

Department Chairs Conference

RETHINKING THE PhD

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My views on the deficiencies of PhD training were formed during thirty years in industry, as a practicing scientist, a manager of scientists, a manager of development engineers, and as Dir. of Research. The current situation, in which jobs in many fields are scarce, and in which the whole national R&D enterprise is being rethought, reinforces, I believe, the appropriateness of what I am about to say, but these current concerns are not the source of my views.

It will be well known to this audience that many engineering schools have recently reassessed their masters degree programs, and many schools have made significant changes in those programs. But there has been little serious reassessment so far of the underlying assumptions, expectations, and requirements of PhD programs in science and in areas of engineering closely allied to science. In my view it is time for such a reassessment.

Depending on the particular scientific field, up to 90% of PhDs will end up working in settings other than a research university. The presumption seems to have been that the process designed to train research professors will do as well as can be done in preparing graduates for employment as science and engineering PhDs in non-traditional roles; teaching in four year colleges, or doing research in industry, or working in government, for example.

Certainly the traditional PhD training is not bad preparation for non-traditional roles, but I believe it can be done better. I grant you that in many respects the PhD programs in science and engineering are in good shape. The technical sophistication of new graduates in their specialties is often breathtaking. New PhD graduates are still the best "vehicles" in the world for technology transfer. Actually, that's not quite right: the best technology transfer vehicle is the moving van which delivers a new PhD to his or her first job. The key to the transfer is the movement of people.

And yet ... there are serious problems as well, problems I came to see over many years of hiring and managing new PhDs. In brief, it is my view that the training of new PhDs tends to be too narrow intellectually, too campus-centered, and too long. Moreover, these deficiencies tend to be worst in what are considered the best universities.

Furthermore, and this is perhaps the most serious of all, many new PhDs have a very confined set of personal and career expectations. The "paradox", of course, is that in the course of deep, specialized inquiry one acquires an intellectual armamentarium and outlook that may be of great general utility. The training of the scientific or engineering specialist in fact provides much of what might be termed training for the advanced technical generalist. It is a further part of the paradox that many new graduates do not seem to value this powerful generalist capability--perhaps because their professors do not value it either as a rule.

This acceptance of over-specialization often has unfortunate consequences for the new engineering scientist's view of him- or herself. Overspecialization can result in a lack both of perspective and of self-confidence; they often believe themselves ill prepared to venture outside their specialty to use their powerful training in jobs in development, manufacturing, and technical management, let alone in tasks even farther afield from their specific training. The burden of over-specialization is compounded by their often total lack of work experience outside the university and by a culture which still, all too often suggests to them that becoming like their professor represents real success.

This paradoxical situation is due in part to the lack of serious requirements for scientific and technical breadth in the typical graduate curriculum, as well as to the fact that there is little or no encouragement, and a lot of implicit discouragement, for the young person who wants to spend time during graduate school off campus in a setting where technical knowledge is actually used. There is, in short, almost no value assigned to technical breadth or to real world experience as an essential part of PhD training.

You may recall that I also asserted that the typical PhD takes too long to acquire. I firmly believe that to be the case, and I see no contradiction between shortening the time to obtain a PhD and my just expressed desire to see young people spend more of their time away from campus as part of their training.

The time it takes to get a PhD does not depend monotonically on how much scientific knowledge the world has achieved. It depends, I think on a linear combination of how long it takes to acquire the currently selected subset of scientific knowledge that is thought to be appropriate, on how long it takes to produce publishable research results, and how long it takes a young person to mature intellectually. I simply do not believe that this time needs to be six or seven years on average; it is a serious disservice to our young people to keep them cloistered that long....or to allow them to cloister themselves that long.

I have made this comment to many graduate students in the last two years, and not once has anyone denied that long stays in graduate school are partly due both to the students'

comfort with graduate student life and to their anxiety about what it will be like in the outside world when they leave the university. This combination of comfort and anxiety tends, I believe, to make PhD training take longer than necessary. This is all possible, of course, because universities and funding agencies permit such long stays.

I believe, that experience out in the world of technical work during graduate studies will significantly lower the typical graduate student anxiety level about finding a job and starting a career.

I believe the funding agencies should exert serious pressure to bring the average duration down by a year or 18 months. Shortening the average duration of graduate study will lower the cost to the Nation for training a given number of young scientists and engineers, provided there is not an offsetting increase in the number of PhD candidates admitted. And shortening the time to the PhD will also saddle the graduates with less of a disadvantage with respect to their contemporaries who are years ahead in experience and seniority in the workplace.

What can industry do to help? It can and should be responsive to setting up PhD cooperative arrangements with engineering research departments. I believe that small firms and start-ups have the most to gain by such arrangements, and also the most to give students in the way of broad perspective. Many of our graduate schools are surrounded by such small companies, many of which have been started from university science and engineering programs. However, except for the students of faculty members connected with these spin-offs, these exciting firms are invisible to the majority of graduate students.

Summary

If PhD training is too narrow intellectually, too campus-centered, and too long, what might be the remedy? Let me suggest actions that can be taken by faculties, funding agencies, and employers.

Faculties should:

1. give serious attention to reinvigorating a requirement for a minor as part of the PhD, and make sure that the minor can be satisfied in ways that truly supplement the traditional programs. This includes creation of new courses as well as the encouragement to take courses in other departments and faculties.
2. begin forming contacts outside the university that can be turned into internships, summer employment, and other 'away from-campus' work experience for grad students.
3. use a larger proportion of their visitors-budget on scientists and engineers from

outside academia who can provide real-world, non-academic perspective and contact both to grad students and to faculty.

Funding agencies should:

1. ask grant applicants about their success in providing real-world experience to their graduate students, and give some modest credit in evaluating grants for success in this area.
2. institute mechanisms and procedures which discourage the continued funding of graduate students past, say, five and a half years on the average. The disincentives should be applied 'statistically', with the possibility of exceptions in meritorious cases.
3. adiabatically alter the balance between fellowships and trainee-ships on the one hand, and research assistantships on the other, with the aim of doubling the fraction of the former over a several year period.

Employers should:

1. Take serious efforts to accommodate summer-interns, co-op students, with job assignments designed to stretch the technical horizons of the students.
2. Be much more open to the advantages of encouraging R&D staff to spend time as academic visitors.
3. Take the considerable effort required to improve their hiring strategies and competence so that they can correctly value the generalist training that comes with a PhD in science and foresee how people with such training have the capability of being more flexible, over a period of decades, than those with more narrowly focused training.