

AMERICAN UNIVERSITY GRADUATE WORK*

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A UNIVERSITY PROFESSORSHIP in a good graduate research department can be the best of all possible worlds. Nowhere else does the recipient have such freedom to do as he pleases, a freedom he has earned presumably by good works—teaching, research, publication, and good citizenship—both on the academic scene and outside.

The relationship between PhD adviser and graduate student is a unique kind of relationship that obtains nowhere else to my knowledge. It is an improvement on the father-son** relationship, for there is less stress, no competition, and resolution of problems without trauma. The PhD adviser follows the career and success of his advisee with great pride and suffers as much as a father when that success is not forthcoming. It is a very enduring relationship, and I know of no other comparable one.

What I have just described is the ideal for which many of us strive. Yet, for some, it is a difficult path to trod, for other things get in the way and interfere with its fulfillment. Not all advisers and not all professors are capable or willing to participate in the venture, or understand, in fact, what is involved in proper PhD training. Other matters and goals interfere and thus many may miss what can be an extremely exhilarating experience.

Not all of it is wine and roses. The road can be a rocky one at times, for standards must be upheld, and

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**This is a personal account, and I have never had an academic father-daughter relationship.



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the research that is done must stand the scrutiny of one's peers.

For example, it is not easy to tell one's graduate student of a few years that the work done thus far does not constitute an acceptable thesis. It is even more difficult to tell him after two or three years that, at the rate he is progressing, he probably will never finish a satisfactory dissertation. These are traumatic times for the student, when his perceived career must suddenly detour to some other goal.

It is even more difficult for Professor X to tell Professor Y that the thesis of the latter's student does not meet the standards of the profession. Such a disclosure is often more a criticism of Professor Y than it is of his student.

One of the most critical and important decisions a department can make is whom to admit to a PhD program, for once admitted, most students plan on getting a degree. Since these are very good students, failure for them would be a new experience, an experience to which some of them have difficulty accom-

modating. Usually, departments are too generous in their admissions policy, and future problems are born which rest on the shoulders of the individual adviser.

Normally, a graduate student chooses his adviser at the end of his first year of graduate study during which he has sat through lectures, worked problems, attended seminars and colloquia, and has, perhaps, had casual interaction with some of the faculty at social functions. If he's the average new graduate student, he has chosen his graduate school after visits to a few places—for at most a day—during which he talks briefly with faculty and students. And he obtains some information from his undergraduate teachers.

But, from my experience, this may be unreliable. He probably has looked into the literature little if at all, and since chemical engineering textbooks are notorious in their lack of original literature references, he probably has never heard of anyone at the school he visits. With this paucity of information he chooses a school for graduate study. (Some years ago, while I was head at Minnesota, I decided to inquire of new graduate students why they chose us for their work. Most of the answers had nothing to do with what we presumed was our exalted reputation. One student allowed as how he chose us because we started later than anyone else in the fall, and he wanted to stay in Europe that summer as long as possible. So much for exalted reputations.)

Now we have the graduate student in place, and he must choose an adviser. Students most of the time have a free choice, and that choice is the result of faculty presentations to the whole group of new graduate students and private consultations for those who want more information. In the meantime, the prospective advisee has consulted with current graduate students who give him the lowdown on Professor X who probably, therefore, will get no students. With this mixed bag of information, the student makes a "free" choice. (Random would seem to be a better word.)

Students, of course, almost never ask important questions like: What will be the need for a certain kind of expertise in five years or so when I finish? How successful has Professor X been in placing his students in responsible positions? How many students has Professor X produced, and where are they? Does Professor X work at the front of his field or is he out of it? As a matter of fact, in a good department the problem a student chooses to do for his thesis has little relevance to what he will be doing in a few years, for successful chemical engineers in industry tend to be moved about.

The important thing in a chemical engineering

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graduate program is that the student learn the fundamentals of his craft, learn how to do engineering research, and be instilled with confidence so that when he leaves he can be successful either in academia or industry. These things depend upon the way the student has been advised and directed for his degree work and over which the adviser has a great deal of influence. At the beginning, however, the student is naive and thinks that his destiny is in his hands, and his alone. Ah, youth!

The new graduate student is intimidated by the sudden thought that he is now involved in research. He is encouraged by his adviser to read the literature, and that's the way he spends his first summer. He must learn the techniques and methods of his trade. This is less difficult than he imagines, and soon he gains some confidence with the insight that there is less known about everything than he had thought. He still has the nagging idea that if he must know something, it will be out there in a book someplace. The reminder that he is in a research mode now rather than a learning mode, and that what he wants to know has not been done, does not comfort him much.

The student at this stage feels that he cannot compete with all the experts he thinks are out there and whose papers he must read. I suggest to him that there are not so many out there and that, when he finishes his dissertation, he is going to wonder where the experts all went, for then he will know more about that topic than anyone else.

In most cases, as the student progresses through the second and third years, he is struggling. The experiment either does not work or the theoretical analysis is more than he can handle, and the adviser plays a crucial role in guiding him and giving him encouragement and advice, suggesting ideas when they are needed. There is a small class of students who whistle through this period with little advice and counsel from the adviser, and the adviser's main function is to get out of the way. Such students recognize early what they want to do, they have no lack of ideas, and their later success is assured.

The other class of students are those who need a partnership arrangement with the adviser. They are good students of high quality, but for a long time require that the adviser direct their work in detail, telling them where to go and what to look for and what

During all of this travail, the adviser must think of the welfare of the student. The adviser does harm to the student if he uses him in the laboratory as a pair of hands on a fixed piece of equipment or as a computer algorithm for a theoretical thesis. The PhD student is supposed to have contributed to knowledge in some way, and that means *he* contributed. One does him no favors by allowing him to do less.

to do if they find it. With students of this class there is a problem, for they must be told that the thesis is their thesis, and if they mean to be called doctor, they must earn it.

My usual procedure is to be very patient until a time arrives when it is necessary to say that I do not want to confer with them again until they can tell me something about their research that I did not know. "In fact," I say, "next time you come for a thesis discussion, I want to be surprised." One former advisee characterized this as being thrown in the water—swim or learn to swim or else.

While this may seem cruel, it is an astoundingly successful ploy, for almost everyone responds to it well. Students who, up to that point, have never presented an original idea suddenly blossom. A few do not respond and unfortunately receive their degrees without contributing much, and their later careers show that they probably should not have made the attempt.

Those who learn to swim leave the institution with a great deal of confidence and become more successful than they might have otherwise. A problem here resides in the fact that undergraduate and new graduate students are seldom asked to do a synthesis or are challenged in a situation where a novel idea is needed. Research, therefore, thrusts them into a wholly new mode.

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From the advisers view, there is always one more experiment to run or one more calculation to make on a thesis, and he treads a fine line before using the student for his own ends. The greatest PR a department can promote is to have students say when they leave, "I'm happy I came!"

Most PhD students go on to other things after their degrees, whether in academia or industry. In academia many of them continue to work in the area in which they did their theses, much to the chagrin of the adviser, for then he has once again produced still

more competitors and has probably supplied the ideas that will be exploited for a time by the former students.

But this is a short-lived phenomenon, and the former students soon become interested in other things. It is rare in industry for a new PhD to work long in the area of his thesis, since the successful industrial chemical engineer must be flexible. For this reason, the choice of a particular thesis topic is probably the least important of the many other factors involved in good graduate study.

Unfortunately, engineering departments are seldom composed of large numbers of the kind of research advisers alluded to above. Universities are strange places, and they attract their own particular kind of strange characters.

Though the freedom allowed at universities is unlimited, the proper research adviser uses this freedom in the pursuit of proper academic goals. But the freedom is abused, since the fetters applied to academics under the name of academic freedom are rather tenuous. A faculty member may spend too much time in consulting and entrepreneurship, seeking financial rewards the academic pursuit will not provide. He gains financially but loses the respect of his colleagues. This is not a wide class, but it exists and does no credit to the institution.

In a well-run department there is a certain spirit, a spirit difficult to imitate, initiate, develop, even to maintain. Faculty must have respect for each other both publicly and privately. The departments that seem to work best are those in which faculty members are also friends, and this requires personality traits more highly developed than in the general population. Regrettably, good collaborations among faculty are rare, occurring far less frequently than outsiders might imagine.

There is severe competition for research space, new graduate students, money for research equipment and supplies, choice teaching schedules, and more. In a university there is always a finite, too small pool of everything, and the selfish individual can be a problem. It is no wonder that in some departments rancor and cancer exist.

I was always proud of the Minnesota department, since they were class chaps (there were no women at that time) who always thought in terms of what was best for the department—a rare commodity indeed.

We called it good university citizenship, a term little practiced in some places. There is no room in a good operation for those who think of every action, how does it affect me? This soon leads to discord, and in a small group it is disastrous.

The Minnesota department had an amazing success, since the sum of its parts was much greater than the whole, not only because of strong intra- and inter-departmental cooperation, but because of the superb personalities that inhabited the place. I think this was in large measure responsible for its almost complete dominance of the chemical engineering scene for the last twenty years. It is not thus all over.

For many years, there were three leading chemical engineering departments: at Wisconsin, and at two other large institutions. Wisconsin maintained its position over the years because it kept its eye on academic excellence. The other two suffered from similar problems—too much consulting, too much entrepreneurship, too little attention to scholarship, and too much inbreeding. One of these is recovering, but at a time when recovery is difficult.

When one carefully examines academic departments, some difficult questions can be posed. Why is it that some departments, which absorb an enormous

number of new graduate students each year, produce relatively few successful PhD's? Why is it that departments of so-called lesser rank almost never (I'm tempted to say never) produce a world class practitioner? Why is it that some presumably eminent faculty members have never produced a really outstanding PhD?

The opportunities for outside activities are so manifold and the amount of money to be made so great that the temptations are more than some in academia can absorb. A really successful PhD adviser with a good stable of students cannot dissipate his efforts outside the enterprise. The rewards for superior research of both quality and quantity and the satisfaction obtained from the success of former students remain mostly intangible, although the academic community has belatedly come to recognize quality.

In no place is graduate work so readily available and run so efficiently and effectively as it is in the United States; it is truly one of the great developments of this country. In France, Germany, England, and Russia, the mechanisms are much different and far less attractive.

American university graduate work is unique in the world. I'm very happy and proud to have been a part of it for over forty years. □

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