NRC Report on Graduate Education

In April, the Committee on Science, Engineering, and Public Policy (COSEPUP) of the National Research Council (NRC) released a report presenting the results of a one-and-a-half year study of graduate education in science and engineering. The report, entitled *Reshaping the Graduate Education of Scientists and Engineers*, examines the trends behind shifts in employment of science and engineering doctorates and makes recommendations for ways in which graduate programs can respond to the changing climate.

In the last few years, many new science and engineering doctorates have had trouble finding permanent employment, especially in academia. The frustration of many of these young people is apparent on the e-mail networks, such as the Young Scientists' Network and the Young Mathematicians' Network, that have sprung up since the job market began to sour.

Cautious in its approach, the NRC study sounds no alarm bells about the job market. It says that the unemployment rate of scientists and engineers, around 1.5% during the 1990s, "compares favorably" with the rate of 6% for the nation as a whole. But the report does acknowledge that much of the pain of the job market has concentrated on new doctorates, a group which in some fields has experienced double-digit unemployment rates. These young people "eventually do find employment, but in some fields the process is taking much longer than it did for their predecessors," the report says. Data from the AMS-IMS-MAA Annual Survey are cited in support of this observation.

The report examines long-term trends in where new science and engineering Ph.D.s are being employed. One surprising conclusion: The percentage of recent Ph.D.s who are employed in academia fell from 51% in 1977 to 43% in 1991. However, this trend was not borne out in the mathematical sciences, where the analogous figures are 74% and 76%. (The report mentions that the 76% figure was a one-year rise that followed "years of decline", though just how large a decline is not indicated.) The percentage of new science and engineering doctorates employed in industry increased from 26% in 1977 to 34% in 1991; the percentages in the mathematical sciences were 12% and 19%, respectively.

On the strength of such data, the report asserts that job opportunities in business and industry will grow. "Over the long term, demand for graduate scientists and engineers in business and industry is increasing," the report states. "[M]ore employment options are available to graduate scientists and engineers who have multiple disciplines, minor degrees, personal communication skills, and entrepreneurial skills."

In collecting information for the study, the committee sent out a call for comments to graduate students, postdocs, professors, academic administrators, industry scientists and executives, and representatives of scientific societies—over 1,000 individuals in all. More than half of the 100 responses came from people in industry, and the report emphasizes their comments. Generally, industry seems to value science and engineering doctorates not so much for specific knowledge but more because they are trained to be analytical, pragmatic, and flexible problem-solvers. The narrow specialization necessary for a Ph.D. was sometimes cited as a drawback, for

industry prefers generalists with a wide range of scientific and analytical tools at their command. Excellent interpersonal and communication skills and the ability to be a "team player" were also deemed desirable.

Perhaps a new type of degree, requiring less original research and more breadth, is in order? The report rejects this idea, saying that such a degree would likely be viewed as a sort of "Ph.D.-lite." Instead, the report advocates adapting the doctorate to include broader academic preparation, expecially coursework in areas outside one's specialty, and more opportunities for industrial internships and interdisciplinary research. The report also emphasizes the importance of maintaining high-quality standards for the doctorate and not increasing the already long time-to-degree. No specifics are offered on how to accomplish this. Instead, the report stresses "local initiative": individual institutions coming up with ideas and standards that work within their own local conditions and that build upon their strengths and interests.

One of the few concrete suggestions in the report is the idea of "education/training grants" to support graduate students. These grants would be made to departments or programs, rather than to individual faculty members. Proposers would have to describe a plan to improve the versatility of the students and to upgrade the advice that faculty give about the full range of employment options. As an example of what a "winning" proposal for an education/training grant might include, the report suggests "an interdisciplinary degree program that [allows] a mathematics Ph.D. student to obtain an MS in engineering."

The report's executive summary lays out a number of formal recommendations which are elaborated in the final chapter. The first recommendation is to offer a broader range of academic options; this would be achieved through changes in graduate programs as well as adjustments on the part of funding agencies in support mechanisms for graduate study. The report emphasizes that individual institutions should take the initiative for change, building on their own strengths and interests, but offers no specifics on what kinds of changes should be made.

The second recommendation is to make better career information available to graduate students. The report envisions a "concerted nationwide effort" to build a national electronic database on employment options and trends that both students and their advisers could tap into. The report also suggests that, when students have completed their qualifying examinations and are about to start the research phase, advisers should encourage students to examine three options: stopping with a master's degree, working toward a Ph.D. with the goal of continuing research, and preparing for work in a nontraditional field by designing an original dissertation that would take less time than a traditional one. "We believe that the first option is typically undervalued and the third option often neglected," the report states.

The final recommendation is to devise a national "human-resource policy for advanced scientists and engineers." To this end, the report calls for a "searching national discussion" about the nation's needs for science and engineering doctorates so that goals and policies can be established for graduate education in these areas. COSEPUP chair Phillip A. Griffiths, director of the Institute for Advanced Study, says that the Government-University-Industry Roundtable, the American Association of Universities, and the Council of Graduate Schools are among the organizations that might lead such a national discussion.

Does the Report Apply to Mathematics?

One question being asked in the mathematical sciences community is how well the report applies to mathematics. For example, the report shows that, of all fields of science and engineering, mathematics has historically had one of the lowest percentages of new Ph.D.s going into industry and one of the highest going into academia. Against this backdrop, does the report's conclusion that growth in jobs is to be found in business and industry apply to mathematics? Griffiths replies: "It could apply a lot better." Currently, doctoral training in mathematics does not prepare students to contemplate a wide range of options for what they might do after the Ph.D.. "The mathematical community is as isolated from what mathematicians might do as any of the other scientific communities," he added. "Compared with other scientific fields, mathematics has been among those that most emphasize preparation for traditional academic research careers. A number of universities, such as Duke, are now actively explaining ways of broadening career options, and this is a very healthy trend." Indeed, Griffiths says he heard the reaction, "This report does not apply to us," from all fields. While recognizing the enormous variation among fields, he believes that the report focused on some common patterns that appeared across the board.

In fact, the report concludes that when it comes to jobs in business and industry, the particular field is not so important. "To some extent the actual area of specialization of a Ph.D. may not be the essential point in the years to come," Griffiths notes. "An in-depth, independent research experience is what's valued, and it

sometimes matters less whether it's in physics or chemistry, or mathematics." However, says Griffiths, it is important that, for example, all mathematics Ph.D.s do not come out of graduate school with the expectation that their main professional activity will be to prove theorems.

COSEPUP member Felix Browder of Rutgers University says he has not heard many reactions to the report, except the comment that it doesn't contain any "sensational" recommendations. "But I don't know if there are any sensational recommendations to be made," he notes. "There is no panacea, no magical solution to these problems." Some of the ideas for recommendations the committee considered and rejected would probably have done little good and might very well have done damage. Pointing to the "deplorable state" of the academic job market, he states, "People had better be aware and be open to all possibilities. That's about the only moral one can draw."

Indeed, as Browder sees it, the causes of the job market crunch are far beyond the reach of an NRC committee. They stem from a far-reaching depression in academia and from state budget policies that call for such priority shifts as reducing higher education to build more prisons. "To put it bluntly, I think [mathematics is] in a terrible state as far as jobs are concerned," says Browder, "and I don't see it changing." Although the report portrays business and industry as an expanding job market for science and engineering doctorates, he is "not terribly sanguine" about such prospects for mathematics Ph.D.s. For example, many of the large industrial laboratories that once hired mathematics doctorates are now cutting back, while the growth is expected to be in such areas as biotechnology.

Griffiths is more upbeat about the prospects in business and industry. As an example of what a mathematics Ph.D. might do as an alternative career, Griffiths pointed to the area of corporate finance. The "mathematician on Wall Street" has become fairly common with the proliferation of new financial instruments such as derivatives. In a similar way, corporate finance is becoming more complex. "Corporate finance used to be glorified accounting," says Griffiths, "but now it's applied mathematics." For example, if a corporation is considering building a new plant, the prospect needs to be formulated and priced as an option, not just in terms of the present cost of materials, labor, etc. "This is a huge potential area of employment for mathematicians, provided one has some exposure to the business world," Griffiths maintains. He says the consensus seems to be that for such work it may be better to get a mathematics doctorate and have some business training on the side, than to get a business degree and pick up some mathematics. (A statement with almost the opposite meaning was attributed to Griffiths in a *New York Times* article about the report. Calling the *Times* reporting "awful", Griffiths says the reporter bungled the quote.)

Some who have been on the job market recently praised some parts of the report and expressed skepticism about others. "All the talk of versatility is really an implicit admission that the job you're being prepared for is likely not to materialize when you're ready to enter the market," says David Atkinson of Western Kentucky University. Although Atkinson, who received his Ph.D. in 1992, recently joined an insurance firm, he says he did not find it at all easy to attract interest outside academia. "The simple fact is that the skills a pure mathematician learns in grad school are not in high demand in industry," he says. Of the report's call for graduate programs to broaden training of their students, Edward Aboufadel says, "I'm not optimistic that this change can occur, given that graduate programs are staffed primarily by academic researchers." Aboufadel, who received his doctorate in 1992 and has been active in the Young Mathematicians' Network, has taken a tenure-track position at Grand Valley State University in Michigan.

Joseph Lipman of Purdue University, a member of the AMS Committee on the Profession, says that the mathematical community has slowly and for a very long time been "broadening" the training of mathematicians. "But whenever we succeeded too well, that piece of the department split off and became a Department of Statistics, or of Computer Science, or of some kind of Engineering," he says. "It will continue to happen, not by fiat, and not because some blue-ribbon group meets a few times and gives expression to some megalomaniacal fantasy about formulating national policy, but because talented individuals will discover and act on the opportunities afforded by the circumstances of their time."

Lipman says that there are some good examples of mathematical programs that have successfully reached out to business and industry. "But you can't just say to any math department, 'Let's start an industrial progam and broaden our students,"' he maintains. "Few people know what to do or have the right background." The report says all the right things, "but we've heard an awful lot of that sort of exhortation in the past few years. So what else is new? It's that we're also seeing some action, both from the professional societies and from some dedicated individuals. That's what I'd like to see publicized."

The report has been criticized in some quarters for carrying the message that the job market for science and engineering doctorates is

not so bad. Atkinson says statistics understate the severity of the problem because they do not take into account the many new Ph.D.s who are underemployed, take jobs at their Ph.D. institutions, or have a series of temporary positions. "It's hard to give much credence to reports of low unemployment when I have seen and experienced so much difficulty," he says. Aboufadel questions the report's assumption that job growth outside academia is sufficient to absorb recent Ph.D.s. "I have been under the impression that jobs in industry were scarce," just as they are in academia, he says. "What reliable data are they using for [such statements]? Why is there such faith in the nonacademic employment market?"

Griffiths says that COSEPUP wanted the report to make a strong statement about the difficulty and dislocation that occurs when science and engineering Ph.D.s leave graduate school. "It's a giant nightmare," he says. But on the other hand, with a 2% unemployment rate for science and engineering doctorates overall, one cannot complain too loudly. "If you go into the world outside of the academic research community and you say you only have a one-year position with no benefits, you wouldn't get a lot of sympathy," he notes. He says one must look at the world at large, where there is a great deal of upheaval in terms of employment.

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The report discusses the issue of foreign graduate students, which has been the subject of sometimes heated debate within the science and engineering community. Some say that foreign students provide a larger pool from which to draw the most talented potential scientists, while others argue that foreign doctorates end up competing with U.S. citizens for jobs or return home to work for economic competitors of the U.S. The report does a good job of presenting both sides of the issue and concludes that limits on the number of foreign students is not a good idea. The report then goes on to say that its recommendations would "make graduate education more attractive, more effective, and accessible to a larger group of qualified American applicants."

If the job market is open to all the top talent in the world, Atkinson says, it makes little sense to encourage more Americans to go to graduate school. "We must accept that Americans are only five or six percent of the world population, and therefore only the most spectacularly talented Americans should expect prosperous science careers in their home country... Encouraging more Americans to enter graduate school when the job market is open to all the top talent in the world seems to me some mixture of foolish nationalism and cruelty."

Offering a different view, John Polking of Rice University agrees with the report's conclusion that no limits should be placed on the number of foreign graduate students. Foreign doctorates contribute a great deal to the U.S., he notes, and in many cases the political conditions in some countries that led to a large influx of foreign graduate students have stabilized. In addition, as other countries continue to develop their own graduate schools, students will stay in their home countries to study. Polking also agrees with the report's conclusion that attempting to cap graduate enrollments is a bad idea. If information on the job market is made available to potential students, "the students themselves would then do an efficient job of controlling the number," he states. "It is difficult for me to see how any governmental or professional organization could do a better job."

Amid all the concern about expanding opportunities for new Ph.D.s outside of academia, little attention has been paid to the impact the job crisis could have on the field of mathematics. Browder says that mathematics has never had an employment crisis like this one, not even in the 1970s. He views the recent, small decline in numbers of graduate students and Ph.D.s in mathematics with a mixture of relief and wariness. "I am very concerned—apart from a humanitarian concern for young people—that the net effect will be to drive people out of mathematics," he says. "Can we get enough bright young people into the field? If we can't do that, then mathematics will diminish if not disappear in this country."

—Allyn Jackson