Whatever Happened to Rochester? Two Years Later, Mathematics Is Getting Accolades

Two years ago the mathematics department at the University of Rochester made national headlines as it battled a move by the university administration to eliminate the department's graduate program. After the crisis was resolved in March 1996 and the administration reversed its decision, the Rochester mathematicians made efforts to improve undergraduate instruction and establish stronger ties to other disciplines. Now, a year and a half later, a remarkable turnaround is in evidence, with the mathematics department enjoying the strong support of the administration and drawing praise—and even prizes—for its work. Says William Green, professor of religion and dean of the college, "It's got to be one of the great success stories of higher education."

Emblem of Departmental Woes

The crisis at the University of Rochester has become emblematic of many of the problems facing mathematics departments in this era of shrinking higher education budgets. It was in November 1995 that the university announced the "Rochester Renaissance Plan", which described a host of measures designed to improve the university's financial position and its attractiveness to undergraduates. The plan called for a reduction of 10% in the number of professors and the elimination of four graduate programs (chemical engineering, comparative literature, linguistics, and mathematics). Mathematics was one of the departments hardest hit, with a reduction in faculty slated for close to 50%.

Shortly after the plan was announced, the AMS dispatched a small group to Rochester to offer assistance in helping the department and the administration resolve their differences. When these meetings did not prove fruitful, a number of AMS representatives—including Salah Baouendi, member of the AMS Committee on the Profession, and Arthur Jaffe, who was then AMS president-elect—orchestrated a campaign to get people outside Rochester to write in support of the mathematics department. The campaign was quite successful, drawing a total of over one hundred letters, many of them from prominent scholars outside of mathematics, including a number of Nobel laureates.

All along the biggest sticking point at Rochester was the elimination of the mathematics graduate program, which the mathematics faculty believed would drain the lifeblood from its research effort and eventually undermine the intellectual tone of the university. When, after nineteen weeks of internal negotiation and pressure from the letter writers, the administration agreed to reinstate the graduate program, the landscape suddenly changed. "I think that at that moment everybody realized that we were all on the same team," says Douglas Ravenel, who became chair of the mathematics department. The department was able to breathe a sigh of relief and address the very real problems the administration had pointed out, and the administration now had an interest in strengthening the mathematics department.

With Ravenel as chair, the mathematics department has been working hard to improve its undergraduate teaching and to reach out to other departments. Because Ravenel is one of the most highly regarded researchers in the department, the fact that he took an active interest in the department's fate was important in bringing about the turnaround. "This is a group of leaders, strong

mathematicians who stepped up" to the challenge, says Thomas LeBlanc, professor of computer science and dean of the faculty. "They are intellectual leaders, not political leaders." That the change came so quickly is quite remarkable. "When you tell people this happened in a year and a half, it seems like we're trying to put a happy face on a bad situation," LeBlanc remarks. "But that's not the case."

Improvements in Teaching

The mathematics department started making improvements in the area that had drawn the most complaints: lower-level teaching. One of the most visible manifestations is WeBWorK, an Internet tool developed by Michael Gage and Arnold Pizer. (Ironically, WeBWorK was under development even before the crisis broke at Rochester.) Earlier this year Gage received a regional prize from the Mathematical Association of America for his role in developing WeBWorK, and he has also received an on-campus teaching award.

WeBWorK supplies students with homework problems in such a way that they all have the same problems, but each has slightly different numbers. Therefore, the correct answers are different for each student. When the student keys an answer into WeBWorK, he or she is told immediately whether or not the answer is right. No hints are given, but with the immediate feedback the students become quite persistent: Eventually, 80 percent of them get all of the answers right. In addition, when a student does come to the professor with questions, he or she has usually thought about the problem quite a bit. "So the direct communication between student and professor is much more specific, much more focused, than student questions are in a traditional course," Ravenel explains.

WeBWorK was introduced in a new course called "Calculus with Foundations", which is aimed at precalculus students. The department found that these students, who tend not to be highly motivated in mathematics, responded well to WeBWorK. "They say that the immediate feedback is a huge asset," says Ravenel, noting that the students also seemed to work a lot harder at the course. This fall the department is expanding the use of WeBWorK into its slower-paced calculus course, which has an enrollment of about 170 students.

The reasons for developing "Calculus with Foundations" provide a good example of the problems the department faced. At Rochester—as on many campuses nationwide—freshmen have been arriving with steadily declining mathematical backgrounds. "There was a widening gap between what incoming freshmen knew about mathematics and what other departments expected them to know as sophomores, and we were expected to fill this ever-widening gap," says Ravenel. With precalculus the situation was even worse, because other departments would steer their students from the course because it offered so few credits. Predictably, these students would flounder in calculus. "Calculus with Foundations" addresses these problems by filling in holes in the students' background while introducing them to ideas from calculus and offering them more credits.

Another new course developed by the department is "Calculus for Understanding". It is tougher than the regular calculus course for science and engineering majors but less theoretical than honors calculus. The hallmark of the new course is the use of two-hour workshops—in which students collaborate on the homework, with a teaching assistant roaming around the room to provide help—rather than traditional recitation sections. The new course is one of a group of "Quest" courses on the Rochester campus, which are designed for highly motivated freshman students and which provide a setting where students work in groups on problems and get a taste of what real research is like. Enrollments in the mathematics department's Quest courses far exceed those of any other department. The department's success with precalculus and calculus courses has resulted in articles in the Rochester alumni magazine as well as in the local newspaper, the *Rochester Democrat and Chronicle*, which on September 27 ran a story entitled "UR Tries to Cure Calculus Fear".

One factor that has buoyed the fortunes of the mathematics department is that the Renaissance Plan's aim to improve the academic preparation of the student body has paid off: the average SAT score for this and last year's incoming classes is just shy of 1300, the highest it has been in twenty years. The mathematics department is seeing the change firsthand, says Ravenel. "We see more people enrolled in these very challenging courses, and this is very encouraging." Thirty-three students made it through honors calculus in the fall semester of 1996, "a huge enrollment," according to Ravenel. What is perhaps even more striking is the half dozen freshmen who enrolled in and succeeded at sophomore-level honors calculus. "Nothing like this has ever happened before," Ravenel remarks, noting that in the past at most one or two freshmen might enroll in that course. And generally the courses in the mathematics department just seem to be popular. Ravenel says nobody knows why last semester a dozen economics graduate students showed up for a graduate course in measure theory. Although the economics department at Rochester has a mathematical bent, having so many economics students in such a theoretical mathematics course is unusual.

At the time the Renaissance Plan was announced many departments had complaints about the teaching in the mathematics department, and relations with engineering were especially strained. The en-

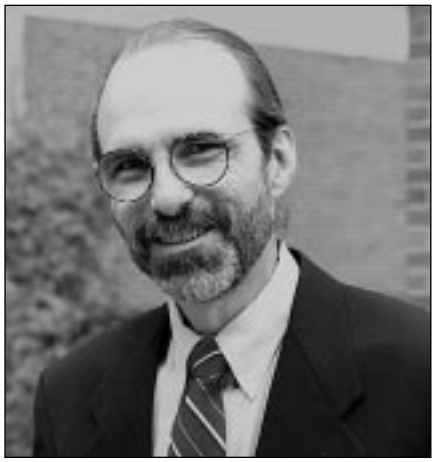
gineers' frustration was compounded by the fact that one of their own faculty, Al Clark, has a doctorate in applied mathematics and is an excellent mathematics teacher. To the dismay of the mathematics department, the engineering school began offering its own versions of some upper-level mathematics courses. Two initiatives have calmed these troubled waters. First, discussions between mathematics and other departments led to the development in the mathematics department of a new differential equations course that better addressed what other departments said their students need. And second, the mathematics department extended a joint appointment to Clark. (A joint appointment between mathematics and physics is also in the works.)

The mathematics department has not only reached out to other departments to address teaching concerns but has also made scholarly connections. There is now a joint mathematics-physics colloquium attended by members of both departments. In addition, an applied mathematics seminar was started last year that brings in speakers from a variety of other departments to talk about the use of mathematics in their own subjects. "There is a lot of mathematics being done outside the mathematics department," says Ravenel, "and this is a very good way to get people together." There have been talks on DNA computing and chemical reactions—and even one that used flag manifolds to help explain the dance language of honeybees. When the speaker suggested a connection between this dance and quantum mechanics, "the physicists went ballistic," Ravenel reports. The speaker "set a new standard for intellectual provocation," he says, and the discussion went on for about half an hour after the talk had ended. (The work of the speaker, mathematician Barbara Shipman, is described in the article "Quantum Honeybees", *Discover* magazine, November 1997.)

One dark cloud looming over the Rochester mathematics department is the administration's insistence that the number of mathematics faculty be reduced to 15. Mathematics faculty member Michael Cranston says that the reduction would make it "impossible" for the department to meet its teaching responsibilities. Since the time the Renaissance Plan was announced the department has lost three faculty: one moved to the University of Iowa when the turmoil erupted, and two others have accepted early retirement packages. With one of the retirees working half-time, the faculty now numbers 18 1/2 full-time members. In addition, the graduate program is currently limited to twenty students, down from a steady-state of the low thirties before the Renaissance Plan. "The size restrictions on the faculty and the graduate program put constraints on our ability to cover the teaching that needs to be done," Cranston says.

Advice for Other Departments

The turnaround in the mathematics department at Rochester can provide lessons for other institutions. For example, "communication with other departments is vital," Ravenel observes. "Mathematicians have a tendency to be politically aloof and not to get involved in the politics of their institutions and not to interact with other departments. This makes us very vulnerable. I think that when you meet with other departments one-on-one and discuss issues related to mathematics, it can be very beneficial." His department has met with almost every other department that has a mathematics requirement to discuss what the other departments want their students to know about mathematics. As a result of these meetings, says Ravenel, "I think there's a feeling around the university that the math department is very approachable and responsive to the needs of other departments."



Chair of the Rochester Department of Mathematics, Douglas Ravenel.

These meetings also revealed some misconceptions on the part of other departments. For example, many believed that mathematics courses were taught too abstractly or too theoretically. "On the other hand, they admit that mathematical maturity is a very valuable commodity and it's something that they want all their students to have," Ravenel notes. Bringing such contradictions to light helps the two sides understand better the problems that need to be addressed. Another misconception, says Ravenel, is that professors in other departments tend to believe that calculus is taught in the same way as when they were in college. "They are oblivious to the changes that have been made in the way that calculus has been taught in the last twenty years," he notes. "The more you can communicate with them about these things, the better off you'll be."

In addition to discussing mathematics instruction, it is also important to forge scholarly connections to other departments through such activities as joint seminars. Asked which was more important, Ravenel says, "if you do it right, these things can reinforce each other." In particular, he believes that having lively interactions with other departments makes the mathematics major more appealing to undergraduates. "Every math department needs to have an attractive major so that they can get more students, and that will improve the health of the department," he notes. In this way

the scholarly and teaching missions are drawn closer together.

Ingredients in the Resolution

According to Paul Slattery, chair of the Rochester physics department, the key ingredient in the solution of the crisis at Rochester was the internal response of the mathematics department. Another important factor, he notes, was the support of physics. "Physicists nationwide had rallied to the support of the math department in significant numbers," says Slattery, "and physicists at Rochester were certainly no exception. Some wrote semipublic letters and some chose to proceed more discreetly, but all fully understood the obvious fact that we would not long continue to be a top quartile department in association with a completely dysfunctional math department." The support of the physics department for strengthening ties to mathematics, through joint appointments and other mechanisms, increased the receptiveness of the administration to reversing its decision.

How important were the letters from well known scholars and Nobel laureates outside Rochester, who took the administration to task for its demotion of the mathematics department? Views on this question vary. Certainly many in the mathematics department believe the letter-writing campaign was critical. "It made it impossible for the administration to ignore, and also for other departments to ignore," says Cranston. That many of the letters came from outside mathematics made them especially influential. It was not just the AMS functioning as "a guild protecting its own members," he notes.

Others see the letters as less important. In fact, Slattery points out that the very intensity of the protest made it especially difficult for the administration to consider reversing itself, "lest it appear to be irresolute in the face of outside criticism." Dean LeBlanc says the letters "raised the temperature" but were not a critical factor. The idea that the administration changed its mind under the pressure of opinion outside Rochester is "wrong," he says, "because without the leadership in the math department coming forward, the letter-writing campaign would not have had an effect." LeBlanc worries that the mathematics community might see Rochester entirely as a political battle, with the lesson being that mathematics must be vigilant and defend itself against its enemies. Instead, he says, mathematicians should recognize that there are real problems in higher education that they need to work on. If they become "part of the solution to those problems, it will be good for mathematics."

Asked about the letter campaign, Dean Green replies that change came not as a reaction to pressure but "through quiet, intelligent negotiation and diplomacy." He credits Rochester president Thomas Jackson with having the courage to reverse a decision to which he had made a substantial commitment. Jackson could have stuck to his decision, for he had the support of the Rochester Board of Trustees (in fact, he took some heat afterwards from supporters of departments in which the decision to eliminate the graduate programs was not reversed). For its part the mathematics department could have retreated into itself and become "bitter and self-righteous," says Green. "But they turned around, looked at the problems, and saw what they needed to do. There was real leadership from the department and from the president."

Many of the letter writers from outside Rochester focused on the central role of mathematics in the scholarly and academic world. In this the letter writers were correct, Green believes, but mathematicians must take this centrality seriously. "The message to mathematicians is that, because your subject is essential to so much, you cannot afford to be anything but powerfully engaged in thinking through the future of your own institutions," he says. "Not all fields have that obligation, but mathematics really does." The centrality of mathematics "does not give you entitlements; it gives you responsibilities."

—Allyn Jackson