PHYSICS IN EUROPE

National styles in graduate training

Despite the widely differing academic conditions, the graduate schools of Europe's various nations produce PhD's remarkably similar to each other and to their American counterparts.

John M. Ziman

The American physicist visiting an academic physics laboratory in Europe will find himself very much at home. The young men and women use the types of research equipment with which he is familiar, and talk about the same fashionable scientific problems. The questions asked in seminars and conferences are equally searching, the topics of lecture courses have the same titles, the standards of published research are entirely comparable. A young physicist from another European country who applies to do advanced research in Bristol may be assumed to have the same level of understanding and research experience as his British or American counterparts. One may even expect a working knowledge of the *lingua franca* of modern science—Broken English.

Graduate education in physics has much the same formal content, and achieves much the same goals, in all advanced industrial countries. It is designed to produce expert practitioners, well grounded in the fundamentals, self-reliant in research, and competent to make sound contributions in the field in which they are specialized. The connoisseur may be able to detect characteristic national differences in research style as he goes from country to country, but such variations are not so significant as the differences in quality and temperament between the products of particular university departments, who have been influenced by professors of a diversity of tastes and abilities.

In every European country there are strong and weak schools of research, major and minor institutions, "metropolitan" and "provincial" universities, covering a very wide range of prestige and scientific competence. We Europeans compare Gothenburg with Liège, or the Orsay group of Friedel with Bassani's department at Rome, not "Sweden" with "Belgium," or "France" with "Italy." Graduate students and research assistants exchange visits between Bristol and Zürich, because these are active centers of research on liquid metals. A postdoctoral year in Copenhagen or Berlin may seem more natural for a graduate from Manchester or London than a Fellowship at Cambridge or even at Cornell!

Yet this general "uniformity in diversity" of actual scientific competence is achieved under wildly different academic conditions. The formal structure of graduate education, the exercises to be performed, the examinations to be passed, the sources of financial support and the prospects of employment differ profoundly from country to country. For those of us who are all too concerned about the defects in the system with which we are each personally familiar, and who advocate bold reforms of organization or curriculum, it is chastening to observe the variety of institutional means by which the same general goals may be achieved, under the influence of historical accident and local cultural traditions.

It is noteworthy, for example, that the major graduate schools for physicists in Britain and Italy are in the universities, close bedfellows with Faculties of Social Sciences, Humanities and other liberal Arts. In Germany and Scandinavia, the leading research departments may also be found in the Colleges of Technology *(Technische Hochschule)*, whose official mission is the training of engineers. The institutional set-up is especially complicated in France, where the graduates of the highly prestigious *Grandes Écoles* move to the laboratories of the various university Faculties for their training in research. Surely the fact that the English or American professor of physics may have been at the same Cambridge college as a judge or television producer has its influence on the place of science in national life—but it is impossible to estimate such subtle effects at the level of graduate studies.

Thesis requirements

A very important characteristic of any system of graduate education is the age at which it is supposed to be complete. In many countries, indeed, the taking of degrees may be a lifetime career, culminating in the title of Doctor of Science bringing esteem to an established full professor. But this article deals only with the stages leading to the equivalent of the American PhD, whatever it may be called elsewhere. Here again, there is a great contrast between the British tradition, where the PhD is usually awarded at 25 or 26, and the normal pattern in France and Germany

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where the "student" may be 30 or more (including perhaps a period of military service) before he is finally free from the burden of producing a dissertation. And what would the average American graduate student make of the system in Italy, where there is no regular research degree beyond the *Laurea* (say, MSc) taken at 23, but where, until recently, every intending university teacher had to submit his list of publications (no less than five, in reputable journals!) and deliver a prepared lecture in a national competition to obtain recognition as a *Docent* in some specific field.

By American standards, I suppose, the British course would seem too short, giving inadequate opportunity for thorough training in advanced research topics. Among some British academics (especially in the Oxbridge tradition), this used to be regarded as a positive advantage—"avoiding cramming with useless knowledge," "gives a chap a chance to show his mettle," "throw him in the deep end and let him learn to swim," and so on—but nowadays formal course work at the MSc level is part of the PhD curriculum in most universities, and special summer schools on advanced topics are arranged by the Science Research Council for the benefit of graduate students from all over the country. This leaves even less time for research towards a thesis, and there is much pressure (especially in highly instrumented team research such as high-energy physics) to add a year or so on to the course. But this pressure is firmly resisted by the Research Councils and other official bodies, not only because it would cost money to prolong studentships but also on the grounds that the graduate student already has time enough to show whether he can stand on his own feet as a research worker, which is the main purpose of the PhD degree.

The German or French student does not reach this stage of intellectual autonomy until he is much older. He must spend six or seven years from his first entry to the university in formal studies, with only a modest thesis requirement, and is not finally quit of his doctoral dissertation until a further three or four years of his life have been used up. The pattern of his studies may be very flexible, as befits a serious scholar, and the dissertation may represent a more considerable corpus of published or publishable research—but there are serious disadvantages. The gain in sheer professionalism is more than offset by the psychological burden of commitment to a specialized field of research, still as an apprentice, still under professional supervision, still without complete independence in the planning of his work, for so many of his most creative years. More serious, perhaps for many uninspired students, is the feeling of being tied to an academic career right into the late twenties, beyond the age of easily choosing an alternative. Many senior physicists in these countries—which also include Scandinavia, Holland and Switzerland—recognize these defects in the traditional academic system; but the weight of interlocking institutional arrangements blocks reform.

A very important characteristic of the British PhD is that it can only be awarded with the concurrence of an external examiner—a scientific expert outside the awarding university. This at least ensures that the minimum standard of a doctorate in physics is much the same for all universities in the country. The elaborate and time-consuming procedures by which the Scandinavian universities satisfy themselves on this essential point defy description. But the French ritual in which a candidate must "defend" his thesis before a jury including external experts has become so conventionalized that it is not clear whether or not this is a genuine examination that the candidate could conceivably fail. In Belgium each university awards its own doctorate, in its own way, on its own judgment, according to criteria that are so variable that the thesis may take 3, 4, 5 or 6 years, depending on the university. In due course, no doubt a European academic commission will be set up to harmonize and standardize the exercises and regulations for the PhD in physics over the whole Continent. Let us wish them well, as they debate for several decades

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Financial support

For a substantive issue, let us look into the provision of financial support for graduate studies. Because almost all European universities are supported by their respective governments, the student seldom has to pay high fees for teaching and laboratory facilities. But undergraduate scholarships to cover living expenses are meager in most Continental countries, and it is not easy for a poor boy to work his way through college, or, except in Scandinavia, to borrow cheaply during his college years.

The exception once again is the UK, where all undergraduate students receive grants (subject to a means test on parental income) that just about cover their expenses. Entry into graduate school is competitive, usually on the basis of degree results, but there are more than enough graduate studentships, awarded by the Research Councils, for eligible entrants to one-year Master's courses or three-year PhD courses. Indeed, it is practically unheard of for a graduate student to offer to pay for himself: As a student once informed me "It would be wrong to buy an education, wouldn't it; if I didn't get a grant that would show that they knew I wasn't really fitted to do research!" Such studentships are, in fact, calculated on the slenderest of margins, in the best traditions of high thinking and low living: Marriage to a working wife is the only alternative to three years of penury!

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It must be emphasized, however, that the grant given to the British graduate student is for "training in research" and is not a (taxable) salary. He (or she) is not an employee of the university or of the research council, and is in no sense assimilated to the academic profession. It is only when he has taken his PhD that he may seek an academic teaching post or research fellowship, against very stiff competition.

In other European countries, the doctoral candidate, being somewhat older, often holds a university post as "Assistant," for teaching or for research. This means that he is somewhat better off financially, and that he already has his foot on the bottom rung of the academic ladder, even though he has not yet shown his ability in independent research. In other words, effective admission to the academic profession is based somewhat more on scholarly performance in examinations and in "book learning" than it is in Britain. This is particularly evident in Spain, where only the Autonomous University of Madrid has succeeded in creating a research school in physics of international standing.

One of the effects of tying predoctoral financial support to an academic post is that the number of such appointments may be gravely affected by fluctuations in the supply and demand for university teachers and research workers. This is evident in France, where the number of established posts in the CNRS was stabilized a few years ago, after a long period of expansion, and soon became saturated so that the opportunities to proceed beyond the "third cycle" to the doctorate were much more severely restricted than would be warranted by the long-term demand for research physicists.

It is ironical that the Expenditure Committee of the British House of Commons has recently come out with a report demanding that all postgraduate education should come after a period of "experience"—that is, university teachers should be appointed on the basis of their performance in the Bachelor's degree, and should later undertake graduate studies leading to a doctorate. But this report is notorious for its misconceptions concerning the role of research training in scientific and technological disciplines, and for the ignorance it displays concerning the way these matters are managed in other countries, where the recent trend has been to copy the British system by providing scholarships and stipends specifically for advanced study and research up to the doctoral level.

Prospects

The employment prospects for young European physicists, like those of their

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American contemporaries, have gravely worsened in the last few years. Higher education is no longer a boom profession, and both government and industrial research expenditures have reached a plateau or are in comparative decline. In response, fewer students enter the universities with the intention of studying physics to an advanced level; if there is no assured job to go to at the end, they prefer to study apparently more interesting and exciting subjects such as psychology or sociology!

In Britain there is little obvious postdoctoral unemployment, because a man with a PhD is still young enough to take a job that does not make use of his specialized research experience, and usually he has an attractive undergraduate record leading to a good Honours degree. Employers complain that the period of research training has been wasted from their point of view—although I suspect that IBM, who take on PhD's in theoretical physics as computer programmers, are shrewder than ICL (our friendly neighbourhood computer corporation) who reported to the Expenditure Committee that "the extent to which ICL needs postgraduates as currently produced at universities is negligible." It is true that we are producing many more PhD's in physics than can be employed as teachers in higher education or in advanced research, but this is not necessarily an unhealthy situation. Sharper competition for tenured faculty positions is not harming academic standards, although we must be careful that people of outstanding ability are not accidentally excluded by lack of a pool of temporary appointments to smooth out the fluctuations.

The situation in other European countries is complicated by a variety of political and economic factors. In Spain (characteristically) nobody seems to know what the trends are in numbers of students or in opportunities for employment. In France the rigid bureaucratic practices and internal politics of the CNRS and other research organizations have a very significant effect.

The most severe crisis is in Italy, where the whole university system is in chaos. Traditionally, all power was in the hands of a small oligarchy of professors who governed a large number of tenured assistants or teachers with yearly appointments. But after years of strikes and discussions, a new system is trying to get born. Threatened by complete collapse of the universities under the weight of student numbers, the government passed a law granting tenure in their post to those who have taught the same university course for two or more years. In addition, the number of professorial Chairs will be tripled over the next three years, but no new assistants will be appointed. So the best hope for a person of postgraduate level is to obtain a teaching appointment and hold on to it long enough to gain tenure. But there are few openings, with so many posts frozen. Perhaps all those new Chairs will help: who knows? But then one has to remember that many of the university teachers on yearly appointment were also on the staff of another government agency, such as the National Institute of Nuclear Physics, which augmented their academic salary. Part of the reform legislation was to restrict such double employment, whilst raising academic salaries. But since the research budget was reduced in proportion, this change did not open up new positions. And so on. The daily realities are not so chaotic as these organizational confusions suggest: Italy has a great tradition for social improvisation. The point is, simply, that the present flowering of academic research and graduate studies in Italian physics is taking place under bizarre institutional conditions, against a background of complete political and economic uncertainty. On a broader scale, in less exaggerated form, the same may be said of physics in Europe as a whole.

The Communist countries

Europe as a whole includes a number of countries under Russian political domination. Although it is now some 35 years since the physicists in these countries had free intellectual communication with their colleagues in the West, the high academic standards of their German-style universities have been adequately preserved. In Prague, Budapest or Dresden, for example, one may meet extremely well trained and able doctoral candidates following a pattern of studies that is not very different from the corresponding curriculum in Stuttgart or Leyden. The main defect, of course, is the restriction on travel. Just at the age when the young research worker can benefit most from visits to foreign laboratories, to summer schools, or to conferences, the East European physicist must stay at home, or get the best he can from an occasional visitor. At present, the Hungarians are the least restricted, and are making good use of their opportunities; on the other hand, Czechoslovak physics is in a desperate state, with many of their best scientists in exile, and others driven out of their own laboratories for political reasons. Indeed, there is some evidence that government policy in Czechoslovakia is deliberately opposed to high scientific culture, so that the damage may go beyond the effects of isolation and the rule of mediocrity.

Graduate education in the Communist countries has also suffered by the imitation of the Russian policy of concentrating research in specialized Institutes administered by an Academy of Sciences, thus starving the universities of research facilities. The age at which the student comes into close contact with the highest levels of research is thus further postponed, and many of the very best scientists are not given the opportunity to teach or to supervise doctoral candidates in the usual professorial role. I have the impression that these and other difficulties put even the ablest physicists in these countries several years behind their Western contemporaries in maturity of thought and independence of mind.

Cultural roots

Perhaps the most important characteristic of advanced scientific training in Europe is that it has deep roots in the culture of that region. The universities have long histories, having provided the administrative and technical manpower of Church and State for many centuries. They are respected and admired by all classes of society, and the professoriate is neither alienated nor over-assertive of its authority. Modern science came out of these institutions, and has not yet been transformed by large-scale industrial applications into an entirely different type of activity. Graduate education in science was invented in Europe in the nineteenth century, and was always directed to both philosophical and technical ends. British pragmatism, German pedantry, French rationalism, Italian flair, Dutch doggedness, Swedish thoroughness, Hungarian craziness and many other national styles have their part to play in the whole corporate venture of science. These characteristics have not yet been merged in a single uniform style.

But the modern European graduate student no longer thinks in purely national terms, nor does he long for the opportunity to emigrate to lusher pastures in the US. Thirty years of peace, rising prosperity, the habit of travel, and the creation of major international institutions such as CERN combine to give him the feeling that even when staying at home he belongs to a single continent, a single great university system, a single intellectual tradition. He also inherits disciplined scholarly standards, respect for academic freedom, and a latent tendency to imitate the proud individualism of the professor who guided and dominated his scientific training. Whatever grave political, economic and technical disasters we may be about to face, this community has enormous spiritual resources for the service of mankind.

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