THE GRADUATE STUDENT

WHY HAS HE CHANGED?

Practical necessity and changes in research, education and specialization have produced more conformity and conservatism, resulting in relatively fewer scientific leaders.

JOHN C. SLATER

FOR NEARLY A HALF CENTURY, since I started my own graduate work in 1920, I have known physics graduate students. Have they changed in that time and are the changes good or bad? What effect have marriage at an earlier age, fewer really new fields and specialization had on his attitude? Why is there less enthusiasm and proportionately fewer leaders?

Changing pressures; changing tempos

Perhaps the two most striking changes are statistical: There are a great many more graduate students now, and most of them are married. Though they may not believe it, money comes much more easily now than it did; otherwise they could not afford to marry. Present students find it harder to settle down to work. Wives and babies take up a lot of the time that my generation put into physics. The wives, it is true, help to type their husbands' theses, but in the older days the necessity of doing this ourselves made us learn typing.

The need for more money than a graduate student can get even now puts a greater pressure on the present graduate student to finish his thesis. For the less ambitious, on the other hand, a graduate assistantship may provide a secure berth that tends to make some students turn into permanent graduate students. (However, I have never seen, since the 1930's, the equivalent of a permanent Harvard graduate student, not in science, who continued his graduate career for many years as a middle-aged man because he liked it.) The practical compulsions acting on a graduate student today are

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A SUMMER SYMPOSIUM IN THE 1930's at the University of Michigan, where students and professors exchanged ideas. Faculty included Enrico Fermi, Paul Ehrenfest and George Uhlenbeck.

quite different from what they were in prewar days and particularly in the depression.

Quite aside from these practical matters, the whole tempo of physical research has changed greatly in the last 40 years or so. The 1920's were the great period of development of completely new ideas in quantum physics. There was a good chance to get into the development of a really new and fundamental field, and there were few enough workers so that one could make a real and significant contribution to fundamental physics. Now this is much harder. The field is so developed that the more obvious areas are already staked out, and it takes a very original student indeed to do more than follow through some line that has been pretty well worked over years before.

On the whole, I believe the students were more original and more resourceful in prewar days than they are now. Those were days of more optimism, of less conformity and of less tendency to follow the leader. The students I knew in the 1920's and 30's included John H. Van Vleck, Hubert James, Robert Oppenheimer and Edward Purcell at Harvard, James Fisk and William Shockley at MIT, Robert Mulliken at Chicago, Edward Condon at Berkeley, Conyers Herring, John Bardeen and Richard Feynman at Princeton and Isidor I. Rabi at Columbia, to name only a few with whom I came into close contact. They were people of an independent spirit, which has carried them to leadership and which I find hard to match in the present generation of graduate students.

High jinks

They showed their spirit early. The MIT physics department in the 1930's was famous for high jinks of many sorts, entirely innocent, but showing the originality of the students and carried on by some of the ablest physicists. There were the famous departmental parties in the physics building, which at MIT forms part of the complex of buildings housing nearly the whole institute. Some years the entertainment was ping-pong, bridge and tiddly winks. One year, however, the faculty got wind that roller skates were to be imported by the students and their dates, with the idea of turning the whole institute into a roller-skating rink. The head of the buildings and grounds department, learning with horror of the plan, dashed into the office of the president, Karl Compton, to see if he knew what was going on. Compton's assistant, Carroll Wilson, who later became general manager of the Atomic Energy Commission, heard the complaint. Asked if he had heard of the plans and what he proposed to do about them, he replied "Yes, I know all about it. I'm planning to be there, and I have my skates ready."

But it was not merely by playing around that the students showed what they could do. Most of the really good graduate students took postdoctoral fellowships – in those days usually the National Research Council Fellowships – and traveled, often in Europe. They became acquainted with international science in a day when the most exciting things were going on in other countries, and they built up the reputation of American physics abroad. I do not want to imply that present graduate students do not have spirit and initiative. I think, however, that there is a good deal more caution, inspired by the temper of the present day as well as by their larger family responsibilities, that leads the present students into more conservative paths.

Too much, too early

Another reason that the present student has a less adventurous spirit is that he is taught too much, too early. The current rage to teach relativity to freshmen and advanced mathematics to juniors destroys the spontaneous pleasure that my generation found in learning these things for themselves at a somewhat greater age, when they were able to appreciate them better. In particular, in the mathematical training, there is too much tendency to teach elaborate mathematical techniques rather than real physical insight. The students feel that they know all the mathematics; they want to use what they know, but have very little feeling for the physics underlying it. I shall not soon forget one of my postwar graduate students who told me he hoped to find a job in which he would never have to compare his mathematical results with experiment. That, he felt, distracted him from the pure mathematics that he preferred.

This preoccupation with mathematics tends to keep the present graduate students from spending as much time

WITH AN ELECTRIC ARC FURNACE producing carborundum from silicon and carbon, MIT students determined conditions for maximal yield and efficiency.

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as my generation did on chemistry, thermodynamics, metallurgy and other studies bearing on the actual behavior of matter in its different forms. In my graduate days at Harvard there were very interesting series of seminar talks on many of these topics that helped tie in the abstract physics of the quantum theory with more ordinary problems of the laboratory. Such things as phase transformations, crystal structure and the theory of gases and liquids are much more likely to be slighted by the present student than they were in earlier days.

Narrowing specialization

The physicist of the present, of course, will say that modern research techniques have grown so elaborate that the student cannot afford time to learn more than his very limited field. The man in nuclear magnetic resonance learns only nuclear magnetic resonance, the man in theoretical physics learns only field theory and the more practical theorist learns only how to use the digital computer. All I can say about this specialization is that it is too bad. One of the great strengths of the physicist used to be his breadth, the way in which he could take advantage of the fundamental unity of physics to apply what he knew of one branch of physics to problems in another. A classic example of this versatility was seen at the MIT Radiation Laboratory during the war. There a great collection of able physicists, originally knowing nothing of microwaves, turned their attention to that problem so rapidly that, in a very short time, they became surpassingly good in the field of radar.

The prewar graduate student found himself in a far more competitive situation than present students. Particularly during the depression, good jobs were very hard to get, and good students had to compete very hard to get them. In addition, the early days of the quantum theory saw a very intense competition among workers in different countries. Students who were able to hold their own in that atmosphere had to show what was in them, to an extent that present students find hard to understand. One of the ways of getting ahead in science is to publish papers, and one seldom saw in prewar days that which is much too common nowadays: students capable of doing good work, but quite unwilling to bring themselves to the point of finishing and publishing what they have done.

Responsibility and leadership

The result of all of these influences was that many more scientific leaders were produced in prewar days than at present, in proportion to the total number of graduate students going into science. In the 1930's, when when I was in charge of the physics department at MIT, I felt that there were half a dozen other members of the physics faculty who had the capacity of being successful department heads, deans or other administrators. Now, in spite of the much larger physics departments that one finds throughout the country, it is harder than ever to find in them persons with the capacity for leadership. Students are brought up to follow in the professor's footsteps, to seek the haven of a department or a research group under a distinguished leader, where they can work in peace and quiet without having to take any responsibility for running the organization.

MIT

STUDENTS IN THE BALANCE ROOM of an MIT laboratory during the early 1920's.

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PAUL EHRENFEST teaching at a summer symposium, University of Michigan.

From all of these remarks, the reader will see that I am a typical old fogey, who looks back to the good old days when things were better than they are now. I plead guilty. But there is perhaps a somewhat different, and more hopeful, light in which we can look at the present situation. I certainly do not feel that the percentage of present graduate students who have the makings of superior physicists is as great as it was before the war. But probably the absolute number of really good ones is as great, in proportion to the total population, as it ever was. The difference is that the total number of physicists has grown much faster than the possible number of really good ones, so that the percentage does not look very good.

It is one of the fallacies of the present age to believe that by enough education one can take any average population and turn them into scientists or toward any other highly developed intellectual discipline. I do not believe that this can be done. I suspect that during the prewar days most of the young people who had the makings of first-rate physicists actually went in that direction, and I doubt if any attempt to draw more students into the science would have turned out a great many more leaders. At present, with the demand for scientists so high, many people who hardly have the capacity for the highest development are being pushed into the field. It is only natural under the circumstances that the average product appears less able than in the older days, when nobody without a real flair for physics would have thought of going into the field. □