible (he asks students to work on problems in class before he and Ms. Ralston demonstrate how to solve them). He also says that many students feel comfortable asking questions.

The professor does some remedial work with students outside of class, but says some of his pupils are better off taking a review class. Each semester about 20 percent of the students who enroll in his course either drop it or switch to a remedial algebra class.

'Dropped Stitches'

In her research on collegiate-math education, Ms. Mingus, the Western Michigan professor, found that one of the main causes of math anxiety is a "dropped stitch" — a gap in a student's prior math education that holds him or her back from learning more-complicated concepts. Because most students do not master every mathematical lesson in high school, dropped stitches are common.

Students are often afraid to ask questions about concepts they feel they should know already, which creates a snowball effect. The student falls behind, and his or her confusion grows with each new mathematical concept. Catching up can seem like an insurmountable task.

"Math is not like history where you can break into the time line and learn from one event forward," says Ms. Mingus. "You don't have to go back to the Peloponnesian War to understand the Civil War. With math, it's like learning a language — you have to master the alphabet first."

For professors, dropped stitches can be an annoyance because sewing up gaps in students' knowledge takes time. Besides, Ms. Mingus says, many of her colleagues take pride in the difficulty of their discipline and expect students to struggle with the material.

This mentality has also influenced how professors have graded math tests: Many will deduct points when a student finds a new way to solve the problem, even if the answer is
correct. Conversely, students with incorrect answers (due to simple miscalculations) who used the right equations and reasoning are often denied partial credit.

Creative approaches to problem solving and proper applications of mathematical principles are indications that the students have grasped the material, says Ms. Mingus, who notes that forward-thinking professors are exploring different ways to grade tests.

Some college math instructors say that once a student is admitted to an academic program, like engineering, a college should not blame his or her failure on inferior high-school preparation.

"A lot of faculty want to see who can survive their courses instead of making it their obligation to have the student succeed," says Mr. Grasso, of the University of Vermont. "But we shouldn't make these courses weed-out courses. The admissions process should be the weed-out process."

At Vermont Mr. Grasso is in charge of revamping the mathematics and engineering schools. He has hired new instructors and plans to work with professors to make courses more interesting to students.

He also appointed Joan Marie Rosebush, a popular math instructor, to a new position: director of student success. For the past few years, Ms. Rosebush has taught math courses and overseen the university's tutoring program for math and engineering majors. At another college, Ms. Rosebush probably would have never been considered for the job, because she has exactly zero math degrees.

Mr. Grasso appointed her to the position because of her reputation as a stellar teacher. Students love her, he says, and she helps those who have failed calculus three times to pass the class. Ms. Rosebush says her approach works because she makes a personal connection with students.

At the beginning of the semester, Ms. Rosebush urges the students to interrupt her with questions as soon as they start to feel lost. If they do not understand the difference between a numerator and denominator (and some of them do not), she will explain that, too.

"I tell students that if they are afraid to ask questions then to just pull their earlobe so I know they aren't understanding it," says Ms. Rosebush.

Rapport with an instructor is especially important in math because students have so much apprehension about the subject, Ms. Rosebush says. In her capacity as an adviser, she often recommends math courses to students based on how well she thinks their personalities will match up with a particular instructor's teaching style.
Experts say students can overcome math anxiety by using two strategies: telling their professors when they are confused, and staying on top of their homework. The latter might sound obvious, but many students give up too easily when they get stuck, according to Ms. Mingus.

"I saw a lot of students who thought that if they didn't grasp a concept in 30 seconds, then it was beyond their comprehension," says Ms. Mingus. "We've become a society that thinks that either you get math or you don't."

Convincing students that math is a skill they can learn, instead of a talent they are born with, is only half the battle. Professors may need to have more faith in their students, too.

Some studies have shown that American math teachers think their best students succeed because they are gifted, while teachers in other countries think their highest-achieving math students succeed because they work hard.

And because students have a variety of learning styles, Ms. Mingus says, instructors should explain a concept in a number of ways.

Fred Peskoff, a math professor at City University of New York's Borough of Manhattan Community College, has won two teaching awards and accolades from students for the variety of teaching approaches he employs. When reviewing basic concepts, Mr. Peskoff will demonstrate both the long way to figure out an equation and a shortcut for solving it.

"The way he did it was very clever," says Jason D. Martin, a nursing student at the college. "I needed the expanded version to understand the concepts, but students who had already learned them benefited from him showing the shortcut."

Some mathematicians may never agree to give up the lecture approach. But a few professors say requiring all math instructors to take at least one education course would help them reach students more effectively.

"As professors, we have to be aware of the issues that impact student learning," says Mr. Peskoff. "We can't just know the content of math. We need to know more about how students learn."