Graduate and Postdoctoral Mathematics Education:

Excerpt from a document prepared for the Council, April 2002

At its meeting on April 13, 2002, the Council discussed mathematics graduate and postdoctoral education. The following essay and several background articles were included as background for the discussion.

Is mathematics graduate education in trouble?

Mathematics graduate education in the United States grew in the early part of the twentieth century as an amalgam of practices from other countries (with Germany[1] the most prominent). American mathematicians adopted customs from abroad into a different environment, however, in which universities served multiple purposes, often more practical than in Europe, and the fit wasn't always perfect.

From the beginning, there was concern about the American doctorate. The long-time Secretary of the AMS, R.G.D. Richardson, wrote an article[2] in the 1936 MONTHLY on "The Ph.D. degree and mathematical research." The aim was to measure how many doctoral recipients remained active in research. The answer—not many. Of the approximately 1300 mathematicians who received Ph.D.s in the period 1862-1933, only 16% had published more than five papers; nearly half had published no papers at all.

Concerns changed in the 1960s as the production of Ph.D.s in the mathematical sciences increased by seven-fold over a decade. New programs sprang into existence as funding expanded and undergraduate enrollments in mathematics and science ballooned, requiring many teaching assistants to accommodate them. It was during this period that the present configuration of heavy use of graduate students for the teaching of elementary courses or recitation sections was put in place. And these same programs struggled in the next decade as funding dissipated, enrollments steadied, and the job market collapsed in the early 1970s.

The difficulties during this period emphasized once again that most Ph.D.s spent their careers teaching (even before receiving a doctorate), and people worried that doctoral programs didn't provide much preparation for the careers most students would pursue. There were sporadic efforts to provide supplemental training (many still in existence), and there was even talk of a *new* degree—the doctor of arts degree—aimed at preparing mathematicians for a life of scholarship rather than a life of research.[3]

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[1] Germany was the country where the largest number of productive research mathematicians received their graduate or post-graduate education.

[2] R.G.D. Richardson, The Ph.D. Degree and Mathematical Research, MONTHLY 43, 1936, 199-211.

[3] Two good examples of such attempts are included with the following material: I. N. Herstein, MONTHLY 76(7), 1969, 818-824, and W. L. Duren, MONTHLY 77(6), 1970, 641-646.

None of this worry had much effect. There are approximately 200 mathematics doctoral programs in the United States, and most have a remarkably similar structure: course requirements, comprehensive or qualifying exams, an advisor, a thesis committee, and a dissertation. There are certain variations in this structure, and occasionally some serious questions about modifying the pieces. Should course requirements include coursework outside mathematics? What's the purpose of the qualifying exams (and the level)? Should there be a way to advise advisors (some of whom are "unskilled")? What should be the roll of the thesis committee (which is remarkably different in mathematics than in other sciences)? What constitutes an acceptable dissertation? And in general, how long should this whole process take? Four years? Six? Eight?

Much of the discussion about the structure of graduate programs is driven by two factors—the job market and the supply of new graduate students. A poor job market inevitably leads to calls for change, usually by changing the course requirements (computer science comes up often) or by adding more practical components to the degree (industrial experience and teaching apprenticeships) The shrinking supply of graduate students is often related less to the graduate program itself, and more to the role of graduate students as teaching assistants. This leads departments to increase the number of domestic students, and secondarily changes the graduate program to accommodate the new mix of students.

Letting these two factors drive the discussion about graduate education misses the essential point, however. Both are important, but they are not *fundamental*. The problem of a varying job market is ephemeral, waxing and waning over the years (which means the efforts it drives wax and wane as well). The supply of graduate students is largely a problem in undergraduate and even K-12 education in that students lose interest in graduate school long before they ever have a chance to enter it.

The most fundamental issue in graduate education is: What is the purpose of the Ph.D.? Mathematicians in doctoral departments are often unaware that only 25% of their students begin their careers in doctoral departments themselves—and a much smaller percentage end up in doctoral departments for the careers. In addition, about 25% of doctoral recipients move outside academic life during their careers.[4] Should these facts change the structure of doctoral programs? Should doctoral programs provide greater flexibility? What should be our expectations for doctoral programs? These are fundamental questions.

In addition to these abstract issues, there are some harder, more practical questions as well. Not all doctoral programs are the equal. Some are small, producing only a few doctorates over a period of years. Some programs have few graduate courses to offer students, relying mainly on supplemental reading. Some larger programs run for years without thoughtful reflection about either the quality or the substance of the program.

[4] Interesting to note that these percentages seem to have changed dramatically over the years. According to data in the article by R.D. Anderson (MONTHLY 77, 1970, 626-641), during the period 1966-69, approximately 50% of the Ph.D. recipients took first jobs in doctoral granting institutions and about 12% took jobs outside academic life.

Should there be minimal standards for graduate programs? If so, should there be a certification process? To what extent should the community of mathematicians intervene in the affairs of individual departments?

Is mathematics graduate education in trouble? Many people say it is, but surprisingly little seems to have changed. Are there nascent changes underway? Should there be? Is there a role the AMS should be playing? These are the questions that the issues that Council will discuss.

John Ewing

Other Included Material

- **Should Doctoral Education Change?**
  An article by Allyn Jackson, NOTICES, January 1996, 19-23. This describes some of the debate in the community about graduate education following the report of the National Research Council on graduate education in science and engineering mentioned below.
  http://www.ams.org/notices/199601/comm-grad.pdf
- **On the Ph.D. in Mathematics**
  An article by I. N. Herstein, MONTHLY 76(7), 1969, 818-824. This is wonderfully written, even if one disagrees with the conclusions. It provides a clear view of the situation just before the end of the great expansion of the 60s, and introduces the notion of a different graduate degree—the doctor of arts.
- **Are there too many Ph.D.s in Mathematics?**
  An article by W. L. Duren, MONTHLY 77(6), 1970, 641-646. This provides an even clearer view of the situation just *after* the collapse. It concentrates on the definition of Ph.D., and can be summarized by a single sentence on page 644 in which he writes, "we need in this country at least ten people with a full graduate education, which gives them a broad capability in mathematics and its related sciences, for every one research specialist."
- **2000 Annual Survey of the Mathematical Sciences (second report)**
  There are three reports published in the NOTICES for each survey. This provides data about graduate students completing dissertations, their first employment, and information about diversity.
  http://www.ams.org/notices/200107/00second-report.pdf
- **Graduate Student Data**
  This is a compilation of data for the past five years, giving the number of graduate students (as well as first year graduate students) in Group I, II, and III departments.
- **AMS Graduate-Related Programs and Services**
  A list of programs and services either for graduate students or affecting them.
- **Agendas for Committee on Education and Committee on the Profession**
  Illustrating the kinds of issues that are discussed by both committees.

- **VIGRE Program Solicitation, Excerpts**
  The National Science Foundation program *most* directly related to graduate and postdoctoral education.
- **Summary: Directors of Graduate Study Focus Group**
  Notes from a recent meeting of directors, specifically addressing concerns about the VIGRE program and its effect on mathematics departments.

Additional References

- **The Ph.D. Degree and Mathematical Research, MONTLY 43, 1936, 199-211.**
  This is one of the first detailed studies of American doctoral students and their careers. The data is flawed, but the conclusions are correct and fascinating.
- **Are there too many Ph.D.s?**
  This is an article written at the same time as the Herstein and Duren articles above. The article is by R.D. Anderson, MONTHLY 77, 1970, 626-641. It provides a detailed analysis of what happened to the job market as well as projections for the future. Much of it was based on the AMS annual survey.
- **Renewing U.S. Mathematics: Critical Resources for the Future**
  This is the "David Report" published by the National Research Council, National Academy Press, 1984. A substantial part of the report is concerned directly or indirectly with graduate education.
- **Renewing U.S. Mathematics: A Plan for the 1990s**
  This is the update of the David Report, also published by the National Academy Press, 1991. http://www.nap.edu/catalog/1598.html
- **Educating Mathematical Scientists: Doctoral Study and the Postdoctoral Experience in the United States.**
  This report came from a committee of the Board on Mathematical Sciences and was edited by Ron Douglas, appearing in 1992. It summarizes practices of a number of successful doctoral programs. http://www.nap.edu/catalog/1996.html
- **Graduate Education and Postdoctoral Training in the Mathematical Sciences.**
  A report from an NSF workshop held in 1995, and published by the National Science Foundation. It emphasizes the balance between research and education, encourages broadening the content of graduate programs, and suggests ways in which NSF might help. http://www.nsf.gov/pubs/stis1996/nsf9630/nsf9630.txt.
- **Graduate Education in Science and Engineering**
  This report comes from the Committee on Science, Engineering, and Public Policy of the National Research Council, and it is often referred to as the COSEPUP report. The committee was chaired by Phil Griffiths, and the report was published by the National Academy Press in 1996. http://www.nap.edu/catalog/1996.html.
- **NRC Report on Graduate Education**
  This is an article by Allyn Jackson in the NOTICES, September 1995, 984-987. It summarizes the mathematical community's reaction to the preceding COSEPUP report. http://www.ams.org/notices/199509/nrc-report.pdf

- **Enhancing the Postdoctoral Experience for Scientists and Engineers ...**
  This is another report from the Committee on Science, Engineering, and Public Policy, published by the National Academy Press in 2000. It is meant to serve as a guide for all those involved in postdoctoral education.
  http://www.nap.edu/catalog/9831.html.