UNIVERSITY CHEMICAL EDUCATION AND INDUSTRIAL EMPLOYMENT IN BRITAIN

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(presented by E. S. Stern)

BACKGROUND

Over the last decade the number of chemists graduating from universities has been increasing rapidly. If the exponential rate continues unchecked, we are told, by 2069 there will be more chemists in the world than people. Although this seems inherently unlikely, there are in fact a number of good reasons why chemistry is a popular subject for university study—for instance, it is taught at school whereas engineering often is not and it requires less rigorous abstract mathematics than does physics. It also happens to be, although this is often forgotten, useful. It is not only useful in an obvious way, in so far as the chemical industry generates a goodly proportion of the wealth of the western world; chemistry is also a useful base from which the graduate can strike out into related subjects: macromolecular science which includes large areas of biology and polymer materials science; biochemistry; pharmacology, etc.

In the U.K. university expansion in the period 1962 to 1967 has been rapid: there are now in the UK 55 departments of chemistry of university status, about 7 000 undergraduates and about 800 university staff. The number of degrees in chemistry conferred in 1967 is summarized in *Table 1*. *Table 1* shows that more students—on a percentage and *per capita* basis—proceed to a higher degree in the U.K. than do so in the U.S.A., but a very much smaller percentage of these students enter industry immediately than do either in the U.S.A. or in Germany. Thus whilst in the U.S.A. and in Germany chemistry and a chemical education are not only recognized as useful but turned to use (by the most highly qualified people entering industry), this aspect—the turning to use, the wealth-generation—has bypassed the U.K. This unique problem of the U.K. merits analysis: why do so few graduates with higher degrees enter industry? as their first posts? Should this trend be reversed, and if so how?

PROBLEM DURING UNIVERSITY EXPANSION IN THE U.K.

The U.K. university system emphasizes the non-vocational nature of chemical education and is built on a school education containing a great deal of science. Specialization from the age of 13 or 14 on science, permits students to graduate early—B.Sc. at 21 and Ph.D. at 24 is the rule. When these young graduates examine what they are able to do on graduation either at the B.Sc. stage or at the Ph.D. stage, they find to their horror that all they are capable of doing immediately is to teach a non-vocational chemistry course, aping that which they have themselves taken. Moreover, all the way through the educational system they have had to choose between either continuing their education or entering the outside world—in the U.K. the decision points are roughly at 15, 18, 21 and 24 years of age—and having chosen to stay on three times and got to know relatively less and less about the outside world, new Ph.D.s are clearly tempted again to stay in the educational system. As long as the universities were expanding this was fine for them and for the students; the universities easily recruited the best of the emerging young men into their ranks. Industry, however, found that not only were insufficient numbers of the best students leaving the universities but many that entered industry did so relatively unwillingly and without any knowledge of the problems faced by industry (in the solution of which they were expected to participate quickly).

Table 1. Degrees in chemistry 1967

Origin	*B.Sc./ B.A.*	*Emerging with higher degree*			*Entering home industry as first job*	
		M.Sc.	*Ph.D.*	*% of total*	*Number with higher degree*	*% of higher degrees*
Federal German Republic	—	—	613[1]	—	435[4]	71
U.K.[2]	2022	360	600	45	180	19
U.S.A.[3]	9872	1805	1700	35	2330[5]	67

[1] From G. D. Ch. Statistics [See also *Angew. Chem.* **16,** Blue p 335, (1968)].
[2] *Swann Report, Cmnd. 3760,* Tables 57 and 59.
[3] *Chem. & Engng. News,* (10 March 1969), p 24A.
[4] *Angew. Chem.* **16**, Blue p 414 (1968).
[5] Comprising 1128 M.Sc.s and **1202 Ph.D.**s (Private Communication from A.C.S.).

Although for the students and the universities in these circumstances there were few problems, for industry and the nation as a whole the problem was severe: in particular the neglect of important and difficult jobs, especially those which were not well paid, say, school-teaching and up-grading the technologically backward industries, has caused delays which may well impair the U.K.'s internationally competitive position for many years to come.

LEVELLING OUT OF UNIVERSITY GROWTH—THE EQUILIBRIUM POSITION

Over the last two years or so the rapid growth of university departments in the U.K. has levelled out. The universities are entering a phase of consolidation and perhaps re-thinking. This presents new problems which should have been anticipated but certainly require solution now. As the numbers of academic staff have stabilized, entry into university faculties has become limited to the replacement of staff lost. This is a very small number—only about 30 vacancies or so will arise annually over the next few years in chemistry. Moreover, the growth of the universities has involved the nation in expenditure which is a noticeable percentage of the Government's total annual expenditure and increasingly, therefore, the universities' cost effectiveness is being scrutinized. The universities therefore feel defensive and under pressure, particularly they feel under pressure to defend their long-held attitude that education is an end in itself; whereas in fact the query is whether the academic Ph.D. course is an 'education' or 'research training'.

The sudden drying-up of academic jobs is an unwelcome surprise to students. They have received grants for 'post-graduate training' and by this have been misled into thinking that academic jobs or at least jobs in research and development will be available to them as of right when they graduate with a higher degree. They are in no way prepared by the university course for any useful job other than academic research and they are having to make very difficult adjustments with almost no guidance from the university departments which are entirely non-vocationally oriented.

Industry is bewildered by the sudden availability of graduates. Numbers of university students have, in fact, been built-up on the happy expectation that sufficient students would have to be graduated to meet the needs of a permanently continuing university expansion and of industry and other consumers of technical manpower. The numbers of higher degree people graduating in 1969 and looking for posts outside the academic life may well be double that of the total research and development jobs available in the U.K. so that a very considerable number of higher degree graduates will be placed in industrial posts where much of the experience provided for them at university is irrelevant. Even now graduating Ph.D.s are realizing that unless they wish to make a permanent career in research and development they could have invested three years of their life in a better way than in pursuing a narrow research target. In fact, in the U.K. only 15 per cent of all industrial scientists remain permanently in research and development and increasingly large numbers are going to start their career in a function other than research and development. Nationally, of course, this extravagant use of three years of the most highly skilled manpower is deplorable; on the personal level the three years are most stimulating while they last, but there often are regrets later. The redeeming feature now is that at last there is a real possibility of using this highly trained brainpower to rectify the past neglect of the less desirable posts for teaching and in backward industries. However, there is still one important question; will the graduates enter upon these posts willingly and with their eyes open about the future they will face; present university courses hardly help them to do so.

PROFESSIONAL ORIENTATION OF NON-VOCATIONALLY TRAINED GRADUATES

In the U.K. today graduates have to find jobs about the existence of which they do not know; nor do they know how their abilities would match job requirements. The reason for this is, of course, that the university course provides career training for about 30 academic lecturers a year. For the remaining 1 000 postgraduate students obtaining their higher degrees it does not provide a realistic basis for the assessment of careers and career prospects; no attempt is made within the university to bridge the wide gap between the academic life and the profession in the outside world. A oneweek course organized by the Careers Research Advisory Centre seems to help the student more than his university contacts do over six years. Less emphasis on pure non-vocational background science and some emphasis within the university on real life situations may help to interest the graduate in problems other than those of academic chemistry and thus help him to orient himself towards a desirable career. What particular problems might be offered to help the student; these problems must be susceptible to study in the academic environment and yet help form a bridge for the university–industry transition. Let us suggest five broad topics of this nature:

(a) Evaluation of utility

Identification of objectives and constraints and their effect on the shape of activities. This subject—which forms a large part of Technological Economics—encompasses systems analysis and elementary operational research.

(b) Communication processes

Increasingly, big projects require team work and hard lessons have to be learned about the best ways of achieving useful rapport and cooperation amongst colleagues. An understanding of behaviour, i.e. study of behavioural science and of the ways information can be passed will greatly help a newcomer to orient himself within his new environment.

(c) The variability of time and of precision

These interacting subjects concern themselves with the need to achieve an objective within a predetermined time. A complex number of different steps, some sequential, some independent, i.e. in parallel, is often involved in a project: it is undesirable to polish off the quickest steps first and be left with the slowest; or indeed to expect unreasonable haste in the slowest step. The precision with which each measurement or calculation will be performed does not necessarily depend on one's ability to achieve a high precision—a time factor has to be taken into consideration and delay avoided.

(d) Conflict theory

The game against intelligent opposition. This differs in depth from the game against non-intelligent Nature and includes the largely mathematical subject of games-theory.

(e) The philosophy of change

This subject concerns itself with the future: how will change affect activities? It involves forecasting: when does forecasting merely require extrapolation of trend curves and when can sharp breaks in the trend curve be predicted? The subject is not limited to technical matters but includes social change as a vital component, which may govern future activities (and at which present work must be directed); how to choose from several achievable futures; and the selection of problems to affect social conditions prevailing *not now* but when the problem is likely to be solved.

If young men have these wider views presented to them at the university they will realize that there is continuity between theory and practice.

Thereafter it is but one step to pass back at a later stage in their career as a matter of course from experiential learning into the cognitive learning environment and thus to up-date knowledge or even to retrain completely in a different technology or aspect of learning. This recognition of the continuity of learning would open a new sphere of activity for institutions of higher education in the U.K. which by and large do little or no in-service or in-career topping up of people who realize that their skills form part of an obsolescent technology. Moreover, teaching and therefore thinking about the philosophy of change might help the universities to set their house in order in time for a further expansion of the higher education system some years hence.

SUMMARY AND CONCLUSIONS

The main point made is that in the U.K. a student concentrates for six years or more on pure science in a non-vocational setting. He is drawn on ever more deeply by the fascination of science unfolding before him. When the time comes to leave the university he is bewildered and unready to face life outside university—and when he does leave he has a traumatic reorientation ahead.

What remains to be explained is the difference between the U.K. and the other two countries whose statistics have been quoted, namely, the U.S.A. and the German Federal Republic. We know that the background education is much narrower in the U.K. than either in Germany or in the U.S.A. where up to the age of 18 or 21, respectively, students read a very wide range of subjects. We think that the difference resides here. We are witnessing the unique unworldliness of the British student—in his work he never comes into contact with money pressures and indeed money is generally despised within the academic environment.

In other countries the importance of money as a measure of social utility is much more widely recognized and accepted. Therefore, there the students accept as natural that education is a preparation for a useful job to be done later in the wealth-generating sector of the community and not merely as an end in itself. The non-vocational nature of the chemistry course does not disguise these facts, because it is coupled with a range of other studies some of which have a direct bearing on industrial problems; and with financial pressures on the student.

In the U.K., the fact that wealth has to be generated at all and that chemistry is of exceptional use as a wealth generator is a rude shock to the student. If British industry is to compete with other countries' industries it is essential to change this attitude and ameliorate this shock. There are several possible ways of doing this. Here we are dealing with remedies that universities could provide. Their contribution can be to reorient the university courses so as to bring the student into direct contact with the community within which he operates but from which he is, at the moment, so completely alienated. One way of doing this might well be to present to the student a range of problems and technology connected with but outside his academic science which can arouse his immediate interest and which later he could recognize and apply in his real-life professional setting.

This admittedly would require a refashioning of the present syllabus—but is this necessarily bad? Changes in the syllabus have in the past only concerned themselves with the advances of science—what you may like to think about is whether it should not also concern itself with the advances made within and for the community as a whole. A great deal has happened since chemistry education was set up as it is at present—perhaps changes in the university course are needed to reflect this.

If such changes do take place the consequences for the universities will be far-reaching. In today's context we suggest that students may well recognize that the universities are able to provide the basis for continuity in learning—cognitive learning at university complementing the on-the-job experiential learning—and they may turn to the university not merely nostalgically but purposefully asking for in-career updating and re-training when obsolescence has taken its toll. The universities of the U.K.—and not of the U.K. alone—will have to act quickly if they are to take their full place in fitting their students for life in the twenty first century.