The state of doctoral education in the United States, particularly in the sciences, is a matter of current concern. A number of people believe that we are producing too many PhDs in relationship to the jobs and research opportunities available, and that the scientists we are producing are being too narrowly trained to be flexible in terms of their career aspirations. The background and some of the current positions are reviewed, and several different approaches for broadening the graduate education of scientists are discussed.

The last time I wrote an article for the AJPE was in 1977. The November issue was the Proceedings of the AACP Teachers Seminar, which that year was devoted to considering issues in graduate education and research. I had presented a paper titled, “The Outcome of Graduate Programs: A Question of Values.” As I reread that article in preparation for writing this one, I was struck by the fact that there has been relatively little change in the problems we discuss (vocational training vs. education in science, cost effectiveness and it’s relationship to quality, etc.), and gratified to learn that I still believe in the ideas I expressed then. Although the times are different, we still wrestle with the same problems. A colleague recently expressed his view of doctoral education for today, and I believe it is worth sharing as a prelude to this piece. “We do have a clear plan. It is based on the premise that the traditional concept of the PhD is not flawed, but that traditional practices need to be rigorously overhauled in order to bring the highest standards of excellence to every step in the educational process.”

The relationship between PhD production and jobs has been of great interest to people involved in human resources planning, university and industry administrators, faculty members, and certainly, students. Ever since Vannevar Bush’s famous paper, Science, The Endless Frontier(1), published after the end of World War II, public and personal investment in doctoral study, particularly in scientific and technical areas, has been widely viewed as being in the national interest, and generally speaking, has been a good investment, considered from almost any point of view. Particularly in the period 1958-1972, when the academic establishment was growing by leaps and bounds and prospects for faculty jobs were very good, bright students were being encouraged to consider graduate school.

In the early 1970s, for a variety of reasons, the academic job market tightened considerably and many disciplines began to discourage prospective students from going to graduate school. The situation turned around by the end of that decade, and we entered the 1980s with good prospects for growth. PhD production, which had been stable for some years, began to increase, largely due to an influx of foreign students in the sciences and engineering, and to a rapidly growing female presence in the doctoral ranks, albeit not in the scientific and technical areas.

Beginning in the late 1980s, and continuing into the early 1990s, several books, articles, and studies appeared that projected an impressive shortage of PhDs, particularly in science and engineering, as well as similar shortage of faculty members(2-5). This was seen as a “window of opportunity,” particularly for minorities and women, but also for American students in general whose presence in these fields had been declining. Recruitment was the order of the day, and the number of doctoral degrees granted during this period increased every year, setting new records each time, and leading to a total of approximately 42,000 in 1994, 27,000 of them in science and engineering(6).

Projections about the future state of the job market affect student demand, but often produce unanticipated results. The problem is that it takes 6-8 years to get a PhD, and in a period like the last twenty years, that is, a period characterized by a high degree of economic uncertainty and instability, the only really predictable outcome relating to the labor market is that unanticipated events are likely to occur that will confound projections based on current events. This is what happened at the beginning of this decade, and for the first time in at least twenty years, new PhDs in physics, chemistry, mathematics, biological sciences, and various engineering disciplines began to encounter difficulties in finding the jobs they wanted, particularly jobs that permitted them to continue to do research in their chosen fields. Although the unemployment rate for PhDs remained low (1-2 percent), the length of time it took to find a first job increased, the rate of underemployment increased, and in almost every field, the number of students taking postdoctoral positions increased(7).

All of these factors, plus an increasingly bitter chorus of complaints from new PhDs who felt they had been misled into devoting long years of hard work for nothing, led to a new series of studies, papers, and reports whose general theme was the need to reform graduate education, particularly at the PhD level. The most widely discussed was probably the report from the Committee on Science, Engineering, and Public Policy (COSEPUP) of the National

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1President, Council of Graduate Schools.
2Personal communication: Robert E. Thach, Dean, The Graduate School of Arts and Sciences. Washington University in St. Louis, September 24, 1996.
Academics titled, *Reshaping the Graduate Education of Scientists and Engineers*(8).

Criticisms of doctoral education have focused on two concerns: that we were producing too many, and that they were too narrowly trained for today’s job market, either in academia or industry. Although some universities are cutting back on graduate enrollment in some programs because of financial or other institutional factors, the COSEPUP report does not suggest any general or systemic attempt to decrease doctoral production. There really is no way to do that in the United States because of the highly decentralized nature of higher education here. Some states have taken actions to reduce support for doctoral programs, and reductions in federal grant support could affect the availability of research assistantships, but for the most part, the attitude has been to let the market work, and not to tinker or attempt artificial “fixes.” In this regard, it is interesting to note that in a recent set of interviews in Science(9), both President Clinton and Senator Dole, in answer to the direct question, “Are we training too many scientists?” said no, and defended investment in graduate education as good public policy.

Qualitatively, much of the discussion has centered on the consequences of specialization, and on the belief that many graduate students are too narrowly trained, too focused on their dissertation research projects, and that this does not adequately prepare them for modern academic or industrial jobs, let alone for other jobs and careers. The COSEPUP report stresses the idea of a broader preparation for doctoral students, one that would give them a larger context within which to place their research specialization. The emphasis is on making students more versatile so that a wider range of career options is available to them. Science and Engineering indicators(10), in referring to the COSEPUP recommendations, emphasizes that “…doctrinal students will need more education than training—education in the broad fundamentals of their fields, familiarity with several subfields, the ability to communicate complex ideas to nonspecialists, and the ability to work well in teams.”

**APPROACHES TO CHANGE IN GRADUATE EDUCATION**

Several qualitatively different kinds of approaches have been suggested:

A. Provide better information about jobs and the job market. Stop referring to anything other than academic or industrial research jobs as “Alternative Careers.”

Given the uncertainties in predicting or projecting what the job market will be when current students graduate, they need to be made aware that there are no guarantees, and that their graduate education is applicable to a wide variety of career options. John Armstrong, in a perceptive article titled, “Rethinking the PhD” stated what I believe to be the essence of the issue: “The training of new PhDs is too narrow, too campus-centered, and too long. Furthermore, many new PhDs have much too narrow a set of personal and career expectations. Most do not know what it is they know that is of most value. They think that what they know is how to solve certain highly technical and specialized problems... Of course, what they really know is how to formulate questions and partially answer them, starting from powerful and fundamental points of view.”(11)

B. Provide seminars on the uses of graduate education in a particular field, and on how graduate education relates to work. Make these available to seniors and new graduate students. Bring back former graduates to talk about their careers and the role graduate education played in their lives.

C. Add more academic content. Here, several different philosophies prevail:

1. Develop minors or collections of courses in closely related areas, *e.g.*, molecular biology for medicinal chemists,—statistics for pharmacologists,—computer science for everyone. The idea is to broaden the scope, but stay close to the student’s major field of study. The student would still plan to “do science,” that is, to be directly involved at the bench.

2. Develop survey courses (perhaps as Certificate programs) in very broad but related areas, *e.g.*, environmental sciences, which can be considered, at least at one level, a place to study the relationship between chemical structure and biological activity. In the social sciences, students have been doing this for years with area studies programs. For example, economists with special interests in Asia might take a certificate program in East Asian Studies. The idea is to retain your expertise, but add a special context. The plan is still to do science, but in a specific area.

3. Develop courses or certificates in totally unrelated areas, *e.g.*, business, journalism, public health, education. In this case, the student no longer plans to do science, but to use it applied to something else—sales, writing, K-12 teaching, etc.

4. Develop programs similar to the Mres (Master of Research) degree recently initiated in the United Kingdom(12,13). Students from different disciplines are brought together to discuss and dissect research in a number of fields. The point is to illustrate the process of defining relevant questions and finding answers that is the basis for scholarly research in all fields. This kind of approach also emphasizes multidisciplinary aspects of problem solving. It is particularly useful for new graduate students. A modification of the Mres approach would be to have all graduate students participate in a research seminar that is multidisciplinary (not just in science and engineering, but including humanists, etc.). Real world problems—global, national, local, etc. would be discussed, and students might work in groups, and/or react to speakers. The emphasis would be on scholarly approaches to evaluating evidence, posing questions and suggesting ways to find answers.

All of these suggestions make sense. Some have been in place for years, some are now being considered, and some have recently been instituted. All suffer from the same drawback: they take time and increase the workload for students and faculty alike. The justification for this expenditure of time and effort is that it will improve the education and the career prospects of the student. If that is what we believe graduate education is all about, then the best advice for graduate students is that today’s job market doesn’t tell us much about tomorrow, just as yesterday’s didn’t tell us much about today. Students should keep their eyes and ears,
their minds, and their options open. The best advice we can give to graduate faculty members is this: In order to prepare students for a variety of possible careers, don't prepare them for any one. Instead, make sure they know their fields, understand the processes of scholarly inquiry, and have a realistic picture of how they can use these incredibly valuable skills in a variety of ways, in a variety of settings, and in a variety of satisfying and rewarding careers.


References
(1) Bush, V., Science, the Endless Frontier, Arno Press, New York NY (1980); (Reprint of 1945 ed.).