Demotion of Mathematics Meets Groundswell of Protest

Arthur Jaffe, Salah Baouendi, and Joseph Lipman

The University of Rochester's plan to downgrade its mathematics program has called forth an extraordinary surge of protest not only from mathematicians but also from well-known scientists both in universities and in business. Statements have been made by at least six Nobel laureates, by dozens of members of the National Academy of Sciences, as well as by other leaders in science and industry. The outpouring comes from many fields, including biology, chemistry, computer science, economics, geology, mathematics, philosophy, physics, and sociology.

The uproar from the scientific community arose for at least two reasons. First, the Rochester plan has become a symbolic attack at the core of the American research university. Secondly, the decision was reached in an apparently arrogant manner: the president and a few intimate advisors made broad judgments in areas far from their own expertise, without the benefit of careful external review. Both these reasons mean events in Rochester are being watched carefully across the country by other universities who might follow this bad model, and by scientists who are appalled both with the methodology and with the results.

Norman Ramsey, Nobel laureate in physics, remarked on being told of the Rochester plan, "Surely you must be joking. If you had only one science department at a university, it would be mathematics, and you build from there." In scientific circles the Rochester plan has become a symbol of the wrong way to downsize.

The Rochester administration announced their controversial "Renaissance Plan", with the stated aim of improving the quality and the attractiveness of the university through downsizing (20 percent students, 10 percent faculty)[1]. Faculty cuts are to occur through encouraged attrition in selected departments. The faculty reduction for mathematics, from twenty-one to ten, is the most severe. Four graduate programs will be terminated: mathematics, chemical engineering, comparative literature, and linguistics. It is clear that the number of graduate students

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[1] *A detailed discussion of these events is available on the Internet at* `http://www.ams.org/committee/profession/rochester.html`.

in mathematics should be reduced nationally. However, the total elimination of a graduate program in a leading department, within a university that claims to remain at the forefront of science and technology, makes no sense.

Addressing the resulting teaching shortfall (over 70 percent of Rochester's undergraduates enroll in calculus courses), President Thomas H. Jackson states, "We do reject the notion that tenure-track mathematicians and mathematics Ph.D. students are the only potential groups capable of offering high-quality mathematics instruction." Vice provost and dean Richard Aslin states, "We can significantly decrease the faculty size in mathematics who are primarily devoted to delivering quality undergraduate instruction to math majors and other sophisticated science majors while seeking other avenues (technology and nonresearch faculty) to deliver instruction in basic calculus (typically for nonmajors)." In fact, President Jackson has acknowledged the likelihood that the best mathematics faculty will leave.

Renowned economist Lionel McKenzie, professor emeritus at Rochester, just returned from Japan, where he received the Order of the Rising Sun. He feels strongly that his university has made a major mistake with respect to mathematics and that his own work would have been impossible without a lot of cross-fertilization from Rochester mathematicians. McKenzie is working within the university to have the administration take a different path.

The collection of protest letters already received by the Rochester administration constitutes a remarkable testimonial to the place of mathematics in research and in education. Many letter writers assert that Rochester cannot maintain its research excellence in the physical sciences and in other quantitative areas—as it aspires to do—without a strong program in mathematics, which it now has. Others state that ending the graduate program in mathematics and consigning the bulk of calculus teaching to adjuncts and faculty in other departments will markedly degrade the quality of education Rochester offers to undergraduates. Hence Rochester will become less attractive both to prospective students and to prospective faculty.

Several writers criticize the reliance by the Rochester administration on rankings of their mathematics graduate program in the *U. S. News & World Report* and in the 1995 National Research Council polls rather than on careful external evaluation of each department. Not only can polls be "based largely on knowledge by hearsay and intuition rather than hard study of programs," but, as explained by Fields Medal winner Michael Freedman, "… departments with specialized strength will be underrated."

Thirty-one professors in the Harvard Physics Department (including three Nobel laureates, thirteen members of the National Academy of Sciences, and the dean of the Division of Applied Science) signed the following statement:

> The Department of Physics at Harvard University is dismayed to learn of the decision by the University of Rochester administration to cut in half the size of their mathematics faculty and to discontinue their graduate program in mathematics. Rochester has a tradition of being one of the leading American universities in science and in technology. Recent history confirms the interaction between fundamental mathematical concepts and advances in science and technology. We believe that it is impossible to have a leading university in science and technology without a leading department of mathematics. We hope that Rochester will reconsider its decision.

Members of the Harvard Chemistry Department, including a Nobel laureate and eight members of the National Academy of Sciences, expressed similar sentiments:

> Our department is dismayed. For centuries, mathematics has rightly been termed "the queen of the sciences", and this is just as apt today. In particular, chemistry has benefited more and more from mathematical developments and concepts. A university that aims to have a worthy program in science and technology simply must have a genuine department of mathematics pursuing original research. We urge the administration of the University of Rochester to reconsider.

Steven Weinberg, University of Texas, Nobel laureate in physics, wrote:

> I was proud to receive an honorary doctoral degree from the University of Rochester in 1979, for I knew Rochester as a distinguished center of research in physics, my own field. But recent news from your university makes me fear that it will not be able to continue to maintain this high reputation.

> I am not a mathematician, but I regard mathematics as the core of any research program in the physical sciences. If you do not have a graduate program in mathematics then, eventually you will have no research mathematicians, which will make Rochester far less attractive to theoretical physicists. Experimental physicists may not feel the loss of the mathematics program directly, but with fewer first-rate theoretical physicists you will begin to lose your best experimentalists as well. You will also be weakened in your ability to compete for good students; both graduate and advanced undergraduate physics students need to take advanced courses in mathematics, which can only be taught well by active research mathematicians. I imagine that similar effects will eventually be felt in your chemistry and optics departments. I would not advise any prospective undergraduate or graduate student who wishes to concentrate on the physical sciences to go to a university that did not have a graduate program in mathematics.

Co-Nobelist Sheldon Glashow adds:

> The study of mathematics (including graduate education, undergraduate concentration, and research) has always been and will always remain an essential component to any entity purporting to be a university.

Joel Moses, a computer scientist and provost at MIT, wrote:

> I for one cannot imagine operating a school of engineering in the absence of a strong and research-oriented mathematics department. The same can be said for a school of science. I am also dismayed at the prospect of covering a substantial portion of the teaching load in mathematics with adjunct faculty. If you carry through with it, I predict that your programs in sciences and engineering will suffer a marked decline.

The University of Rochester has a well-known program in optics. In reply to a recent solicitation for graduate applications for an optics fellowship at Rochester, Professor Peter Pershan of Harvard wrote, "I will be happy to advise prospective students about the optics program at Rochester; however, the recent budget problems that have induced the University of Rochester to propose closing their mathematics graduate program will certainly be noticed by our students. It has already been widely discussed within our physics department."

George Backus, research professor of geophysics at the University of California at San Diego and a member of the National Academy of Sciences, wrote:

> At UCSD, the Institute of Geophysics and the Scripps Institute of Oceanography often recommend that our Ph.D. students take graduate courses in the UCSD Department of Mathematics. Modern theoretical geophysics and physical oceanography simply cannot be done without sophisticated modern mathematics. To teach these [advanced mathematical subjects] with sophistication and insight requires people for whom they are the primary research interest.

Expressing an industrial point of view, Neil A. Frankel, manager, Advanced Components Laboratory at the Xerox Corporation, wrote in the December 7 issue of the Rochester *Democrat and Chronicle*:

> It is evident that neither [Kodak nor Xerox] is well served by the elimination of two technology-related [graduate] departments [chemical engineering and mathematics]. To stay ahead of the very significant competition from Japan and elsewhere, [Kodak] will need all the quality engineering talent it can find. The availability of a quality university in Rochester enhances our ability to attract the very best people to our company. If graduate mathematics is eliminated, I really don't see how UR can support first-rate programs in the sciences and in engineering, and I fear that all of these will decline.

Professor Sir Michael Atiyah is director of the Newton Institute in Cambridge, England; he is master of Trinity College (Newton's own college), and he is also the past president of the Royal Society. Sir Michael emphasized the unity of pure and applied mathematics, writing:

> Increasingly the complex problems that scientists now face require more sophisticated mathematical understanding. The advent of more powerful computers has in no way decreased the fundamental relevance of mathematics. I can illustrate the

> scope of mathematical interaction with other fields by listing just a few of the interdisiplinary programmes that we have run at the Newton Institute in the past few years: computer vision, epidemics, geometry and physics, cryptology, financial mathematics, and meteorology.

Edward Dougherty, editor of the *Journal of Electronic Imaging*, wrote in the January 1996 issue:

> While at first this might appear to most people as simply one major research university deciding to restructure itself into a not-so-major university, for those of us in the imaging community there is much more at stake. Because it is home to both Kodak and Xerox, Rochester is one of the major imaging centers in the world, and therefore the future of imaging is closely tied to significant imaging events in Rochester. Suspension of graduate research and teaching in two key foundational imaging disciplines is not insignificant.
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> Chemical engineering plays a role in imaging materials, toners, and numerous other staples of digital imaging. The case for mathematics is even more compelling when it comes to digital imaging.
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> Simply put, there is no scientific phenomenology without mathematics. The kind of mathematics graduate courses necessary for contemporary research in image processing might simply cease to exist in the city of Kodak and Xerox.

One justification given by Rochester's administration for eliminating the mathematics graduate program is its perceived weakness in comparison with other programs. While acknowledging the presence of several world-class mathematicians on their faculty, the administration has been significantly influenced by rankings by *U. S. News & World Report* and by the National Research Council. However, many letter writers have defended the quality of the department, pointing out that its strengths are specialized. But in several subfields Rochester is extraordinarily strong, and in algebraic topology the department is among the very best in the country. Ironically, the areas of strength are subfields which have had a major impact on related disciplines (physics, economics, or engineering).

Marvin L. Goldberger, dean of the Division of Natural Sciences in the University of California at San Diego, was cochair of the recent NRC study of graduate departments. He is also president emeritus of the California Institute of Technology, former director of the Institute for Advanced Study in Princeton, and a member of the National Academy of Sciences. He wrote:

> I was absolutely appalled and dumbfounded to learn … of the University of Rochester's intention to do away with its graduate program in mathematics and to have only a service program in the field. It is hard to imagine that a first-rate university with an outstanding mathematics faculty (The National Research Council survey not withstanding, and as cochair of that study I speak with some authority on the significance of those rankings) would take such an action, no matter how dire financial circumstances might be.
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> Not only is mathematics an exciting and vital intellectual endeavor, but from a number of standpoints [it] plays an exceptional educational role at both the undergraduate and graduate levels. Advanced mathematics is essential in all areas of applied science; economics; technological risk analysis; to an increasing extent in fundamental and applied biology (e.g., drug design); in national security issues involving communication, cryptanalysis, satellite reconnaissance—the list is endless, but one more example is particularly relevant: in recent years topology has played a central role in elementary particle physics where string theory is a candidate for "Theory of Everything". This is another case of the remarkable and mysterious relationship between mathematics and the physical world. Topology is one of the strengths of the Rochester Mathematics Department.

Saunders Mac Lane, Max Mason Distinguished Professor Emeritus of Mathematics, University of Chicago, and former vice president of the National Academy of Sciences, wrote:

> I am surprised and shocked to see the extent to which NRC "ratings" have figured in the decision… I am famil-

iar with the work of the NRC. (I was chairman of the "Report Review Committee" of the NRC for eight years.) I simply do not think that these NRC ratings are serious enough to be used for administrative decisions at universities.... I do not think that the *U. S. News & World Report* has any standing whatever as a serious source of information. In particular the device of listing the "top 15" or the "top 30" seems to me almost meaningless... The use of *U. S. News* (page 2 of your "Rationale for restructuring" memo) to calculate the number of Ph.D. programs needed ["to attain a national ranking higher than Rochester's as an institution attractive to undergraduates"] seems to me barren and superficial ... As you know, the Rochester Mathematics Department has chosen to specialize in analysis and in homotopy theory (I know the latter field; Rochester is eminent there). This choice seems to me reasonable for a smaller university. However, it may have a strong effect on ratings, as, for example, for raters not familiar with homotopy there.

Barry Mazur, William Petschek Professor of Mathematics at Harvard University and a member of the National Academy of Sciences, wrote:

> The University [of Rochester] is one of the not-very-numerous places in the country where active research in number theory is undertaken. But this is not the only field of mathematics in which the current program at Rochester is important. In the hard classical problems in algebraic topology, for example, Rochester is very strong. Individually (and perhaps collectively) the algebraic topologists at Rochester are responsible for some of the most productive new turns in that field, and I guarantee you that few universities (Harvard included) could boast as distinguished a faculty in this area.

Richard Kane of the University of Western Ontario wrote:

> It is my strong belief that many of the students produced [there in topology] are outstanding—as good as topology students produced ANYWHERE. These students have created a very positive image of Rochester.

Dean Aslin explains what the university intends to offer its undergraduates in mathematics. "There are other ways to service our need for calculus instruction, including the hiring of nonresearch adjunct faculty and/or the redirection of other qualified faculty from other disciplines. ... The refocused department that emphasizes quality calculus instruction ... and individual research excellence will best serve the needs of the college. A reduction in steady-state faculty size over time from twenty-one to ten FTEs, with additional non-tenure-track teaching faculty who staff much of the elementary calculus sequences, can achieve these goals."

Kenneth A. Ross, president of the Mathematical Association of America (MAA), a professional organization with about 30,000 members concerned primarily with collegiate mathematics instruction, wrote on behalf of the Executive Committee:

> Mathematics and mathematics instruction are constantly changing. Recent initiatives by the National Science Foundation have, for example, resulted in major changes in the way that calculus is taught. Advances in technology have affected not only mathematics pedagogy but also the curriculum. To attract and retain the brightest undergraduates requires that those who are responsible for instruction be active mathematicians and be aware of the ways that both the subject and its instruction are changing.
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> In view of this the Board of Governors of the MAA at its annual meeting in January 1995 passed a resolution that makes it clear that it is a disservice to students and to the profession to relegate the teaching of mathematics to adjuncts and faculty from other disciplines.

Alan H. Schoenfeld, professor of education and mathematics at the University of California, Berkeley, wrote:

> My considered judgment is that, despite your best intentions, your plan for restructuring will inevitably worsen the quality of undergraduate mathematics instruction at Rochester. [It] is a recipe for disaster. Here are the two main reasons why. First, such a plan is likely to result in the complete demoralization of the department's faculty. The best researchers will leave because they can

and because the environment is clearly not hospitable to a major aspect of their professional lives. There is no way that you can hope to maintain a dedicated mathematics teaching faculty under those conditions. High-quality teaching takes place only where it is a widely shared priority and people are respected for it.

Second, there are very serious dangers in placing calculus instruction in the hands of others. After many years of stagnation the undergraduate mathematics curriculum, stimulated by "calculus reform", is undergoing a significant transformation. That reform has come from within the mathematical community and is rapidly taking hold within it. Keeping abreast of such change—in particular, major pedagogical and content changes in calculus—requires being connected to the mathematical community. Creating and delivering instruction consonant with reform requires both knowledge and commitment. The odds that faculty from other departments would (a) know about such reforms [and] (b) be willing to make the effort required to implement such changes in service courses outside their home departments are virtually nil. One of my responsibilities as chair of the Mathematical Association of America's Committee on the Teaching of Undergraduate Mathematics was gathering data on and trying to fix the "adjunct/temporary instruction problem" in mathematics. I'll be blunt in summary: such instruction is typically cheap, and you get what you pay for. A major instructional and administrative commitment is required to make appropriate use of such staff under the best of circumstances… I conclude that the changes you propose are almost certain to produce a significant lowering of the quality of instruction in mathematics courses—no matter how you staff those courses. This is the direct opposite of what you intend.

David Hoffman, head, Scientific Graphics Research Initiative, Mathematical Sciences Research Institute, Berkeley, recalled his undergraduate experience at Rochester:

> As an honors-program history major [at Rochester] with a strong interest in the sciences, I took graduate courses in mathematics, hung around the math department, and got to discuss math with graduate students and young faculty. I also attended many literature courses. I was exposed to a great deal of science firsthand in an atmosphere that highly valued the humanities and the arts. It is evident to me, and I hope it is clear to you, that this has been a strong influence on my career. For me, all these things came together around mathematics. Without a strong graduate program in mathematics, I could not possibly have had this formative undergraduate experience. Such an experience will be impossible after the "Rochester Retrenchment". Replacing mathematics professors by part-time and temporary workers will lower the quality of instruction at the entry level. A "teaching specialist" in calculus could never have given me the insight, challenges, and encouragement I got from professional research mathematicians at the U. of R., even those who were not great classroom instructors...

Tom Davis, principal scientist at Silicon Graphics, wrote:

> No matter how much time you spend trying to convince yourselves otherwise, this will certainly hurt the quality of your undergraduates' mathematics education (and hence their education in all the engineering and scientific fields).
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> In the thirteen years since I helped to found the company Silicon Graphics, I've noticed that it is becoming more and more difficult for us to hire students with a sufficient background in mathematics. Every year we require more, and the students seem to have less. So if you're interested in producing students who can compete in these rapidly growing job markets, you should be thinking about how to increase the amount and quality of mathematics they learn.

Richard Ernst, Nobel laureate in chemistry, wrote:

> The natural scientists and engineers at the ETH [Swiss Federal Institute of Technology] would very violently re-

> ject a proposal that the courses in mathematics should be given by members of their own applied departments or by mathematics teachers who are not at the same time active at the research front.
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> I expect that universities with a weak or nonexisting mathematics department will be the first ones to disappear. I am sure that you do not want the University of Rochester to belong to those institutions.

Summing up, Herman Feshbach, the former chair of the M.I.T. Physics Department and past president of the American Physical Society, remarked, "With one action, Mr. Jackson has reduced Rochester to a second-rate university."

On December 6, 1995, the American Mathematical Society sent a fact-finding delegation to Rochester. On December 12, President Cathleen Morawetz sent the report of that committee to President Jackson, along with a letter stating in part: "Let me state firmly that in tough times tough decisions must be made and everything is on the table. I have learned this as director of the Courant Institute of Mathematical Sciences (NYU) (1984–1988), trustee of Princeton University (1972–77), director of NCR (1978–1990), and trustee of the Sloan Foundation (1980–1995). This has also given me insight into how decisions are made and ought to and can be changed before they do irreversible damage."

She also offered the assistance of the Society in finding a way to preserve the integrity of the mathematics program consistent with the overall goals of the university.

In the absence of any change in the Rochester administration's position, the Society has appointed a task force, chaired by the president-elect. The task force, while still being formed, consists of mathematicians and prominent scientists as well as persons from the world of business. It is a testimony to the central role of mathematics that Marvin Goldberger and Alexander Rich have agreed to serve along with others on the task force, as have Nobel laureates Walter Gilbert (biology), Dudley Herschbach (chemistry), Robert Solow (economics), and Steven Weinberg (physics). The charge of this group is to follow developments, to inform the community, to facilitate assistance to Rochester, and to solicit support.

Every two years the American Mathematical Society invites a well-known scientist from outside mathematics to address the Society. This Gibbs Lecture is a major event, generally attracting several thousand listeners. In January 1996 Steven Weinberg ended his Gibbs Lecture with a description of the central role of mathematics in all of science and a forceful statement that the closing of the graduate program in mathematics at Rochester is a symptom of general malaise in our universities. Weinberg concluded, "I am proud to be a member of this task force."

This groundswell of protest from the scientific community demonstrates that the Rochester plan is not only bad for mathematics, but it is also bad for the University of Rochester, it is bad for American science, and it is bad for the country.