Proceedings

Who is asking the question?

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The perceived problem

To introduce the symposium, it is helpful to set the scene for the subsequent discussions of the main topic. Our theme is prompted in part by criticism aired in the press, Research Councils and learned societies that the skills of graduates in general, but here confined to chemists, may not match the expectations of employers. For example, in a recent DTI document,[1] the statements are made that
"Companies we have consulted have said that our universities are failing to produce people with the right understanding of the fundamentals of chemistry, relevant practical experience, and basic skills upon which they can build."
"UK universities are not addressing the deficiencies of their intake."
"… an absence of 'core-skills' – communication, IT, numeracy/maths, and basic chemistry was a real concern across the [chemicals] industry, and needed to be addressed."

The changing scene

For the most part, such statements are anecdotal, and are often offered in ignorance of the profound changes which have taken place in secondary and tertiary education in the past two decades, which has seen the tertiary sector move from elitist to mass education. Some of the differences are summarised in Table I, where the situation in the 1960s is compared with that of the present day.

Against this background, it must be said that (again quoting from the DTI Chemicals Directorate),
"Employers now expect their new recruits to have higher levels of skills than their predecessors."
"There is an increasing demand from industry for graduates to have experience of a broader range of multidisciplinary skills. These are needed for problem-orientated team working which is becoming common in the workplace."
So, expectations are higher, resources lower, and entry qualifications probably poorer.

Given this move to a mass education, it is not surprising perhaps that the direct comparison between current graduates and those of yesteryear is difficult. We would be better engaged upon a definition of what skills we would see to be essential or desirable in today's chemistry graduates, recognising the breadth of provision within the university sector. This poses an immediate problem, since there seems to be little consensus about what these essential skills are; hence the title of this short piece.

Table 1 Changes in Higher Education Institutions

	1960s	Present
School qualification	GCE 'O' and 'A' level (elitist)	GCSE, A and AS level (wider participation)
Participation level	10% of age cohort	35% and rising
Number of universities	50 plus 45 polytechnics	95 universities
Alternatives	Good apprenticeship training, technician training	Technician training now replaced by graduate training
Outcome	40% Good degrees in Chemistry. Full employment, vigorous chemical industry, jobs for life	75% Good degrees in chemistry, changing pattern of employment, less security, changing chemical industry, rise of SMEs
Funding	Adequate	40% reduction in annual spend per capita in the last decade

Table 2 Employment destinations for chemistry graduates

Research (leading to a higher degree)	Academia Industry School teaching Other (government, finance, consulting)
Education	School teaching Other education
Technical	Production Sales Laboratory management
Non-specialist scientific	Management Sales Consulting
Non-scientific	Finance Communications IT Management Accountancy

What are the required skills?

To begin, we should consider who might be asking the question. The answer must include future employers, those professionals responsible for HEI provision and, importantly, the 'customer' students themselves. From a consideration of these, we may be able to distil 'core' skills that all graduates should have. Some major employment destinations for chemistry graduates are listed in Table 2.

It would not be surprising if different types of employment required a different balance of skills. What does the employment market want?

An 'ideal' chemistry graduate might have the following accomplishments:

- Superb academic understanding of all branches of the subject
- Ability to apply knowledge in problem solving; flexibility in problems to be tackled
- Very high competence in the laboratory
- Articulacy, excellence in verbal communication
- Numeracy, good IT skills
- Ability to write correct, precise English
- Foreign language skills
- Familiarity with 'team-working'

While all of these must be present to some extent, different employers will of course place different emphasis on various components of the mix. Thus, academics seeking research staff might emphasise the first three; industrial employers may place great emphasis on problem-solving and communication skills; SMEs might emphasise versatility; non-scientific employers would certainly emphasise problem-solving skills, literacy, numeracy and IT.

Core skills

All graduates in chemistry should have

- Academic competence; but this might be at a level different for a research market than for a non-research market or non-scientific market
- Laboratory skills
- Communication, IT skills
- Problem-solving abilities
- Numeracy, literacy

It is not my purpose here to debate what scientific material should be included in a 'core' chemistry course; this is for individual Departments and accreditation agencies, such as I.Chem.E. and RSC to determine. I would make the observation, however, that in my view we almost invariably include too much material. All HEIs now pay attention to 'transferable skills'; some do it in a diffuse manner by embedding them in teaching modules. It will be argued elsewhere[2] that explicit, dedicated provision should become the norm and at a level significantly higher than is currently the case in most institutions.

All the attributes of the 'ideal' graduate can be fostered to varying degrees in HEIs with, in my view, the exceptions of numeracy or mathematical ability and literacy, which ideally should have been acquired during secondary education. However, what is required at national level is the supply of a broad 'range' of employable chemistry graduates with a diversity of skills in recognition of their different employment destinations.

However, we must emphasise that whatever the prospects of employment for chemistry graduates, student motivation to study chemistry may be for quite other reasons, including genuine interest, even passion, for the subject. In identifying what any employer may want to see in graduates, we must never lose sight of the need to satisfy student client expectations in this regard, and also to recognise the opportunity a chemistry course offers of providing a general, sound education. The best of students wish to be 'stretched'; the poorest want to learn how to achieve a qualification with least effort; the vast majority want stimulation and enhanced employment prospects.

Which way forward?

The nation must decide how best to produce this range of graduates. There are several possible models. At one extreme, individual HEIs may seek to supply one type of graduate aimed, say, at the research 'market', with others providing a different training. This diversity by institution may happen to some extent *de facto*, but the UK HE funding models do not promote it since financially all Departments are dependent upon relatively high-volume undergraduate teaching and research for survival. Given this situation, individual HEIs may satisfy student client requirements by offering a diversity of courses; and this necessarily leads to debate about the content, duration, and qualifications achieved. Most Departments now offer, some exclusively, an 'enhanced' degree course of four (sometimes five) years' duration, leading to an M.Chem./M.Sc. qualification. While this is satisfying academically to many undergraduates, the courses are largely research oriented. Such courses may well become a requirement for graduates wishing to pursue a Ph.D. Given the large number of successful three-year B.Sc. degrees, some provision will be required for well-qualified B.Sc. graduates to progress to Ph.D., probably via M.Res. type courses. There has long been debate about the various options such as '2+2'and '3+1' schemes. Suffice to say that there has not yet been a serious attempt by QAA or accreditation agencies to standardise qualifications, or by research councils to establish requirements for entry to higher degree programmes; nor have the Funding Councils really provided the financial framework for diversity of provision to be explored widely.

The changing markets for graduates, the financial pressures on student consumers of our courses, the decline in percentage terms of student numbers seeking entry to chemistry courses will all conspire to ensure that the nature of what we offer, and the methods used, will be constantly reviewed in coming years. Whatever changes are made at national or institutional level, we must never lose sight of the goal of providing our students with a challenging, enjoyable, rewarding experience which will be recognised as such by them, by future employers, and by ourselves.

References

1. *Learning and Skills Issues in the UK Chemicals Industry-A Competitiveness Study Report 1-Education-related issues (up to and including post-16students)*, Chemicals Directorate, DTI [This is a recent internal DTI document with some limited external circulation, but it reflects views widely expressed in industry and elsewhere.]
2. P.D. Bailey, *U. Chem. Ed.*, 2001, **5**, 80 (the Nyholm Lecture).