Forum

Rochester Four Years Later: From Crisis to Opportunity

Douglas C. Ravenel

The events that took place at the University of Rochester in 1995–96 are known to many of the readers of the *Notices*. In November 1995 the university announced its Renaissance Plan, a comprehensive strategy to cut costs while improving the quality of undergraduate education. Most alarmingly to the mathematics community, the cost cutting measures included reducing the size of the permanent faculty in mathematics by more than half and *the elimination of its graduate program*.

The events of the ensuing four months are now referred to in Rochester as "the war" or "the crisis". Nearly two hundred letters of protest were sent to the administration by mathematicians, scientists, and alumni. The AMS was most helpful in rallying this support. They surmised that if Rochester could eliminate its graduate mathematics program, several other universities would follow suit in short order. Articles about the controversy appeared in the *Notices*, the *New York Times*, *Science*, the *Chronicle of Higher Education*, and eventually the *Encyclopedia Britannica*. The matter had become a cause célèbre in the scientific community.

Meanwhile senior members of the department conferred with senior administrators and with the heads of various departments in science and engineering. The end result of these conversations was a decision by the university at the end of March 1996 to reinstate the graduate program (albeit on a smaller scale than before) and to plan on less severe long-term cuts in the size of the faculty. In the midst of all this confusion, I was asked to take over as department chair.

In this article I will address the following questions:

- Why was mathematics the subject of such severe cuts?
- What has the Rochester mathematics department done since then to improve its position in the university?
- What can other mathematics departments learn from these events?

Why Were Cuts Planned for Mathematics at Rochester?

The answer to the first question is rooted in patterns of behavior common in mathematics departments today, namely:

- We were doing a reasonably good job at undergraduate teaching, but we made no effort to convey this fact to anyone outside the department. (In this article "we" will always refer to mathematics faculty at Rochester.) As a result, we were blamed for the mathematical shortcomings of science and engineering majors. The mathematical preparation of incoming students had been gradually declining for many years, but the expectations of other departments were not declining with them. We were caught in the middle of a widening gap between the amount of mathematics that incoming freshmen knew and what sophomores were expected to know.
- We had little interest in or understanding of university affairs. Like most mathematicans, we were apolitical, if not antipolitical. We regarded administrators as adversaries rather than as partners. We regarded ourselves as a friendly, enlightened group surrounded by ignorance and hostility. Few of us had any contacts or friends outside the department.

These traits are probably familiar to many readers. They add up to a department that is perceived as insular and detached from the institution that supports it and one that is therefore vulnerable in times of financial stress.

Mathematics departments need to communicate effectively with their administration, with faculty in other departments, with their students, and with the outside world. However, it is common for academic mathematicians not to regard this as part of their job description. The best

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calculus teaching in the world can go unnoticed if no effort is made to let the rest of the university know what is being done. Deans are not telepathic, and if a department is doing something good, they need to be told about it. *A good mathematics program can be a source of pride to any school, and giving the administration something to brag about is always a good idea. A calculus program that is perceived as friendly is a great asset.*

The Importance of Good Calculus Instruction

Inevitably the bulk of any mathematics department's interaction with the rest of the school is through calculus. Huge numbers of students take it, and for them the stakes are very high. Anyone with career aspirations in science, engineering, or medicine must do well in calculus. A poor showing can be a major setback, if not a career crisis. This central fact of undergraduate life should be understood by all concerned: by the faculty and teaching assistants in the mathematics department, by faculty in neighboring departments, by the administration, and by the school's academic support apparatus. *If university officials do not understand the importance of good calculus instruction, it is the mathematics department's responsibility to educate them about it.*

Here are two examples of how this understanding has played out at Rochester recently.

- In 1996 we persuaded the university to include a mathematics placement exam in the orientation program for entering freshmen, 70 percent of whom take calculus. We said that it was better for a student to have a bad summer afternoon caused by an exam than to have a bad semester caused by being in the wrong course.
- In 1997 we argued successfully for some new temporary faculty positions on the grounds that without them we would have to double the size of many calculus classes. The dean, knowing that for many students calculus is the most challenging course, did not want to add to their stress by depersonalizing the classroom.

The Conflict with Engineering

Like many mathematics departments, we had a conflict with some of our engineering faculty about how mathematics should be taught, and for a few years they were teaching courses in direct competition with ours. We have since solved this problem, but similar difficulties remain elsewhere.

Mathematicians and engineers may disagree over what topics should be covered, how much theory should be stressed, and how technology should be used in the classroom. Dialogue is essential for dealing with each of these topics. In some but not all cases much of the conflict can be relieved by a straightforward exchange of views. The mathematicians need to know what the engineers want and why. The engineers need to have realistic expectations about how much can be taught in the time allotted.

In any case, it is the responsibility of the mathematicians to be at least as knowledgeable as the engineers about all relevant educational questions. In particular, the former must be familiar with any technological issues that are on the table. *Ignorance of or unwillingness to master software is not a sound pedagogical argument against using it.*

The Rochester Mathematics Department Today

Our situation now is much improved over 1995. A crisis is characterized by both danger and opportunity, and we have had plenty of the latter. We have gone from being nearly invisible within the university to being a high-profile department. We are well represented in the university's legislative bodies. We publish an annual newsletter. We run seminars that are well attended by faculty from other departments. Overall enrollment in our courses has increased despite a planned reduction in the size of the student body. Two of our faculty (Michael Gage and Steven Gonek) have won generously endowed university-wide teaching awards, and the department itself was given a substantial prize for the improvements in our calculus program. These include the following:

- In anticipation of attracting better students through an improved recruiting strategy, the university has encouraged departments to develop a series of challenging courses for highly motivated freshmen. Nearly a third of all enrollments in such courses are in mathematics. The number of students in our honors sequence (possibly the most challenging freshman/sophomore-level course in the entire university) has doubled.
- In these courses traditional recitations have been replaced by two-hour calculus workshops. Here students work together on assignments in small groups, guided by a teaching assistant trained to facilitate their active participation. Student response to the workshops has been so positive that we are extending them to other courses.
- In the months after the crisis ended we met individually with every department having a mathematics requirement for its major and discussed the mathematical needs of their students. These meetings were extremely useful. They resulted in the strengthening of the mathematics requirement for computer science and led to the development of a new sophomore-level course on linear algebra and differential equations. More importantly, we made it clear that we were interested in helping other programs succeed and that their faculty could come to us with mathematics-related problems. *Good will is an invaluable asset.*
- Before 1996 it was impossible for us to grade calculus homework, and this was a major weakness of our program. We have developed a software package called WeBWorK that delivers and grades homework through the Internet. It is now being used by 700 students, and homework counts for a substantial portion of every calculus grade.

WeBWorK was written by two of our faculty, Michael Gage and Arnold Pizer. For a hands-on demonstration of it, see

`http://webwork.math.rochester.edu/`

It includes a random number generator which assures that each student in a class gets a slightly different version of each assigned problem. This allows students to swap methods but not answers. The program can accept symbolic input and is smart enough to know when a student's answer is mathematically equivalent to the correct one. It tells the student immediately if the answer is correct (no hints are given for wrong answers) and allows any number of retries, up to a deadline. This immediate feedback is a good motivator. *Roughly half of all students using WeBWorK eventually get every single homework problem right for the whole semester.*

What Does It Mean to Be the Queen of the Sciences?

Every mathematics department needs to have a clear vision of its role in its university. Mathematics professors are not merely researchers reluctantly teaching on the side in order to pick up a paycheck. Mathematics is a tool used in essential ways by many disciplines, and a university where it is not done well cannot succeed. This means that mathematicians in academia have both special privileges and special responsibilities. This vision needs to be shared within the department (it is not enough for just the chair to have it), and it needs to be communicated to faculty and administrators outside the department.

The central role of mathematics in science, engineering, and technology gives each mathematics department the opportunity to be a linchpin in the mission of its college or university. Too often, as in the case of Rochester before 1996, this role has been abdicated by mathematics professors. They tend to be too wrapped up in their research to care about their institution.

The Renaissance Plan at Rochester was formulated as a strategy for improving the quality of undergraduate education, because our administration reached a clear understanding of the importance that undergraduate education holds for the future of the institution. Ultimately it is the undergraduates who pay most of the bills. Surely Rochester is not unique in this respect. Most universities are under increasing financial pressure and can no longer afford to shortchange their students, as many have done in the past. Mathematicians in research universities may be accustomed to administrations that pay lip service to good teaching while rewarding only good research, but this folly is unlikely to continue forever.

It is likely that many schools will pay more attention to their undergraduate programs in the future, and mathematics departments should see this as the great opportunity that it is. Their role in this enterprise is indispensable, and they can use it to great advantage. A politically savvy department chair can parlay the intellectual centrality of mathematics into an influential role for mathematics in university affairs. It is a pleasant surprise to see how much this effort has been welcomed at Rochester.

Every mathematics department can become a major player in its university by interacting effectively with faculty and other officials outside the confines of its own building. Too many mathematicians dismiss this effort as a waste of time. It most certainly is not.

News Flash

Proof Announced of Taniyama-Shimura-Weil Conjecture

At the opening lecture June 21 of the Institute for Advanced Study/Park City Mathematics Institute (PCMI) on arithmetic algebraic geometry, Kenneth Ribet of the University of California at Berkeley stunned his audience when he mentioned in passing that all elliptic curves over the rationals are known to be modular. The modularity of such elliptic curves is the celebrated Taniyama-Shimura-Weil Conjecture. Ribet was saying that the conjecture was now a theorem!

When quizzed about his comment after the lecture, Ribet explained that the theorem had been announced several weeks earlier by Christophe Breuil, Brian Conrad, Fred Diamond, and Richard Taylor. Ribet had learned of this announcement in an e-mail message; he imagined incorrectly that the news had already reached most members of the audience.

As it happened, Brian Conrad was a co-organizer of the research program of the PCMI. Conrad gave two one-hour lectures on the result during the conference, focusing on the new ingredients needed to treat those cases of the conjecture that were not covered by previous work.

Following work of G. Frey, Y. Hellegouarch, B. Mazur, and J.-P. Serre, Ribet proved in 1986 that the Taniyama-Shimura-Weil Conjecture implies Fermat's Last Theorem. Andrew Wiles, partly in collaboration with Richard Taylor, then proved Fermat's Last Theorem in 1994 by establishing the Taniyama-Shimura-Weil Conjecture for all elliptic curves with square-free conductor—this was sufficient because elliptic curves arising from prospective counterexamples to Fermat's Last Theorem have square-free conductor. Ribet wrote for the *Notices* about the Wiles approach in a July/August 1993 article.

Until recently the best result in the direction of the full Taniyama-Shimura-Weil Conjecture was a proof when the conductor is not divisible by 27. This result is due to Conrad, Diamond, and Taylor and appears in a 1999 article in the *Journal of the American Mathematical Society* (vol. 12, pp. 521–567).

The validity of the Taniyama-Shimura-Weil Conjecture provides further evidence for the "Langlands program", a far-reaching web of conjectures due to Robert Langlands that relates congruences over finite fields to infinite-dimensional representation theory.

—Anthony W. Knapp