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# Chemistry education for a changing world

PROCEEDINGS

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Graduates well qualified for the future must show independence of mind and spirit, and must be creative innovators. This implies change in the way they learn; a change which requires partnership between educators and employers, and which leads to something different from either academic or vocational education as we have known them. To be educated and effective for the future world, graduates will need:

- the ability to pursue the stages of an argument within the language of a discipline and to explain them in lay language to others;
- ease with measurement and quantification;
- to work well with others, which requires not merely intellectual ability but also moral qualities such as courage, patience and sensitivity;
- to go through life in a spirit of critical but humble questioning and learning.

University educators need to recognise that industry values the well-taught graduate ahead of any research output from universities.

## Education for life

Five years ago it seemed sensible to ask "what do employers expect of graduates?" so that academic courses might be planned simply to provide it. It was suggested that the partnership of universities with employers was mainly one of supplier to customer: as if new graduates were to be seen as 'products', more or less shaped by universities to the specification of the demanding consumer-employer.

Of course, that will not do at all. Good university teachers cannot subscribe to partnership in those terms. The teacher's calling is to do with amazingly varied individuals, not standard models. It is to do with critical reflection, not conformity to existing norms. It is about widening the range of people's choices in life, not about narrowing them down, but it is also a preparation for working life. We do not know what that working life will be like, but we do know it will be one of change. I want to discuss the kind of change we think most likely. Against this background we need to plan the way we educate our graduates.

## Employers' perception of need

Major employers recognise that they are unlikely in future to employ many graduates for their lifetime. They recognise that this confers a responsibility on themselves to keep employment options open by operating schemes for

continuing education. But they also point out that, to be prepared for this change, the quality needed in those well educated for the future is independence of mind and spirit. This concept is expressed in different ways and includes words like *independence*, *transformative agents* and *innovation*.

Two years ago the Association of Graduate Recruiters, which brings together those employers which recruit large numbers of graduates, published an excellent report called *Skills for Graduates in the 21st century*<sup>1</sup>. It stressed the challenge to universities to educate for *independence*; for, in the new uncertain world, graduates would above all need

*"the skills of self-reliance."*

Another recent report<sup>2</sup>, based on face-to-face interviews lasting between half an hour and an hour and a half with 258 employees and managers in 91 organisations, drew a number of clear conclusions including

*"Employers want people who see change as an opportunity, not a threat."*

This report demonstrates that employers look for graduates to be transformative agents who can help organisations to evolve. Transformative agents, by definition have ideas, 'look outside the box', and look ahead. They also bring about innovation. But

*"transformative people can be seen as threatening, as rocking the boat, in short as (causing) friction."*<sup>2</sup>

All over the world the industrial stress is on *innovation*. The word carries a similar boat-rocking message. Much industry has traditionally organised itself around the idea of a chain of activities, arranged to convert industry's inputs into the outputs it offers to customers (often called the supply chain). The essentially simple idea of the efficient supply chain within or between companies has recently been vastly complicated, but rendered far more interesting and fruitful, by adding to it a second strand of innovation which is interwoven with the chain at every point. That strand is represented not by the essentially conservative questions "Are we doing these things well (or smoothly, or efficiently)?" but rather, "Is this what we should be doing at all? What about something entirely different?"

That is an inherently awkward and upsetting strand of thinking. The idea was once expressed succinctly but enigmatically by an imaginative company chairman:

*"In a brainpower-intensive market-place we depend on the educated minds the universities can offer us, but don't give us what we say we want in those minds or we will never get what we need."*

In 1990 the Council for Industry and Higher Education made a similar point as follows:

*"As they respond to change and try to manage the present,*

*companies are coming to see their competitive power in virtually continuous innovation in an uncertain world. Business is beginning to describe managerial virtues in the vocabulary of 'imagination', 'vision', 'sensitivity', 'creativity'. In such a climate, the iconoclasm of a trained critical mind is a powerful business qualification.'*<sup>3</sup>

The message is that we need, more than ever, an education which encourages independence and innovation; only this will produce the *transforming agents* needed in the world of the future. Such an education needs to be planned through a partnership between universities and industry.

### Partnership in education

The partnership between universities and industry is not about working to specification. It must be a richer and more inspiring business altogether. It is to do with educating for change and growth. The partnership must come to consist in joint recognition by educators and employers (all employers, not only industrial ones) of a *shared responsibility*: that of trying seriously to enable people to learn and develop throughout their lives. That partnership includes others alongside employers and educators. Students are partners, since they must learn to plan and navigate their own course of living, working and earning. Governments are partners, being in a position to direct public subsidy to encourage a style of education which is appropriately, but not exclusively, related to a vision of tomorrow's working world.

Recently bodies representing all the universities, the academic funding-bodies and major representative organisations for industry and commerce took a respectable step forward in recognising this need for partnership. They put their names to a public *Declaration of Intent*<sup>4</sup> to take part in a joint national effort towards a common goal: that within a given period (two years perhaps) they would see that those in higher education are enabled to develop a range of personal and intellectual attributes, thought necessary for success at work, but which may go beyond those traditionally made explicit in the criteria for mastery of an academic discipline. I hasten to say that many of those have been implicit, or at least held to be implicit, in much teaching for centuries.

But the signatories to the *Declaration of Intent* are careful to define their own roles in this endeavour.

*It is not for employers to become amateur curriculum-planners, but to contribute to academic discussion their own insights about the world they foresee. The prior need is for employers to try to describe the working world of the future as best they can, and what that world will demand of those who hope to thrive in it, create opportunities and adapt to change.'*<sup>5</sup>

### The world of the future

Perhaps the most striking feature of the world's opportunities, as confronted by future graduates, will be their huge variety. In the UK (where until ten years ago higher education still catered for an elite) 60 percent of the oncoming age groups already have a statistical expectation of higher education –

about 30 per cent on leaving school, 10 per cent four or five years later, and getting on for 20 per cent (on present participation rates) during their later years. We expect participation to grow further: in Scotland it already has. Such enormous cohorts will find a range of jobs far wider and with a much wider spectrum of employers than hitherto. Relatively few will be those fast-track management and professional trainee openings which the British traditionally call 'graduate jobs'; most will be doing more ordinary work. It has to be the graduates' challenge to enlarge the scope of whatever job they do by adding a reflective, critical or innovative dimension.

Notwithstanding that great variety, what might be the general emphases of an education designed to be appropriate to an information-rich, technological society? A technological society is inclined to judge all knowledge by its *usefulness*; it is a society in which it becomes increasingly difficult to be useful without the knowledge, understanding and skill which are the outcomes of education. In that world the key words are not (eg) *software*, *chip*, or *gene*, but a quite different vocabulary, of which words like *implementation*, *application* and *effective* will be central examples.

People in *that world* will typically be ready to ask "what is it supposed to be for?" "Does it have to be done this way?" "Is this the best way, the way our world-class competitors operate?" It is a world in which future graduates will ask of their teachers "just what is the relevance of this course to *my future*?" To that question, a convincing reply will be something like "it will help you to understand something of the world: it will give you competence, skills, capability; above all it will enable you to *get things done* and think for yourself".

Already some of these aspects of a technological society are reflected in the UK's plans and targets for secondary education. Our National Education and Training Targets are that by 2000 well over half our eighteen year-olds should qualify for higher education. Significantly, it is expected that more than half of them will be qualified through the newly developed non-academic, worldly and work-oriented, demonstrably useful General National Vocational Qualifications. Some want to re-christen them 'Applied A-levels'. No doubt young people with such qualifications will constitute a considerable proportion of the pool of applicants for university places to read chemistry.

It is with these applicants in mind that the Council for Industry and Higher Education has written as follows (about post-18 education) to Gillian Shephard, Secretary of State for Employment and Education.

*"Much imaginative effort is needed now to develop new forms of higher learning not to replace, but to complement, the older ones. To convince students of the worthwhileness of rigorous study, they will generally need to be organised around areas of the working world's concerns and ways of doing things. To appeal to more practical minds they will often need to be grounded, we expect, in actual tasks and projects, in the concrete here-and-now rather than in the speculative or abstract. Above all such an applied education must offer a breadth that encourages versatility for a changing world and widens the range of choices students are equipped to make."*

That is something different from either academic or vocational education as we have known them. Perhaps its key characteristic is to begin with practice and move back into theory, rather than the other way round. It will deal not just with the knowledge-base of the discipline, but, more explicitly than at present, with the skills to apply and exploit that knowledge.

## Abilities for the exploitation of knowledge

### Communication

Our world is, of course, increasingly automatic. The central strength of an automated economy is its ability to follow routines. Its machines follow them, layer upon layer of routine and sub-routine, with far greater persistence than poor, bored humans every could. But they mean that in future many more working people must give increasing priority to dealing with the irregularities and creativity of humans (human resources) rather than the relatively predictable regularity of *things*.

So educated workers of the future must rely more and more on the traditional human thought-enabler – their own language. ‘Communications skills’ is not just a matter of flip-chart management or business report-writing. The aim is more fundamental and obviously worth serious academic attention: that of enabling all our graduates to pursue the stages of an argument within the language of a discipline and to explain them in lay language to those based in another discipline. It is about attentive listening and clear speech as well as precise writing; about supporting generalisation with example; about persuading, and being persuaded by others or resisting them. Our language shapes our world and defines our capabilities.

### Numeracy

Another characteristic of the working world for which its recruits must be prepared is its *measurability*. Employers have to be concerned to seek the greatest precision they reasonably can to minimise the risks implied by vagueness whenever it is economic and feasible to do so. They must measure where they can. They must compare themselves through benchmarking with standards and targets which are explicit and quantifiable not fuzzy and vague.

So in working discussion, merely verbal impression will seldom serve where a degree of numerical precision is available. Some years ago The Council for Industry and Higher Education urged recruiting companies to:

*“declare their preferences (as loudly and unanimously as possible) for recruiting from higher education only graduates demonstrably able to manipulate ideas, and express them to others confidently, in the best language of the time, which now includes mathematical concepts and terms.”*<sup>5</sup>

Perhaps this is a peculiarly British anxiety. The French, after all, can be heard to complain that they impose an obsession with mathematics on their elite. In any case respectable numeracy is not too daunting a goal and one which no doubt chemistry graduates take for granted.

### Teamwork

The next striking feature of the future working landscape is its *complexity*. Such complexity is inherently beyond the scope of single individuals; its vehicle is the *team* of people to which each member contributes from their own speciality. Successful complexity reflects successful teamliness. Our employers increasingly stress that their graduates must develop the special abilities to work in teams.

Advocating team-work involves more than hinting that university courses ought perhaps to include a group project, though that may well be true. The central importance of the team in employment is that it becomes the source of authority for its own activities; its own collaborative effort is the best available response to a complex challenge. Correspondingly the quality of its discussion, the comprehensiveness, objectivity and liveliness of its debates, are the only possible guarantee of the best possible answer to the question “What shall we do next?”

Those contributing through teams, therefore, must in principle decide for themselves what their own contribution to an issue must be, and stand by it. They must accept and offer criticism with as little fear or favour as they can manage. Experts in one discipline will need an imaginative understanding of how that discipline fits in with others. Specialists must learn the trick of explaining the principles of their ideas to others from different specialisms. That is part of the professionalism for the teamworker.

Successful teamwork, interestingly, is difficult to describe without the use of moral language. It needs *courage* to defend a viewpoint in a critical group, *patience* to listen to others and choose one’s moment, *sensitivity* to encourage the less forthcoming to chip in and so on.

All of this has implications for the learning methods that academics encourage. You cannot simply teach the principles of teamworking; it has to be experienced. The process of learning gains in importance alongside the content. The temptation of students and lecturers to collude in a spoon-feeding process plainly has to be strenuously resisted!

### Lifelong learning

Underlying the future working landscape is the apparently never-ending, possibly steepening, slope of technical and organisational advance. What we learn is obsolescent, and going out of date with accelerating speed. That changes the definition of educated people. They are no longer those with a given level of achievement (knowledge, understanding, skill capability, competence, syllabus-coverage) but those who have learnt to go through life in a spirit of critical but humble questioning and learning. They are those who at the end of their university courses are impressed less by the extent of what they have been taught than by the limitless prospect of learning in the future. The most important function of higher education is to inspire students with a passionate inquisitiveness to continue learning through life. The learning society is more than an idea for the future. Competitive industry is already becoming a learning world, though still stumbling along through unpreparedness.

The concept of learning as a central human activity, has important implications for judging the appropriateness of first-degree syllabuses. Most ought to be judged as *foundational*, as inherently preparatory for continued learning. They should be judged to fail, unless they widen horizons and provide the basic 'grammar' of a subject as a versatile base for future advance. The best sort of academic qualification might be more like membership of a club of those pledged to return to formal study at intervals in future. The choice of first-degree subjects strongly affects the *languages* which determine how the learner will grasp the world, the language in which she or he will ask questions about it. Thus the scientist will learn science-language for thinking and perceiving with; engineers will see with the eyes of engineering.

New and stimulating challenges confront all those bodies which validate and accredit courses, suggest equivalencies, propose competencies, set professional standards, and so forth. Flexibility, adaptability, wider horizons, inquiring minds, collaborative virtues, do not always easily fit their picture. Here should lie the nub of the debate about what national frameworks of vocational and professional qualifications can best contribute to higher education. How can professional institutions provide milestones along a continuing path of personal and professional development?

### Education for a changing world

Liberal educators have often feared that students will be short-changed by being offered courses based in practical learning and leading to clear vocational ends. This is a misplaced concern. However, students will be inexcusably let down if, in the cause of immediate applicability, their course excludes them from a general understanding by which they can adapt themselves for unforeseen applications and developments. They will be let down if they are not led to grasp the place their skills will take in the wider scheme of things and how they fit into the pattern of others' skills and knowledge. In short, they will be let down by vocational work unless it is made the vehicle for education into a wider capability, both practical and intellectual, for an unpredictable future.

I have chosen not to speak about academic research or technology transfer. That reflects one of the clear priorities of our Council and especially of its industrial and commercial members. It is *people* they want to talk about and the training of new minds for renewing the world. They have called for a new emphasis on creative teaching and learning in universities:

*"We cannot emphasise too strongly that among universities' outputs, it is well taught, broadly grounded, appropriately skilled people that industry values most, and ahead of any research output. Industry looks to university laboratories, for example, first of all for properly trained and thoughtful researchers. It sees technology as being transferred in the heads of well-educated graduates who can apply their knowledge systematically. It looks for people taught to develop understanding by reflecting on experience."*<sup>6</sup>

This clear emphasis on teaching and learning apparently surprises many academics. It emphasises the need for continuing constructive conversation between those

concerned with the best of the working world and those concerned with higher education. I have suggested that our definition of an educated man or woman must have some relation to their ability to meet, adjust to, and modify the demands of the world they will have to work in. People will look to universities to help students become both wise and effective in the world. That definition of their role extends the task of the university beyond the purely intellectual, and this may imply a shift in academic priorities and methods.

In recent years various initiatives have been taken in Britain to encourage institutions of higher education to engage in that 'continuing constructive conversation' with employers and the working world. *Enterprise in Higher Education* is perhaps the best known. But for many academics their deepest commitment is to their own discipline and to those engaged in advancing that discipline across the spectrum of universities and colleges. When a *discipline* as a whole looks at its responsibilities to its students and to knowledge in the light of our changing world, it might reasonably ask whether these can be met without taking its engagement with the rest of the working world with greater seriousness.

I am not surprised that Chemistry should be, as far as I know, the first discipline to rise to that challenge. The Royal Society of Chemistry, in partnership with our own Council for Industry and Higher Education have begun to invest quite generously in a venture to redefine the service that the discipline of Chemistry ought to offer to the world at large and to its students in particular. A substantial research project is on the launch pad to help us understand the demands of the working roles and lives that chemistry graduates follow and seem likely to follow in the future. That in turn will inform structured discussions with chemistry departments across the university system about the implications those conclusions might have for their own teaching and research.

I should not want to conceal our Council's hope that Chemistry's very forward looking move may prove to be an exemplary method to other great academic disciplines.

### References

1. *Skills for graduates in the 21st century* 1995 (The Association of Graduate Recruiters, Cambridge)
2. Harvey I, Moon S and Geall V with Bower R 1997 *Graduates' work: organisational change and students' attributes* (Jointly published by Centre for Research into Quality at The University of Central England and The Association of Graduate Recruiters, Birmingham and London)
3. *The humanities for the working world* 1990 (The Council for Industry and Higher Education, London)
4. *Helping students towards success at work* 1996 (The Committee of Vice Chancellors and Principals, The Confederation of British Industry, The Council for Industry and Higher Education, London)
5. *Towards a partnership* 1987 (The Council for Industry and Higher Education, London)
6. *A mass spectrum of opportunity* 1996 (The Council for Industry and Higher Education, London)