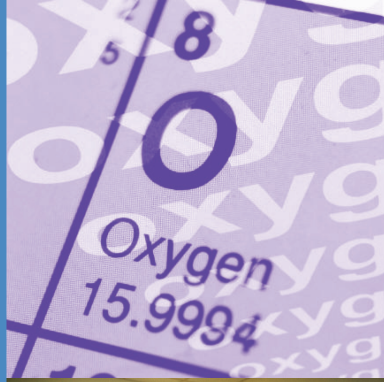
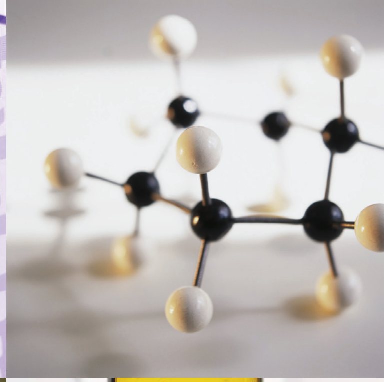
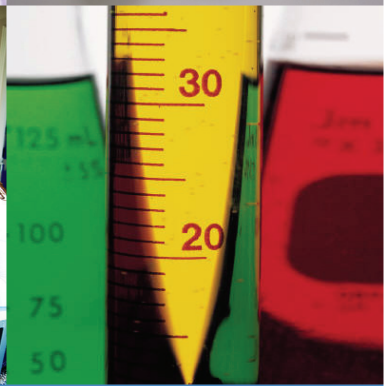
Chemistry







Review of the Student Learning Experience in:

CHEMISTRY

2008

The Higher Education Academy
Physical Sciences Centre

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1. Foreword

In 2007 the Higher Education Academy commissioned three Subject Centres to produce National Subject Profiles in Materials, Microbiology, Biochemistry and Art, Design and Media. Although not part of this pilot scheme the Physical Sciences Centre believed that the time was right to carry out a similar review of the undergraduate experience of teaching and learning in chemistry and in physics. This report is the product of that review in chemistry.

The aim of this report is to provide a snapshot view of the state of the student experience in UK chemistry departments in 2008. We have used online and paper questionnaires to determine the views of undergraduate students and all levels of staff across a wide range of institutions. This information has been supplemented by detailed interviews with Directors of Study in several institutions. Although these samples were not statistically significant we are confident that they do represent a cross section of views.

Overall, this review demonstrates that chemistry education in the UK is in good shape. Recruitment is showing indications of upturn and students are generally well qualified. They are overwhelmingly satisfied with their experience. Perhaps most surprisingly, the nature of the student experience differs very little across different types of institution.

We hope that this report will be of value to all those involved in teaching undergraduate chemists and to those in a position to influence curriculum developments. It should make a useful companion to the baseline information obtained from the National Student Survey.

We would like to thank the members of the Advisory Panel for their constructive support and sound advice. Thanks are also due to the academic staff and undergraduate students who took the time to complete the substantial questionnaires and to provide advice and feedback through the development phase by attending focus group meetings. Mike Edmunds and Michael Gagan, consultants on the physics and chemistry reviews respectively, have produced reports of outstanding quality and should be congratulated.

Professor Tina Overton
Director, Higher Education Academy
Physical Sciences Centre

2. Preface

It is a pleasure to write the preface to this Review of the Student Learning Experience in Chemistry. Although this has been produced simultaneously with the National Subject Profiles supported by the Higher Education Academy (HEA), the present report was not so commissioned. However, chemistry is such a vital subject in the pantheon of the sciences, and opens the student career gateway in such a variety of ways, it was felt that a parallel study was essential for chemistry, and it is hoped that readers will agree. The Review has therefore been funded independently by the HEA Physical Sciences Centre.

This report is intended primarily for

- Departmental Heads and other managers of HEIs for use in considering the future organisation and delivery of chemistry teaching
- industry to use in dialogue with HEI Departments
- the Royal Society of Chemistry (RSC) and other bodies to use in presenting and representing the discipline of chemistry to Government, the public, and industry
- potential students and departments in providing evidence to support their recruitment of both students and staff
- use by Vice-chancellors and senior university management in supporting the chemical sciences, and understanding the nature of the subject, and its role within science, engineering and medicine.

The Panel felt the results of the surveys were a cause for optimism about the subject.

An Advisory Panel, which met throughout 2008, consisted of a range of university staff from all types of institution, representatives from industry and the RSC, and HEA staff. The principal methods for the survey were questionnaires to academic teaching staff, to Directors of Teaching in selected HEIs, and to students. The questionnaires were informed by pilot face-to-face meetings with staff in selected HEIs, though these results have not been used in the survey. Returns from staff were good, and are clearly statistically valid. Returns from students were proportionately smaller, and thus statistically suspect, though it should be said that the present results agree substantially with independent student surveys.

The Panel felt the results of the surveys were a cause for optimism about the subject. The majority of students and staff have a very positive view of their teaching and learning experiences. The readers should discover this for themselves, but two points are particularly noteworthy in my view

- Despite prior beliefs that the teaching and learning experience of students and staff in institutions of different types would be very different, the survey shows a wholly contrary view, that the differences are relatively small.
- The importance and enjoyment of laboratory experience is a core feature in chemistry courses. Practical work clearly plays a key role in the recruitment of students into chemistry, and remains an essential ingredient for recruitment of graduates into industry. This element of chemistry courses must be maintained.

I would like to thank all of the Panel members for their immense insight into the teaching of our subject, and for their dedication and hard work over the past year.

Professor David Phillips, OBE, FRSC
Chair, Chemistry Review Advisory Panel,
December 2008

The majority of students and staff have a very positive view of their teaching and learning experiences.

3. Executive summary

1. This Report aims to present an overview of the education provided for full-time, chemistry undergraduates in UK universities, to inform academic staff, administrators, students, parents, employers and planners about the range and nature of the provision.

2. Chemistry makes a massive contribution to the quality of life, and is a major contributor to national prosperity. It is therefore essential to continue producing high quality chemistry graduates.
(section 5.2)

3. Employment prospects for chemistry graduates are extremely good in comparison with many other graduates.
(section 15)

4. The quality of the student experience across different types of institutions (Russell, 1994 and Alliance Groups) is remarkably similar.

5. A wide variety of courses is available in the chemical sciences, but despite their different emphases, they are overall providing a high quality education.

6. Almost a third of the students rate teaching excellent overall, and very few say they experience poor teaching.
(section 13.1)

7. Most undergraduates will experience excellent or good teaching accommodation in laboratories and lecture rooms.
(section 5.7)

8. Although average tariff scores for entry to chemistry are increasing, scores obtained by entrants exceed the entry requirements.
(section 6.2)

9. The enhanced degrees (MChem/MSci) are generally preferred to the BSc degree, by both staff and students.
(section 5.4.2)

10. Staff report that entrants are not generally well-prepared to become independent learners. Their mathematical ability, practical skills and problem solving skills are causes for concern.
(section 6.4)

11. The percentage of students gaining a First Class Honours chemistry degree has hardly changed since 2004 despite a steady rise over the physical sciences. Very few students on MChem/MSci courses leave without a first or second class degree.
(section 7.3)

12. Students have a high number of teaching contact hours per week, but only seem to work independently for half the number of hours that staff expect. They find tutorials the most effective teaching method, and practical work the most enjoyable. They believe that attending a lecture is time well spent. Staff prefer tutorial groups of 4-6 students.
(section 10)

13. Students find e-learning the least effective and least enjoyable teaching method, but appreciate on-line library access and external internet resources. Staff regularly use presentational software, and a virtual learning environment.
(section 11.5)

14. Students are mostly positive about spending long hours in the laboratory, as they recognise the importance of developing practical skills. The average student will spend more than half as much time again writing up outside the laboratory. Alliance Group students spend significantly less time in laboratories than other students, and almost all their staff think their students spend too little time for them to become competent laboratory workers.
(section 11.6)

15. All departments include extensive project work in the final year of both BSc and MChem/MSci courses.
(section 11.8)

16. All departments promote the development of transferable skills, but not many students think this has enhanced their learning experience.
(section 11.10)

17. Staff provide learning outcomes for all course components, but they think that most students ignore them. One third of students seem to use them regularly.
(section 11.9)

18. Most students have an option to study some modules outside chemistry, and most find this useful.
(section 11.12)

19. Most students think the amount of assessment is about right, but nearly half would like to see more emphasis on continuous assessment. Just over half the students feel assessment accurately reflects their level of ability, while two thirds of the staff hold that view.
(section 12)

20. Almost all departments collect regular feedback from students, and staff believe that student feedback is improving their teaching.
(section 13.1)

21. Most students would prefer more regular and prompt feedback.
(section 13.2)

22. Most staff who attend teaching development events use material or ideas they pick up and pass them on to colleagues.
(section 14.1)

23. Few staff read current research in chemistry education, or undertake research or scholarship relating to undergraduate teaching. Twice as many women as men staff, *pro rata*, have been actively engaged in chemistry education research.
(section 14.1)

24. Staff spend about half as much time again on informal support to students as on their timetabled teaching load, with many operating an open door policy. Staff in Alliance Group departments seem to have the heaviest teaching loads.
(section 14.2)

25. Most students think their courses are providing them with knowledge and skills that will be useful in their expected career, but some feel departments should offer more help.
(section 15)

26. Nearly all students are given the option of an industrial placement. Every department believes this is a good way to prepare for employment, and almost 90% of the students who participate agree. Three times as many students take up work placement as foreign exchange.
(section 16)

27. Few DoTs are convinced that their departments engage effectively with employers. Many rely on informal contact through their industrial placement schemes.
(section 17)

4. Introduction and methodology

When in late-2006, the Higher Education Academy (HEA) (1) proposed that surveys should be undertaken to examine the student learning experience in various disciplines in higher education (now called National Subject Profiles)(2), the Physical Sciences Centre (3) Advisory Committee endorsed this idea and agreed to conduct surveys in the areas of chemistry and physics. This seemed to be an appropriate time to investigate the state of teaching and learning in the chemical sciences, and provide a baseline for subsequent studies, to gauge the direction and rate of change in chemistry education at an undergraduate level. Although these subjects were not selected by HEA for the pilot investigations, the Centre put aside funding to enable separate surveys to proceed in the two disciplines. Two consultants were appointed in the summer of 2007 with the aim of completing the task before the end of 2008. An Advisory Panel, chaired by Professor David Phillips OBE of Imperial College was convened to oversee the development and production of the Chemistry Review.

Three questionnaires were devised after much consultation, and distributed in the first half of 2008. Those for staff (4) and students (5) were made available in paper and on-line format; that for Directors of Teaching (6) (or staff in an equivalent position) was distributed via e-mail. Where the responses to individual questions are discussed within this report the questions are referenced as stuxx, stayy or dotzz, respectively.

Departments invited to participate in the survey were all offering undergraduate degree courses in chemical sciences – the 4-year MChem/MSci and the 3-year BSc – that had been respectively Accredited and Recognised (7) by the Royal Society of Chemistry (RSC) (8). At least one of these courses was described as Chemistry, or had chemistry in the course title. For the purposes of analysis, the departments covered by the survey are grouped into Russell (9), 1994 (10), and Alliance (11) Groups. Although the Russell Group is the Group as officially constituted, some similar departments have been added to the official listings of the other two Groups (*Appendix 1: Grouping of University Chemistry Departments*).

All the Russell Group departments offer an accredited MChem/MSci degree but only eleven of them also offer a BSc in Chemistry. 1994 Group departments all offer both accredited MChem/MSci and BSc courses; and whereas all the Alliance Group departments offer BSc chemistry, only nine of them also offer the MChem/MSci[dot16] (12). The overall ratio of MChem/MSci:BSc students in the Russell and 1994 Group departments is about 60:40, while in the Alliance Group departments this ratio is reversed at 42:58[dot17]. The responses to the student questionnaire show a higher proportion of MChem/MSc students than this (see Figure 3 below).

All departments have the option of transferring students from the BSc course to the MChem/MSci course (or *vice versa*) at the end of the first or second year[dot18]; and it typically requires students to achieve a minimum score falling between 50 and 66% by the end of Year 2[dot19].

Only about 10% of students are not given a choice, at some stage of their course, as to whether they take a BSc or MChem/MSci degree[stu86] (13).

departments[dot3], and it is notably different from the distribution between male and female chemistry graduates, which reached 49% male: 51% female in 2007 (15). Overall, around 6% of

Table 1: Chemistry department staff data by departmental Group

	Profesors: Average (range)	Other teaching staff: Average (range)	Ratio Profesors: others	Male staff: Average	Female staff: Average	% Female staff
Russell	18 (30-8)	25 (48-13)	1:1.4	38	7	16%
1994	11 (21-3)	19 (34-10)	1:1.7	25	5-6	18%
Alliance	4 (10-1)	13 (22-4)	1:3.2	14	3	19%

The survey of chemistry department teaching staff yielded responses from 237 staff in 45 Chemistry Departments from across the UK (14). Responses were received from across the whole range of teaching staff in departments – Professors - 47, Readers - 20, Senior Lecturers - 55, Lecturers - 60, and other teaching staff - 28. Others identified themselves as Head of Department, or Director of Studies/ Teaching[sta3]. Russell Group departments have a higher ratio of professors to other teaching staff[dot2 & website data], but a lower proportion of female staff[dot3] (Table 1).

Figure 1 and Figure 2 show the age distribution of staff responding, indicating a roughly normal distribution[sta4].

chemistry professors are female, an increase from only 2.4% in 1999. (16, 17) The staff gender distribution differs only slightly from this in each Group of departments[dot2]. Of our staff sample, 69% were submitted in the 2008 RAE (18), a distribution of 78% of male staff, and 51% of female staff[sta6].

Returns to the student survey were received from 328 students in 29 universities. Of these, 141 students were attending Russell Group universities, and 187 non-Russell Group Universities[stu1]. Overwhelmingly these students came from Departments named Chemistry (286 students), or something similar (see *Appendix 2: Names of Departments in Universities teaching Chemistry*). Other students came from

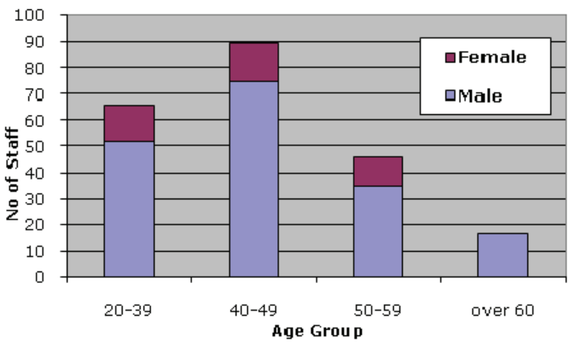

Figure 1: Age distribution of staff responding (showing gender)

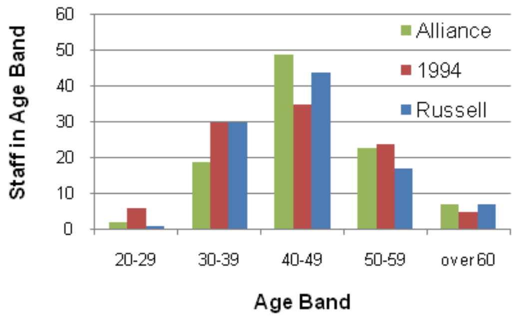

Figure 2: Age distribution of staff responding by institutional group

There was a gender distribution in responses to our questionnaire of 82% male: 18% female[sta5]. This represents the usual distribution between male and female staff in

biosciences departments (including medical and veterinary sciences, and pharmacy), engineering, health, physical sciences, and others[stu2].

Figure 3 and Figure 4 show that of the students who responded to the questionnaire, those who are taking MChem/MSci courses - 218 outnumber those taking BSc courses - 107 by about two to one[stu4]; and also that male and female students responded in similar numbers in all years[stu5,6].

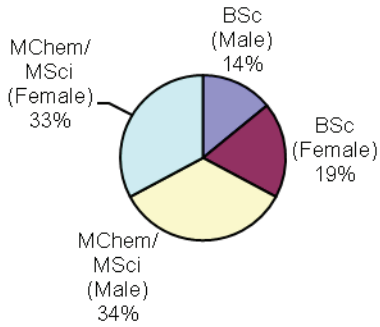

Figure 3: Gender and course distribution of students responding to the Student Questionnaire.

The male:female ratio among the respondents corresponds quite closely to overall figures (19) shown in Figure 21.

Directors of Teaching from 8 out of 18 Russell Group Chemistry Departments, 10 out of 12 1994 Group Chemistry Departments, and 13 out of 18 Alliance Group Chemistry Departments returned questionnaires[dot1]. The surveys were supplemented by focus and discussion groups attended by 54 students from eight departments. Further information about departments was also obtained from their websites.

Although considerable efforts were made to obtain a representative sample of responses to the survey questions, there must always be some doubt about the true generality of the results obtained. Not all units responded, reducing the comprehensive nature of this data. Staff and student respondents were self-selecting, and so may have been biased towards those with more polarised views. Especially with the views quoted directly, it must always be remembered that these are statements from individual staff and students, even though selection has been made only of comments supporting a consensus view. Despite these limitations, the author and advisors consider that the overview given in this document provides a generally reliable picture of the teaching and learning experienced by under-graduates studying for a degree in the chemical sciences at the present time.

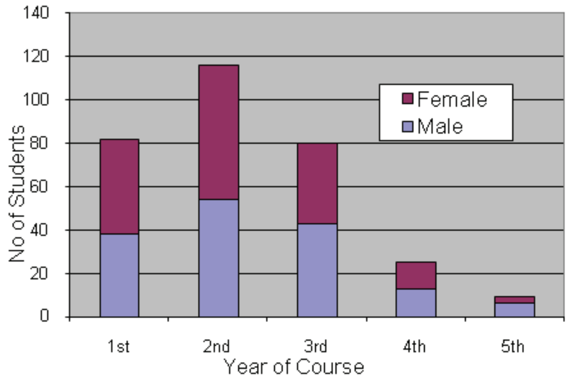

Figure 4: Distribution of students who responded to the questionnaire by year of course and gender.

A government enquiry is currently taking place to investigate several of the areas covered in this report, but on a wider scale. (20)

5. Background and context

5.1 The interaction of chemistry and society.

In 2001 the RSC published a timeline (27) showing the most significant chemical discovery or achievement in each of the previous 50 years. These included the determination of the structure of DNA (1953) and vitamin B_{12} (1955); the synthesis of Kevlar (1964) and insulin (1966); the discovery of Nutrasweet (1965) and Viagra (1989); the launch of superglue (1958) and TAXOL (1993); the production of silicon chips (1961); and the application of DNA fingerprinting (1984). So, although the public perception of chemistry (and more particularly chemicals) is often rather negative, these events and the brief list below demonstrate the overwhelmingly positive contribution made by chemists to human welfare and our modern lifestyle. (21, 28, 29)

Pharmaceuticals (30)

- Antibiotics – (For example: sulfonamides, penicillins, cephalosporins, -mycins, carbapenems and tetracyclines)
- Antiretroviral drugs to contain the human immunodeficiency virus that leads to AIDS (efavirenz, zidovudine, lamivudine)
- Antiviral drugs for herpes, hepatitis, influenza and other viral diseases (Aciclovir, Rimantadine, Tamiflu)
- Anti-ulcer and anti-heartburn drugs (Cimetidine, Esomeprazole)
- Cholesterol lowering drugs - statins (Simvastatin, Lipitor)
- Heart disease drugs – antithrombotics (blood thinners - Clopidogrel), ß-blockers to counter angina (Propranalol, Atenolol), blood pressure (hypertension) reducers (Captopril, Norvasc)
- Anti-asthmatics (Seretide, Salbutamol)
- Anti-cancer drugs (Cisplatin, Chlorambucil, Vinblastine, Tamoxifen, Sunitib)
- Drugs to counter mental illness – schizophrenia (Olanzapine, Risperdal), depression (Venlafaxine)
- Oral and injection contraceptives (Progestins, Mifepristone, Depo-Provera)
- Drugs to counter diabetes (Exenatide), insomnia (Eszopiclone), obesity (Acomplia)

Materials

Materials can now be made to almost any specification, especially by the use of composites, in which the properties of different materials can be combined. Artefacts that in the middle of the twentieth century were made from the traditional materials of wood, metal, rubber, card, paper, leather, ceramics, glass, wool, cotton and silk are now made of plastics, or artificial fibre.

Plastics – polythene, polystyrene, polycarbonate, synthetic rubber
Resins – melamine, epoxy resins and adhesives, polyurethanes, ion exchange resins (for water softening and purification)
Fibres – nylon, polyester, Lycra, optical fibres, carbon fibres, nanotubes
Organics – liquid crystals (for liquid crystal display units in electronic devices, and flat screen television sets), conducting polymers
Inorganics – ceramics, superconducting magnets, high specification alloys
Catalysts – noble metals (catalytic converters), zeolites

Energy

Batteries - rechargeable nickel-metal hydride, lithium ion for the personal digital industry
Photovoltaic cells for harnessing solar energy.
Fuel cells offering clean energy

Health and Safety

Advances in the analysis of chemical substances – in food science, forensic science, industry and the environment – make it possible to detect minute quantities of toxic metals, explosives, or performance enhancing drugs quickly and reliably.

Achievement

British chemists and biochemists have won four Nobel Prizes for Chemistry in the last 20 years – Richard Roberts (1993) for discovery of the mechanism of gene slicing, Harry Kroto (1996) for the discovery of buckminsterfullerene, John Walker (1997) for elucidating the biomechanism of ATP synthesis, and John Pople (1997) for developing computational methods in quantum chemistry (31).
See also references 21, 28 and 29.

5.2 Chemistry in the UK economy

More than any other science, chemistry underpins an extensive and successful industry. The UK chemical industry, which includes chemicals, pharmaceuticals, nuclear, oil & gas, petroleum and polymers (32, 33) is critically dependent on research, especially towards green chemistry (34), much of which is pursued by graduates from UK chemistry departments. An output of well-qualified chemistry graduates must be maintained, or increased, for the health of the industry (35).

- The UK chemical industry has an annual turnover in excess of £160 billion, (a 32% rise since 1997) (36).
- The industry's 15,000 employers provide more than half a million jobs (37, 38).
- In terms of productivity (i.e. value added per employee) the UK Chemical industry ranks 3rd in Europe and 5th globally amongst OECD countries, at about £100,000 per employee (36, 39).
- The UK chemical industry spends over £2 billion a year on new capital investment.

Chemicals

The UK chemicals sector includes industrial gases, dyes and pigments, fertilisers, pesticides, soaps and detergents, perfumes and toilet preparations, explosives, glues and essential oils.

- This sector accounts for 2% of UK Gross Domestic Product, and 17.7% of manufacturing industry's gross value added (36).
- It is manufacturing's number one exporter, with 92% of its output (£31.8 billion) exported in 2004.
- It produces a trade surplus of just under £5 billion.
- It is estimated that each UK household either directly or indirectly spends around £30 per week on products of the chemicals industry (39, 40).

Pharmaceuticals

This sector produces the active chemicals and the preparations in which they are delivered.

- It employs 71000 in just under 600 companies, generating in 2003, a 20% UK share of the sales of the world's top 100 prescription medicines (36, 41).

Nuclear processing

- The UK is the 10th highest nuclear generating country globally. (38)
- Nuclear power provides about 18% of the UK's electricity (42).

Oil, gas and petroleum

UK still has substantial recoverable reserves of oil and gas, potentially exceeding the amount already produced (43, 44).

- This sector includes extraction and initial processing, and stabilising, refining, and blending of oil and gas.
- The nuclear, oil and gas, and petroleum industries employ 114000 (including retail) in about 5300 companies (35).
- Up to 60% of the output from the UK's nine petroleum refineries is transport fuels.
- The industry is working on making petroleum-fuelled vehicles even cleaner and less polluting; but their chemists are also creating new 'greener' fuels (45, 46).

Plastics and synthetic rubber

- The UK shows an output of 2.5 million tonnes of plastics per annum, amounting to more than 2% of the UK GDP (47, 48).

5.3 Chemistry as a teaching discipline in the UK

> "Chemistry is one of the core scientific disciplines. Advances in chemistry contribute directly to our everyday lives – to the medicines we take, the food we eat, the clothes we wear, the environment we live in. In combination with other sciences, chemistry will help underpin much of the progress we can make in the future – and the prosperity which will flow from it."

So said the Rt Hon Tony Blair in 1999 in the Royal Society of Chemistry's millennium publication, *The age of the molecule* (21). The need for a regular supply of highly-skilled chemistry graduates is implicit in this statement, and the chemistry departments of British universities have already been teaching to meet this need for more than a century.

A succinct definition of what is meant by chemistry is found in the chemistry benchmark document from the QAA:

> "Chemistry can be defined as the science that studies systematically the composition, properties, and reactivity of matter at the atomic and molecular level." (22)

There is also a description on most chemistry department websites. The example below complements the more formal definition above:

> "Chemistry is a discipline central to the sciences, ranging from the interface with physics to those with biology and medicine. It is concerned with all aspects of materials, including living systems, their physical and chemical properties, how we determine their composition and structure, and how we synthesise such materials and modify them for use in a modern society." (23)

Traditionally chemistry has been sub-divided into the distinct branches of inorganic, organic, physical, and analytical chemistry, but this demarcation is gradually being eroded, especially where the boundaries of the subject are being extended into bioscience and human sciences, as well as other physical sciences.

The nature of a chemistry education at university has changed considerably in recent years. As the bounds of the subject have increased the emphasis has moved away from building up an encyclopaedic knowledge to acquiring a thorough understanding of chemical principles and an ability to apply them. In line with other academic disciplines, students of chemistry are expected to take responsibility for their learning. Evidence for this is seen in the widespread introduction of project work, group exercises, problem-based learning, and the learning and practice of transferable (generic) skills.

Subject benchmark statements covering the BSc (Hons) in chemistry were approved by the QAA (24) in 2000 (25), and have since been used for guidance by HEIs, the QAA and the RSC in designing, reviewing, and affording recognition to new programmes in the chemical sciences, setting standards for quality assurance, and in developing course and module learning outcomes. They were used in developing the Budapest descriptors which describe the chemistry graduate at Bachelors, Masters and Doctorate levels (26). Recently a revised set of statements has been published (22), that now provide guidance on integrated masters (MChem/MSci) awards also.

5.4 Recent events of significance for undergraduate chemistry teaching

5.4.1 Departments and programmes

A certain amount of rationalisation in the provision of chemistry courses has taken place across the university sector in recent years, with the closing of some chemistry departments. At the present time, Chemistry degrees are taught not only within administrative units called Departments of Chemistry, but also in a variety of departments with more extensive subject coverage. Often a number of related sciences are grouped together in a School. The titles include Departments and Schools of Physical or Natural Sciences; of Science and Technology; and those in which Analytical, Biological, Biomedical, Engineering, Environmental, Geographical, Health, Forensic, and Pharmaceutical Sciences occur alongside Chemical Sciences[sta2] (see *Appendix 2: Names of Departments in Universities teaching Chemistry*). This merging of departments into larger schools has enabled a greater variety of degree programmes encompassing chemistry together with either other sciences or quite different complementary subjects.

In the decade 1998 to 2007, there was a 31% fall in the number of single honours chemistry degree courses offered by UK higher education institutions. (49) Joint honours degree programmes (Chemistry and …), where chemistry is approximately 50% of the degree content, generally seem to be less in favour with departments[dot21] than combined honours degree programmes (Chemistry with …), where chemistry is significantly more than 50% of the degree content[dot22]. The latter programmes include courses in the chemical sciences, with titles like Analytical Science or Medicinal Chemistry.

A large majority of the students completing the questionnaire in our survey (221) is studying Chemistry, with the name of the degree sometimes specifying 'with a Year in Industry/ Industrial Experience/Industrial Option,' or 'with a Year Abroad/in Europe.' (See *Appendix 3: Names of Degree Courses followed by students responding to the questionnaire*). In other combined honours courses chemistry is associated with medicinal chemistry (15 students), forensic science (27), and analytical chemistry (11)[stu3]. For the most popular of these programmes within the departments see *Appendix 3a: Other popular courses offered by departments.*

5.4.2 The 'enhanced first degree courses'

The introduction of integrated masters degrees, MChem or MSci, from 1993 was a major development for chemistry at university level. The Higher Education Chemistry Conference (HECC – now HCUK)(50), supported by the Chemical Industries Association (CIA)(33) and the RSC, decided "that with the theoretical basis of the subject, the technologies relevant to it, and the range of its applications ever advancing, coupled with the broader range of transferable skills being required, courses had become of insufficient duration for graduates wishing to become career chemists." (51) To distinguish this 'enhanced first degree' from the BSc it needed to include additional advanced material, practice in applying fundamental principles to solving problems, opportunity to become a competent practical chemist and learn basic research methods, while developing professional skills to a higher level.

The proportions of staff who think students gain an advantage by taking an MChem/MSci course rather than a BSc are shown in Figure 5[sta63]. The preference shown by both students and staff for the MChem/MSci does have an influence on how the department promotes its programmes of study to potential students[dot110].

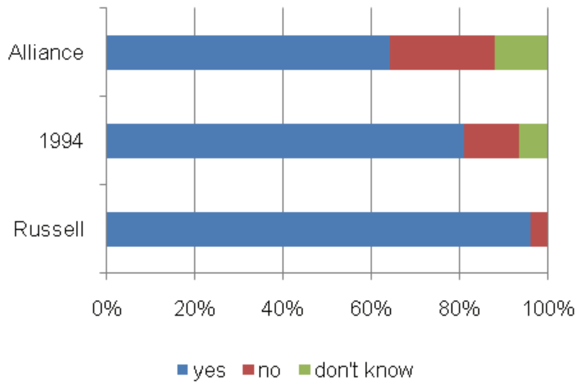

Figure 5 Staff response to the question: "Do you think that students gain an advantage by taking a four-year Masters course rather than a BSc?

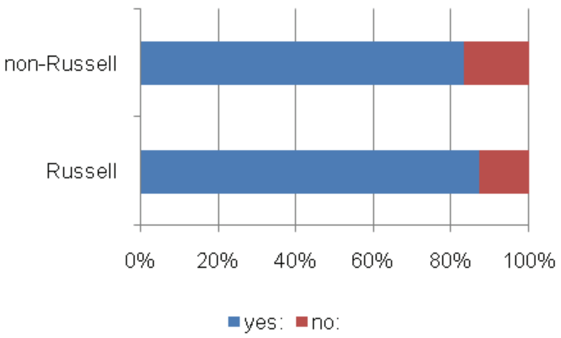

Figure 6 Student response to the question: "Do you personally think there is an advantage in taking a four-year Masters course rather than a BSc?"

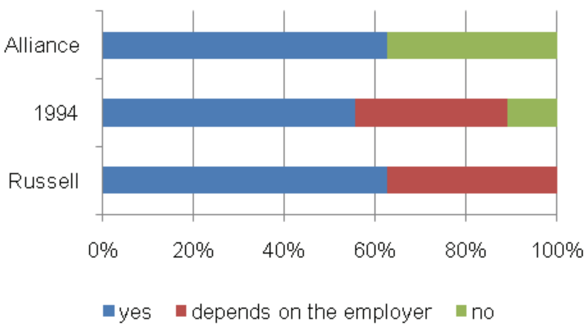

Figure 7 DoTs response to the question: "Do you think employers believe that the MChem/MSci is a more valuable degree than a BSc?"

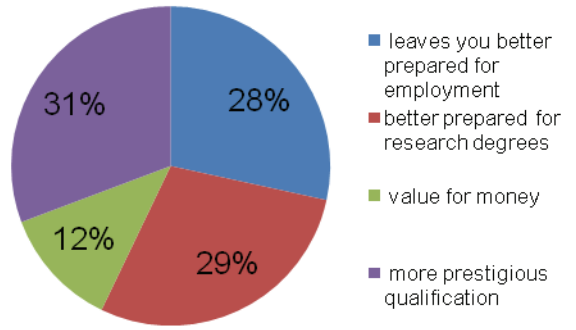

Figure 8 Principal reasons why students would favour the MChem/MSci course.

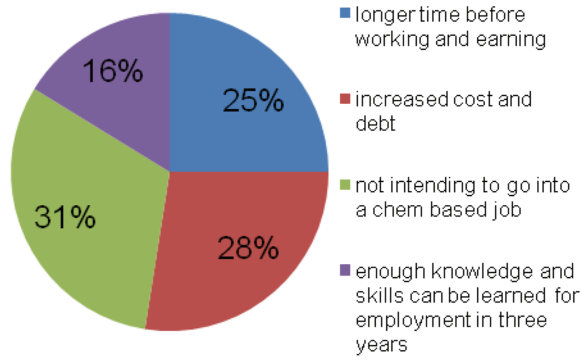

Figure 9 Principal reasons why students would choose not to take an MChem/MSci course.

The value of the four-year Masters course rather than a BSc also seems to be well established in the minds of most students (Figure 6), with more than five times as many students thinking that this gave them an advantage as disagreed[stu87].

DoTs gave a similarly positive answer to a slightly different question (Figure 7), although they expressed the reservation that for some types of employment it may not be advantageous[dot109].

The main reasons students give, for and against, are shown in Figure 8 and Figure 9. Students were allowed more than one choice, and the 271 students who felt the MChem/MSci gave them an advantage, gave in all 700 responses[stu87a]. The much smaller group of 52 students mustered 80 disadvantage responses between them[stu87b].

Among other supporting reasons were having the opportunity given to do a year's industrial placement linked with the MChem/MSci but not the BSc, and the better recognition afforded to the MChem/MSci by employers – in both large and small/medium enterprises, both home and abroad. An additional reason for choosing a BSc was that it was possible to proceed from BSc to a higher degree, with the option of doing this in a different university. Male students were more concerned that an MChem/MSci means a longer time before working and earning, while female students were more convinced that enough knowledge and skills can be learned for employment in three years.

Staff noted that the value of the MChem/MSci depends on students' career aspirations. The overwhelming justification staff would give for the extra year is that it prepares students better for their future careers, especially if they plan to do a PhD. They also place giving a better educational experience high on their list of reasons for recommending the MChem/MSci[sta63a]. The principal disadvantages listed by staff are the inappropriateness of the qualification for a non-chemistry career, and the considerable extra cost entailed[sta63b].

5.4.3 Improving teaching quality

When the Quality Assessment Committee of HEFCE (now the QAA)(24) developed and introduced a scheme (Teaching Quality Assessment – TQA) for the assessment of teaching and learning in higher education by peer review in 1993, chemistry was one of the 15 subjects included (53). This exercise was influential in establishing a new culture of review and evaluation of teaching and learning in chemistry departments, and led to a universal adoption of aims and objectives (learning outcomes), incorporation of transferable skills, development of active feedback systems, and improved relationships with other stakeholders in the ultimate product, the well-educated chemistry graduate. Currently a scheme of institutional audit, or review, is in place (52).

A major catalyst for development in higher education was *Higher Education in the Learning Society*, the 1997 Report from the National Committee of Inquiry in Higher Education (the Dearing Report) (54). The Committee was appointed to advise on the long term development of higher education, and among its recommendations were to focus on students' learning, to ensure staff and students are able to make full use of IT, to develop high quality computer-based materials, to provide access to teacher training for their staff, to value good levels of competence in communication, numeracy and the practical use of information technology, and to develop ability in critical analysis and learning how to learn. Our questionnaires made enquiries into the progress of all these recommendations in the views of chemistry staff and students.

Progress had already been made in the chemistry community towards implementing several of these proposals. Chemistry had one of the first CTI (Computers in Teaching Initiative) Centres (55), publishing *Software Reviews* and demonstrating computer assisted learning through roadshows, and the TLTP Chemistry Courseware Consortium. The CTI Centre was part of the DTI-funded Network for Chemistry Teaching, together with the Chemistry Video Consortium (CVC)(56), and the *eLABorate Project* (57). Two chemistry projects were supported by phase 1 of the Fund for the Development of Teaching and Learning (FDTL); *Project Improve* and *Personal and Professional Development for Scientists*. *Project Improve* (58) set out in 1996 to address the criticisms of chemistry teaching in the QAA Overview Report of the Teaching Quality Assessment exercise (59) and generally to disseminate good teaching practice, by establishing a network of staff in chemistry departments. Out of this project, in 2000, developed the Learning and Teaching Support Network (LTSN) Physical Sciences Centre – now combined with physics and astronomy, which ultimately became the Higher Education Academy's Physical Sciences Centre (3).

5.4.4 European developments and influences

In June 1999 the Education Ministers for the UK and 28 other European countries were signatories of the Bologna Declaration (60), which committed their countries to adopt 'a common framework of readable and comparable degrees' by 2010. In subsequent years the development of this framework has resulted in the general acceptance of a three-cycle structure, corresponding to bachelors, masters and doctoral studies of three, two, and three years respectively. While many countries across Europe (e.g. Denmark) (61) have embraced this structure wholeheartedly, the UK has been unwilling to follow suit (62). The degree structure in Scottish universities fits well into the Bologna format, and so does the English BSc; the stumbling block has been the adoption of a two-year masters programme, and the stipulation that "access to the second cycle shall require successful completion of first year cycle studies." These arrangements fit neither the continuous MChem/MSci programme nor the three-year BSc followed by a one-year MSc in place in England, Wales and Northern Ireland (63, 64). Many departments feel they are not able to do anything on their own and are awaiting guidance from Government; but progress seems to be slow relative to other European countries[dotint3]. The RSC has supported the *Mastering Bologna* project (65) which aims to create a strategy for UK chemical science degree programmes that will enable them to meet the requirements of the Bologna Process.

The European Chemistry Thematic Network (ECTN) (66) has been funded since 1996 as part of the EU's Socrates-Erasmus programme 'to map and enhance education, and to facilitate European co-operation.' ECTN organises an annual conference, but its main activities are organised through working groups, most of which have UK membership. Early working groups developed a core chemistry curriculum, and initiated the EChemTest, (67) a large bank of objective questions administered electronically and available in a number of European languages. Current projects include the image of chemistry, support for newly appointed university chemistry teaching staff, and dissemination of innovative approaches to teaching chemistry.

The ECTN Association (68), a permanent body maintained by subscriptions from its 120 institutional members, was formed to develop projects that originated in the ECTN working groups. It has been at the forefront of developments designed to implement the Bologna declaration through the EU's Tuning project. The Eurobachelor (69) has been developed as the framework for a European first-cycle degree in chemistry. Eurobachelor status has been awarded to 45 degrees at 37 institutions across Europe. The second-cycle Euromaster (70) framework has been more recently developed; 19 such awards had been made by September 2008. ECTNA has developed the Budapest descriptors, relevant to chemistry degrees for each cycle, based on learning outcomes and competences (26).

Another prominent European body is the European Association of Chemical and Molecular Sciences (EuCheMS) (71), which has the stated object 'to promote co-operation in Europe between non-profit-making scientific and technical societies in the field of chemistry and molecular sciences.' In membership are 50 national chemical societies, representing some 150,000 individual chemists in academia, industry and government in over 35 countries across Europe. Its Division of Chemical Education (72) meets once a year, when each society delegate provides an annual written summary of chemical education activities within their own country, thus providing an opportunity for dissemination of fresh ideas and good practice. The Division organises the biennial European Conference on Research in Chemical Education (ECRICE) (Istanbul 2008) (73), and, with the Tertiary Education Group of the Royal Society of Chemistry, the European Variety in Chemistry Education conference (Prague 2007; Manchester 2009)(74), that provide fora for researchers and practitioners in chemical education. The Division has also published a number of handbooks and guides (75). ProChemE (76) is the EuCheMS standing committee on educational, professional and ethical issues. The Division also oversees the

European Chemist (EurChem) designation (77), a title indicating a high level of competence in the practice of chemistry.

5.5 The role of the Royal Society of Chemistry in chemistry education

The Royal Society of Chemistry (8) is the learned society for chemical science and the professional body for chemists in the UK. Under its Charter, the Society has the responsibility 'to establish, uphold and advance the standards of qualification, competence and conduct of those who practice chemistry as a profession.' So not surprisingly, it offers wide ranging support to chemistry education at all levels – primary science to PhD and professional development – through its permanently staffed Education Department and its Education Division, drawn from the membership (78). The Education Division Council provides a route from members to the permanent staff, and hosts Subject Groups with specialist interests in Tertiary Education, Educational Technology and Chemical Education Research. Through Education Division Travel Grants it is able to supply bursaries, especially to young chemistry staff, for attendance at educational conferences, for which funding is not otherwise easily available. The RSC has a significant input into education policy by providing evidence on current issues and problems, and rightly claims that it is the largest non-Government supporter of chemistry education in the UK. It supports the Heads of Chemistry UK group, and collects statistics relating to education in chemistry (15).

The RSC Education Department is active in trying to enhance numbers of students on undergraduate programmes in the chemical sciences, and subsequently into academic and industrial chemistry, through poster campaigns, a nationwide series of exciting schools lectures, competitions, and the chemistry at work exhibitions. It is a participant in HEFCE's Aim Higher scheme through *Chemistry: the Next Generation* (79), and in their Strategically Important and Vulnerable subjects (SIV) initiative with *Chemistry for our Future* (80, 81), which aims to maintain 'a sustainable chemical science base within higher education, providing courses appropriate for students and employers in the 21st Century.' It recognises the importance of a well informed, highly motivated and inspirational teaching force at secondary level, and provides resources for teachers' use on a regular basis, through booklets, meetings, in-service training, and the magazine *Education in Chemistry* (82) (that also includes a pupil supplement, *InfoChem*, aimed at the 14-18 year group). The website *LearnNet* (83) also provides a host of resources for students and teachers of chemistry. The RSC enables teachers to experience the chemical industry through Industry Study Tours, has an ongoing teacher fellowship scheme to allow selected teachers to work on practical educational projects, and acknowledges excellence in teaching though annual awards.

At tertiary level, the RSC is responsible for the accreditation and recognition of degree programmes; and provides awards, and teaching publications and resources for university staff. It supports the web-based, peer -reviewed journal *Chemical Education Research and Practice* (CERP) (84), and the annual *Variety in Chemistry Education* conference (85). The RSC supports student chemistry societies, encourages the use of the *Undergraduate Skills Record* (86), and provides advice on employment and further study opportunities to university students in the form of guidance documents, industry tours and careers conferences.

RSC accreditation and recognition (7) is intended to establish standards but not to restrict the development of a wide range of course curricula 'designed to meet evolving needs.' Virtually all staff respondents are from departments whose degrees are accredited and/or recognised by the RSC, and the returns show that nearly 60% of staff seem to be satisfied with the procedures applied by the professional body. About 20% however would appear not to value them[sta74] (Figure 10). A revision of the criteria for accreditation is currently under consultation (87).

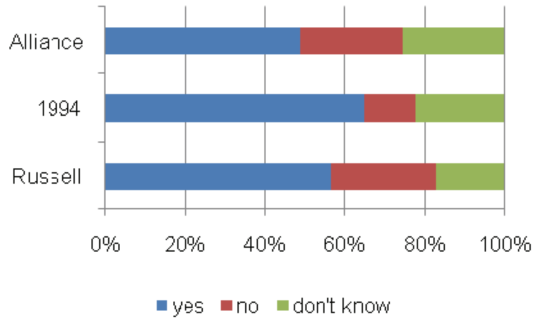

Figure 10 Staff opinion on the helpfulness of accreditation of chemistry degrees by the Royal Society of Chemistry.

5.6 The role of the HEA Physical Sciences Centre in chemistry education

The background to the HEA Physical Sciences Centre has been outlined in Section 5.4.3. It is one of the 24 Subject Centres of the Higher Education Academy (88), a UK-wide initiative supported by the four Higher Education Funding Councils, and has as its mission, 'to enhance the learning experience of students in the physical sciences (chemistry, physics, astronomy, and most recently forensic science) by addressing the needs of the subject community and relevant stakeholders.' Its principal aim is 'to disseminate good practice and innovation in learning and teaching of the physical sciences,' and it does so through organising professional development activities for university staff, including workshops, and science-specific induction events for newly appointed lecturers; and by providing information and resources relating to the practical aspects of university teaching, and pedagogic research.

A recent readership survey shows that the range of journals and monographs published by the HEA Physical Sciences Centre is well appreciated. *Physical Sciences Educational Reviews* (now *Reviews*) covers books as well as software; *New Directions in the Teaching of Physical Sciences* includes reviews of areas of physical sciences education and educational research, together with communications on innovative ideas; and the *Physical Sciences Practice Guides* are monographs providing practical advice and guidance on particular aspects of higher education. In addition briefing papers, primers, toolkits and a newsletter, *Wavelength*, are produced.

Each year the HEA Physical Sciences Centre invites competitive bids for funding for development projects, to enable academics to carry out educational research or development so that the results can be reported at *Variety in Chemistry Education* (for which it is joint sponsor with the RSC), or published in the Centre journals. This encourages academics to investigate in depth, perhaps for the first time, ideas they may have had about some aspect of teaching, learning or student support at university level.

5.7 Generic background issues not specific to chemistry

The Royal Society, in its 2006 report "*A degree of concern?*"(89) evidenced that there has been a reduction in the unit of funding of students over a long period. This may have been offset somewhat by the introduction of 'top-up fees' in 2006 but, it is still too early to quantify the effects of fees on the resources for teaching and learning.

Between 2002–03 and 2004–05, typical figures for overall space per student in higher education went down by 3%, with reductions, particularly in teaching space, taking place in nearly 60% of higher education institutions. Support space and office provision for academic and support staff hardly changed. As overall student numbers rose faster than space, this has put pressures on teaching, especially of laboratory-based subjects. However the proportion of teaching space in good condition for a typical university has increased over these years. (90).

This certainly seems to be true for chemistry departments. Figure 11 shows that for all three Groups, more than half their lecture rooms and classrooms could be described as excellent modern teaching space with all facilities available, and that only 10-12% of the teaching rooms are in need of refurbishment and additional facilities[dot35].

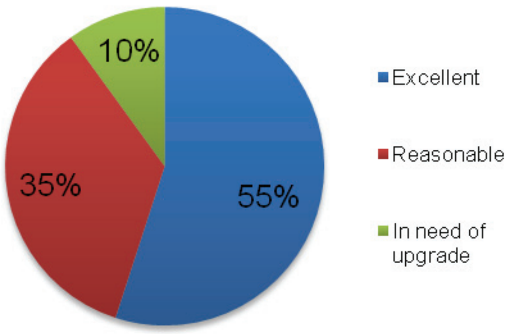

Figure 11 DoTs' perception of the quality of lecture rooms and classrooms used by their departments

Chemistry is a practical subject, and becoming a competent chemistry graduate entails a considerable amount of time spent in the laboratory. With the development of new courses like medicinal and forensic chemistry, and with the introduction of the MChem/MSci, the need for specialised laboratories has increased and this need has not always been met. As numbers have increased laboratory space has become insufficient in some HEIs, resulting in restricted time for student practical work, and causing problems with any reorganisation of the curriculum. Resources have generally become more limited for technicians, demonstrators, and new or replacement equipment[dotint2].

Nevertheless, as Figure 12 shows the quality of laboratory teaching space is high[dot48]; several departments have recently completed extensive teaching laboratory refurbishment programmes. Only a few Directors of Teaching say there are health and safety constraints against mounting the type of laboratory course their department would wish to provide for students[dot46], but a much higher number say there are financial constraints[dot47]. Both problems seem to be more severe in Alliance Group departments.

In their report, the Royal Society expressed the view (as it did in 2005 to the House of Commons' Science and Technology Committee) that university teaching is under-funded and subsidised from research activities, and possibly from lower-cost teaching activities. As stated "Laboratory-based projects in the final years of BSc Honours programmes are especially expensive, and laboratory-based subjects have been particularly badly hit when research income from the Funding Councils has been cut" (89). From 2007, the Higher Education Funding Council for England allocated £25 million per annum in additional funding over four years to support subjects (including Chemistry and Physics) that are very high cost because of the requirement for expensive specialist chemicals, equipment and facilities, and strategically important to the economy and society.

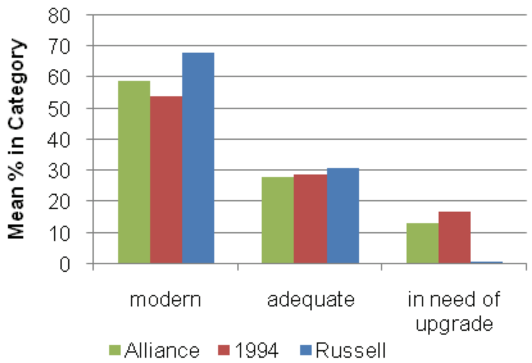

Figure 12 DoTs' perception of the quality of departmental teaching laboratories

Across all university departments there appears to be a perceived emphasis on the importance of research as opposed to teaching in the career progression of academics. This perceived pressure against committing time and energy to teaching is easing somewhat with the introduction in some parts of the UK of national and local schemes, which recognise excellence in teaching (National Teaching Fellowships, for example) (91). Furthermore, many local promotion criteria now make specific reference to contributions to teaching in all its aspects, including for promotion to professorial level.

In our survey, about one quarter of staff responding said they were aware of staff being promoted on the basis of good teaching[sta11], but almost two thirds of the Directors of Teaching reported that good teaching had not been a *primary* cause of promotion[dot6]. It would seem that a definite contribution to teaching is expected for promotion, but that it is still unusual for that to be the determining factor[dot30].

A major HEFCE initiative for the improvement of teaching in higher education came with the establishment of the 74 Centres for Excellence in Teaching and Learning (CETL) in 2005. These Centres have as principal aims the rewarding of excellent teaching practice, and investing further in that practice to deliver substantial benefits to students, teachers and institutions (92). There are two CETLs directly related to chemistry; the Chemical Laboratory Sciences CETL (ChemLabS) (93) at the University of Bristol – with its aims to transform the student experience of learning practical chemistry, and set new standards generally for laboratory-based teaching and learning of practical experimental science; and the Centre for Effective Learning in Science (CELS) (94) at Nottingham Trent University – endeavouring to create a new more relevant, accessible and achievable image for science; although several other more generic CETLs may also have an influence on chemistry teaching. ChemLabS hosts a state-of-the-art teaching laboratory, and supports both school teacher and university teacher fellows on secondment; CELS also works at both schools and higher education levels.

5.8 Teacher training

In school science the proportion of non-specialist teachers is relatively small. A survey (104) of one in five secondary schools found that 25% of the teachers who are teaching science held a degree in chemistry, or specialised in chemistry in initial teacher training; the predominant science specialism was biology (44%), with a further 19% with a physics background. Teachers with a degree in chemistry tended to be more strongly represented in schools with an age-range of 11-18 years. (105) A report in 2002 noted a shortfall in the requirement for chemistry-qualified teachers in schools of nearly 3700. Although pupil numbers have fallen in recent years the teaching profession still needs to recruit many more chemistry teachers. (106)

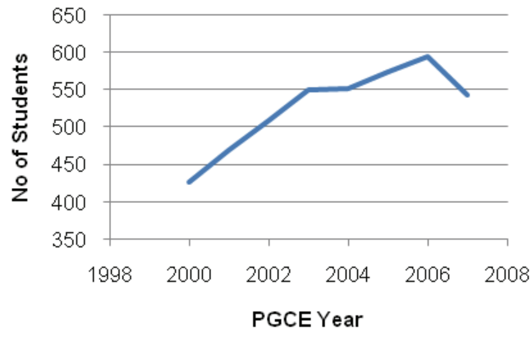

Figure 13 Variation in acceptances for entry to Post-Graduate Certificate in Education Courses 2000-2007

The numbers of graduates wishing to train as chemistry teachers fluctuates considerably over an extended period. The government bursary scheme has had a positive effect, and other variations may relate to the availability of other employment opportunities. A number of PGCE providers entitle their courses Science or Combined Science rather than specifying a particular discipline.

Figure 13 shows that after a steady rise since 2000 in the number of graduates accepting a place on a post-graduate certificate of education course, there was a distinct fall in 2007 (15).

The most recent figures show a decline in the number of applications in 2008 from 2007 of 14%. The government is providing funding for science learning centres, and introducing changes in school science education, "but until there are increased numbers of quality teachers, then effective science educational reform will never truly succeed." (J Osborne in Ref 99)

6. The School-University Transition

6.1 Secondary education qualifications

Although students study a more varied combination of A and AS Level subjects than in the past, a student wishing to study science at university still needs a strong background of science subjects at entry. At GCSE, the single subject chemistry now represents more than 9% of the total science entry, and AS chemistry nearly 5% of all AS examinations taken.

However, Table 2 shows that in recent years well under 10% of the students passing A Level chemistry have begun a chemistry degree.

Figure 14 indicates how numbers of entrants for A Levels in the three major sciences have remained fairly steady since 2001, with chemistry showing an increase in recent years, although overall there has been an increase of more than 10% in the number of A Level candidates in that period. After reaching a high

Table 2 The progress of yearly cohorts of students; i.e. the students who sat GCSE in 2001 (column 1) would begin their degree after A Level in 2003. * These numbers are supplemented by students from the EU and other overseas countries. ** Estimated from previous trends.

	2001	2002	2003	2004	2005	2006	2007	2008
GCSE entries	46862	47068	48802	51225	53428	56764	59219	76656
AS Level entries	39058	45605	46586	48166	49951	50855	52835	54157
Scottish Higher passes	7222	6871	6812	6831	7169	6858	7239	7347
A Level passes	33468	31883	34341	35689	37142	38502	38835	40221
UK Entrants to chemistry degrees*	2887	2836	2754	2790	3191	3267	3525	3650**
% successful A Level candidates who begin a chemistry degree	8.6%	8.9%	8.0%	7.8%	8.6%	8.5%	9.1%	9.1%**

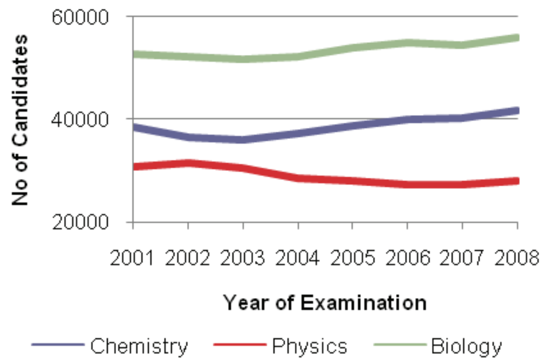

Figure 14 Changes in the number of entrants to the three major sciences at A Level

of 5.5% of A Level entries in1997, and then declining, chemistry is now back up to about 5%. (15, 95-99)

In a survey of over 500 GCSE pupils in Birmingham nearly half said that biology was their favourite science, with chemistry chosen by just over and physics just under a quarter of the sample. Half these pupils would not like to take chemistry at A Level, and a further quarter were not sure. (100)

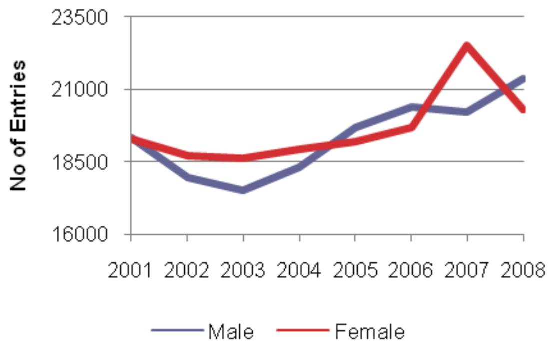

Figure 15 Entry of male and female students for the A Level chemistry examination

Figure 15 shows the fluctuations in numbers of male and female candidates over the last few years.

The pass rate for A Level chemistry is about 96%. The proportion of A Level A-grades in chemistry has steadily increased from 27% in 2001 to 34% in 2008, with female students generally performing slightly better than male students. By contrast A Level A-grades overall have increased from 19% to 26%. Despite this academic staff still have considerable misgivings about the preparedness of first year students for university study (Section 6.4).

In Scotland students sit the Scottish Higher examination in chemistry (about a quarter of the number that take A Level chemistry) representing about 6% of all Higher entries. The pass rate in recent years has been about 75%.

6.2 Levels of entry qualification

Table 3 Average points tariff requested by each departmental Group (* = only one response – 220)

MChem/ MSci (average)	***2006***	***2007***	***2008***
Alliance	*	*	258
1994	297	300	308
Russell	300	317	323

BSc (average)	***2006***	***2007***	***2008***
Alliance	204	217	235
1994	274	277	288
Russell	293	307	314

Students enter a chemistry degree course with a variety of qualifications, but a principal requirement is an A-Level, Scottish Higher, or equivalent in two or more academic subjects. A points scoring system (see *Tariff* in *Glossary of Terms*) (101) is used to assess student overall attainment. There seems to have been a slight increase in the average minimum points scores asked for entry to chemistry departments over the last three years
(see Table 3)[dot9,10 & data from websites].

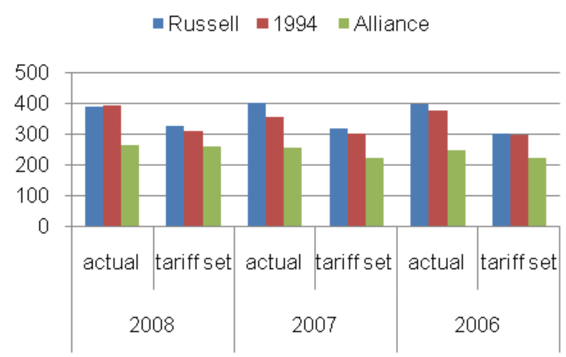

Figure 16 Comparison of average tariff set by each Group of departments (for MChem/MSci entry) with average A Level (or equivalent) points score of first year students

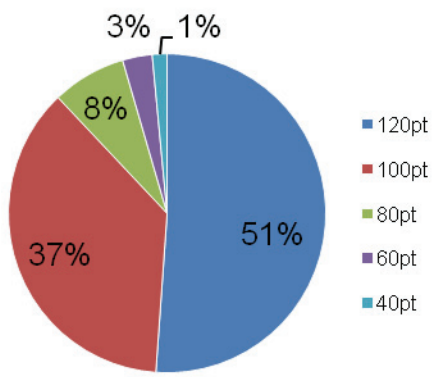

Figure 17 Highest grade (tariff score) in a chemistry qualification attained by students before starting a course at one of the Russell Group departments

A similar trend can be seen (Figure 16) in the

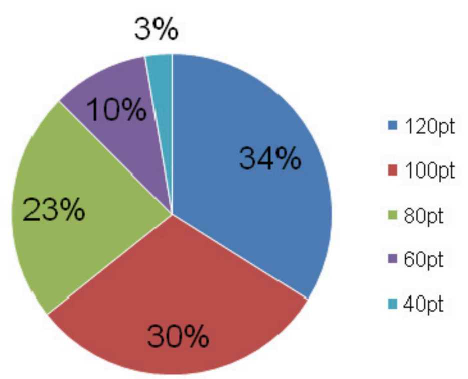

Figure 18 Highest grade (tariff score) in a chemistry qualification attained by students before starting a course at a department other than one of the Russell Group.

average actual points score of students who began courses from 2006 to 2008 (102, 103). A positive feature is the differential between the tariff scores asked for and the scores actually obtained by entrants, which shows that on average students obtain higher grades than departments are seeking.

Some departments lay down a minimum A Level points score in chemistry as well, and where it is applied, this is generally 120-100 for Russell Group, 100-80 for 1994 Group, and 80 for Alliance Group departments, for students wishing to enter BSc courses[dot11]. Only occasionally is this tariff raised by 20 points for MChem/MSci entry. Figure 17 and Figure 18 show that students entering Russell Group departments have a higher average points score than those entering departments of other Groups[stu7].

A high proportion (85%) of students beginning Year 1 of an honours degree continue into the second year of the programme[dot58]; and 80% complete their programme by obtaining a degree[dot59]. This rounded median hides figures for individual departments that can show a less healthy continuation rate.

6.3 Trends in entry to full time

programmes in chemistry

In the academic year 2006–07 the total number of students within UK higher education was 2,362,815 including 1,208,645 full-time university undergraduates. Figure 19 shows how the total number of full-time under-graduates (including all overseas under-graduates) studying for degrees in the major sciences has changed in recent years. Over this whole period, chemistry has comprised an

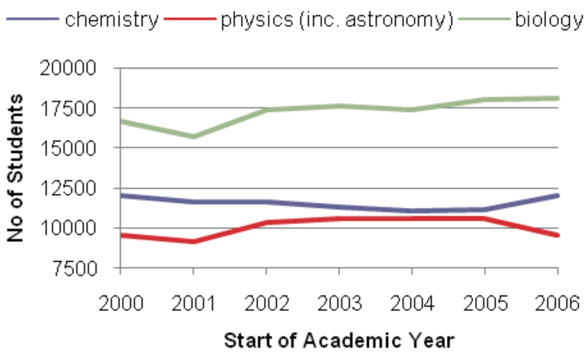

Figure 19 Changes in the numbers of all full-time undergraduates studying for degrees in the major sciences 2000-2006. Physics includes Astronomy; and from 2006 all biosciences are included in Biology

average of 1.0% of the undergraduate population, compared with physics and astronomy at 0.9%, and biology at 1.5%. After a period of slight decline in numbers, chemistry is beginning to rise again in popularity, with the number of first year full time entrants rising from a low of less than 3300 in 2001 to just over 4000 in 2008 (Figure 20). (113, 114, 115)

It seems the increase in all sciences is being sustained, as *The Guardian* reported in August 2008: "The number applying for biology is up by three percentage points, chemistry by five points, physics by four points, mathematics by seven points, and engineering subjects by six points." (116) However, as the total number of university students has risen, the proportion of chemistry undergraduates has fallen from 1.2% to just over 0.9% during this period.

In Figure 21 the ratio of home entry male to

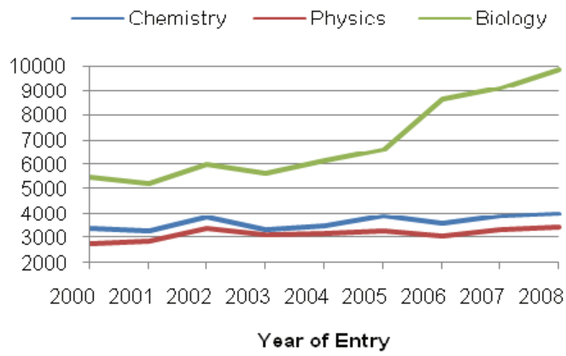

Figure 20 Changes in the number of entrants to UK undergraduate courses in the three major sciences.

female students is seen to have stayed fairly constant at about 56:44 over the last few years. When full-time undergraduates across all disciplines are considered, the male to female ratio is almost exactly reversed, and the proportion of female students seems to be rising slowly. (19)

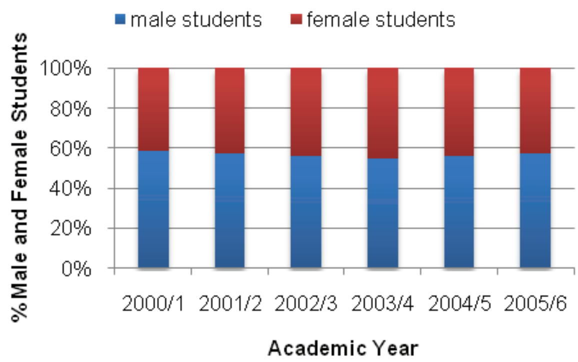

Figure 21 Distribution of home entry male and female full-time chemistry undergraduates 2000-2006

6.4 Starting a university course

More than half the students who responded considered that their schools prepared them very well for starting a university chemistry course, although male students think themselves to be better prepared than do female students. MChem/MSci students feel they are better prepared than BSc students. Fewer than 10% thought they were not really prepared well enough[stu64].

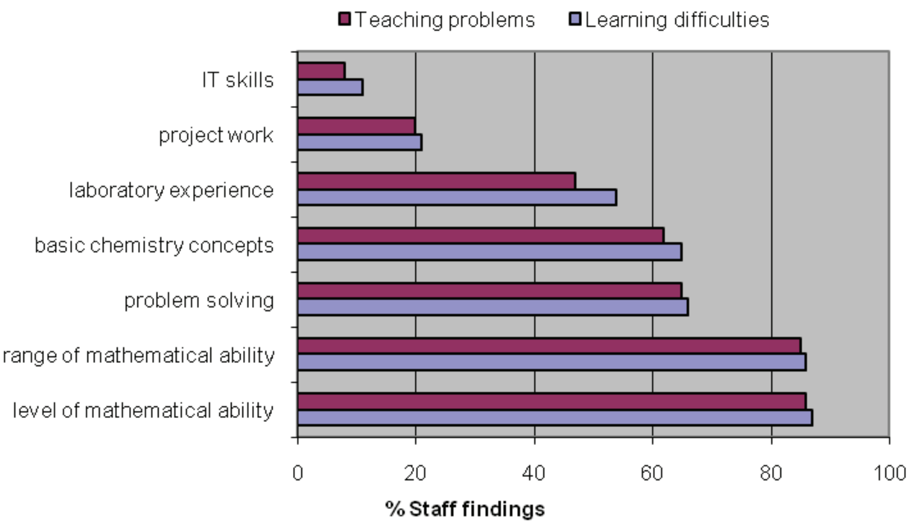

Figure 22 Comparison of areas that cause teaching problems to staff with their perception of areas that cause learning difficulties to students on entry to the department.

Figure 22 shows there is a close correspondence between the learning difficulties the students encounter in making the transition from school to university, and the problems that the staff have with teaching new entrants[sta51]. Most of these issues have been recognised as the A and AS Level curricula have been revised (107). In the view of more than 80% of staff, the range and level of mathematical ability of students on entry is causing both learning difficulties for some students, and problems for the staff teaching them. This is perceived as a major problem at the school to university transition. Students often arrive with poor practical skills because of their limited use of laboratory equipment, or the tendency in schools to rely on demonstrations[dotint34]. The weakness in problem-solving ability probably stems from the difference in teaching methods between schools and universities. Directors of Teaching comment that universities expect independent learners, whereas at schools students are teacher-led[dotint34]. A high level European group has also recommended that improvements in science education should be brought about through the introduction of inquiry-based approaches in schools (108).

Not many chemistry departments administer diagnostic tests to entering students[stu63,dot116], and it appears that these are for the benefit of the department and not for the students[stu63a]. There was a mixed opinion as to whether they were useful or not[stu63b,dot117]. Similarly there is relatively little streaming of students, most usually for tutorials, practical work, or maths classes[dot118]. Some students thought streaming based on school results was a good thing, "otherwise the good students could get bored, or the weaker ones left behind."

Figure 23 shows student responses when they were asked what might have helped them to perform better when they entered university to start a chemistry course. It would seem that

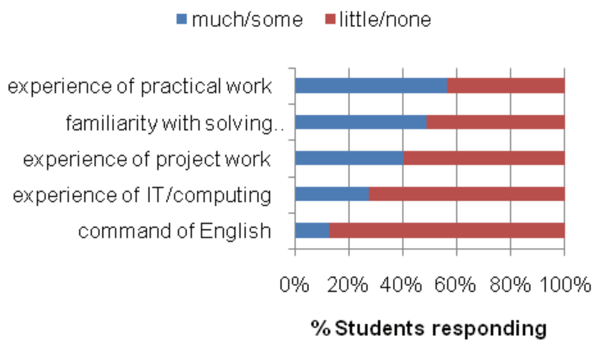

Figure 23 Student preparedness in essential skills on entry to university to study chemistry.

they mostly need more skill in practical work and greater familiarity with solving problems[stu68]. The problems of providing effective laboratory work in schools, and the need for more hands-on experience, have been identified elsewhere as one of the main requirements for students intending to start a chemistry degree (109). Financial constraints on providing laboratory accommodation in schools are severe with the result that only 34% of school laboratories were rated good or excellent in 2004 (110-112)

A considerable proportion of staff is unaware of the content of current A level syllabuses[sta48], and relatively few staff use this information when developing their first year modules[sta49]. Even less use is made of students' A Level scores when planning for teaching the first year students[sta50], although several departments do provide additional support for students. Nevertheless, Directors of Teaching were confident that the first year modules in their departments generally take a pragmatic approach to the variations in students' pre-university courses[dot120].

Departments have adjusted their first year to meet the needs of a students with varied academic backgrounds[dotint35]. Introductory modules in Year 1 reinforce and extend A level chemistry concepts to match the abilities of the less well-prepared students, and teaching proceeds more slowly than previously to bring all students to the same level of understanding. An introductory course of basic laboratory skills is sometimes used as well. Some departments operate an exemption scheme for students who are able to demonstrate they have the necessary prior learning, for example in mathematics. Alternatively, or in addition, ancillary courses are available to all students lacking particular skills. These may be taught in-house in a chemical context; or, particularly with support for mathematics and English, offered in regular workshops by the university centrally.

7. Undergraduate programmes in chemistry

7.1 The chemistry curriculum

On the whole students are satisfied that their courses are well balanced[stu89]. Practically all students feel they are being challenged, at least in some modules of the course, and around three quarters would say this of the course as a whole[stu67].

Figure 24 shows how Directors of Teaching view their department's approach to teaching. More than one choice was allowed from the five descriptions. The Russell Group consider themselves as offering the most modern curriculum, and the Alliance Group consider themselves as the most applied. Ten departments described their teaching as both modern and traditional; presumably they aim to combine the best of the old with the best of the new[dot70].

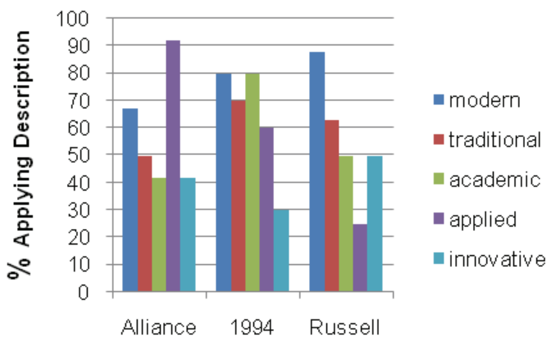

Figure 24 Descriptions applied by DoTs to their departments approach to teaching

Most departments still organise their curriculum around the traditional subdivisions of chemical science – organic, inorganic, physical and analytical chemistry[dot71], but almost all also make some attempt to integrate their teaching across the divisions, even if it is only to some extent[dot72]. More than three quarters of the students recognise their departments' attempts at integration[stu90]; and a large majority of Directors of Teaching[dot73], and students, think that the departments have the correct proportions in the mix[stu91], with the emphases given to each subject about right. Table 4 shows how students describe the curriculum they are offered[stu89].

Only about half the students think that their course covers enough areas of modern research (Table 5a)[stu92], with the BSc students feeling this lack more keenly than the MChem/MSci students. This is unexpected, as only one Director of Teaching said the department does not aim to develop a link between teaching and departmental research, including the less research-intensive Alliance Group[dot68]; and almost all departments consider these links to be important[dot69]. Just above half the students say that enough emphasis is given to applying basic chemistry to more general areas and problems (Table 5b)[stu93]. "Real world problems and applications, and learning with a view to opening career paths, both encourage effective learning." Staff are rather lukewarm about introducing more options in both these areas[sta72,sta73], with those in Alliance Group departments easily the most enthusiastic.

Table 4 Students' description of their chemistry curriculum

	All	BSc	MChem/ MSci	Russell	non-Russell
too academic:	15%	18%	13%	23%	7%
too applied:	2%	4%	1%	2%	2%
well-balanced:	83%	78%	85%	75%	91%

Table 5 Student's preferences for the inclusion of more research-based or world problem oriented course components

Table 5a	Russell	1994	Alliance
more based on research	36%	46%	67%
no more based on research	64%	54%	33%

Table 5b	Russell	1994	Alliance
more on solving world problems	41%	56%	73%
no more on solving world problems	59%	44%	28%

7.2 Curriculum review and development

Many staff seem to be satisfied with their curriculum as it stands, because they have a regular program of review and are continually implementing recommended changes. Individual modules are normally reviewed after each presentation, and several departments have a major review and revalidation exercise every 5 years[dot75,dotint21], where redundant topics are removed and appropriate additions made. In the first two years most degree courses aim to cover material from all areas of chemistry that will underpin later study, largely informed by the National Chemistry Benchmarks[dotint17] (25). Thereafter curriculum content and development is informed by the individual expertise and research interests of staff, by feedback from industry, and by national developments and ideas from educational conferences[dotint 21]. In most departments responsibility for curriculum development rests with a departmental committee, but it is also shared in different departments between the Head of Department, the Director of Teaching, and individual lecturers[dot74]. There are some indications from the staff that the curriculum is becoming more modern, more exciting and more relevant[sta70]; but alternatively there is a feeling that more challenging topics have been dropped, the amount of practical work has been reduced, and the degree course overall has been simplified[sta71].

Various topics have been added to the chemistry curriculum making it more topical – like computational chemistry, nanotechnology, green and sustainable chemistry, and atmospheric and environmental chemistry[dotint17]. More than two thirds of staff have introduced new topics into their teaching programme from their own research or scholarship, or from other workers' research[sta68]. More recognition has also been given to subjects on the fringes of chemistry like chemical engineering, biological, medicinal, and materials chemistry, and forensic science. Other changes have been made to reflect developments in the research profile of the department; or required because of the retirement of key members of staff[dotint17,18].

Rather more seems to have been added to the curriculum than dropped from it, but the teaching of statistical mechanics has been abandoned by a number of departments, along with some of the more descriptive chemistry of transition and main group elements, and natural product chemistry[dotint18]. Some material – like analytical, polymer, and bioorganic chemistry, has been transferred into specialised degree programmes.

Curriculum developments that some staff would like to see are often structural rather than changes in the content of the courses. A more flexible modular framework to allow students more choice – like more, but shorter, modules in the early part of the course – would be welcomed, as would better integration between sections of the department, more problem-based learning and chemistry relevant to real life, and an increase in the linkages between teaching and research[dotint20]. Students have benefited from continuous curriculum review and the introduction of variety into teaching methods[dotint22]. They appreciate greater choice, covering up-to-date research material in later parts of the course, and the transferable skills programme integrated into chemistry teaching modules. More workshops and problem based learning has made the learning experience more varied; and the use of a wider range of assessment techniques has given students new opportunities to demonstrate their ability.

7.3 Class of degrees for chemistry students

Average degree grades from the last three years are shown in Table 6[dot13], and indicate that very few students on MChem/MSci courses leave without a first or second class degree. This is because students have to attain at least 50% at an interim stage (usually the end of Year 2) in order to be accepted on to an MChem/MSci course. By contrast, BSc grades are more normally distributed.

Table 6 Average distribution of degree classifications for MChem/MSci and BSc students in the three Groups of departments ('Other' degrees include 3rd Class Honours and Pass Degrees)

	Class 1	Class 2.1	Class 2.2	Other		Class 1	Class 2.1	Class 2.2	Other
Russell	39%	45%	15%	2%		17%	30%	33%	19%
1994	32%	39%	23%	5%		10%	24%	35%	31%
Alliance	28%	52%	13%	10%		16%	28%	36%	20%
	MChem/MSci students (average)					*BSc students (average)*			

The overall percentage of students gaining a First Class Honours degree has been rising steadily in all subjects since 2001, and in the physical sciences it had risen from 16% to 19% by 2007 (117). In chemistry the figures overall (Figure 25d) do not follow this trend, showing only a rise of 1% over the four years. Within the separate departmental Groups (Figure 25 a, b, and c) the proportion of First Class Honours degrees fluctuates from year to year, with Russell and 1994 Group awarding on average a slightly higher proportion of Firsts than the Alliance Group (118). Some unclassified degrees are also awarded, but most of these are awarded by Scottish universities (87% of all unclassified degrees in 2007).

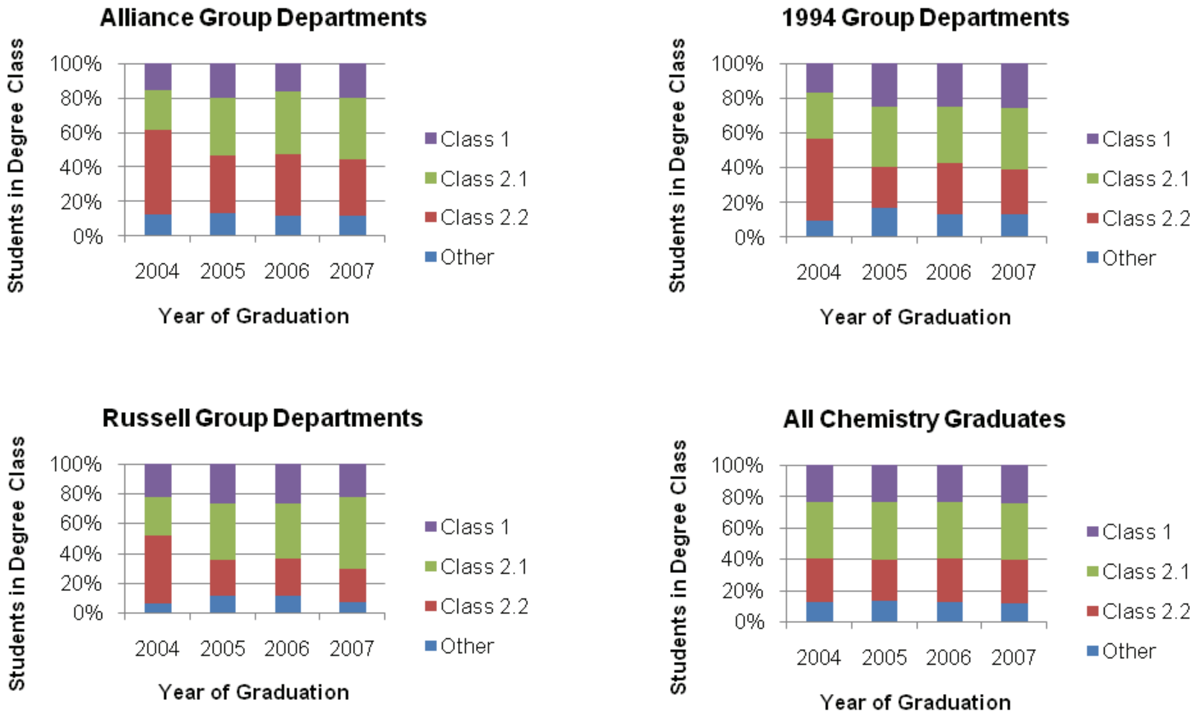

Figure 25 a, b, c, and d. Average distribution of degree classification for departments in the three groups of covered in this survey, for students graduating from 2004 to 2007, and all chemistry graduates ('Other' degrees include 3rd Class Honours and Pass Degrees)

8. Student satisfaction with their programmes

Chemistry undergraduates overall show a high level of satisfaction with their courses. In 2005 the first full National Student Survey was carried out in England, Wales and Northern Ireland (119) to investigate students' views of the higher education institution they were attending, "to provide the public and the HE sector with comprehensive, comparable views of students about the quality of their education." (120) The questionnaire used had 21 items designed to capture six essential dimensions of teaching quality – Teaching and Learning, Assessment and Feedback, Academic Support, Organisation and Management, Learning Resources, and Personal Development – together with a final Question 22 seeking a measure of overall satisfaction. It has been repeated in essentially the same form in subsequent years. Across the whole of the university sector the students response was very positive, with four out of five students stating that they mostly agreed or strongly agreed with the statement 'Overall, I am satisfied with the quality of the course'

Table 7 Number of chemistry departments participating in the 2007 and 2006 National Student Surveys

	Russell Group	1994 Group	Alliance Group
2007	18	10	9
2006	14	9	6

Table 7 shows the number of chemistry departments participating in the Survey in 2006 and 2007, with some departments returning a combined 2006-7 set of responses. In all more than 1500 chemistry students returned completed questionnaires.

Table 8 Percentages of students who 'Definitely agree' and 'Mostly agree' with Q22 on the National Student Survey (the same Groups of universities were used in calculating the values for All departments)

	2006	2007	2008
All universities, all departments	80	81	82
1994 Group chemistry departments	90	93	
Alliance Group Chemistry departments	90	86	
Russell Group chemistry departments	86	87	

Table 8 shows that overall student satisfaction with their courses has generally been increasing year on year; and that chemistry students show a consistently above-average degree of overall satisfaction (102, 103).

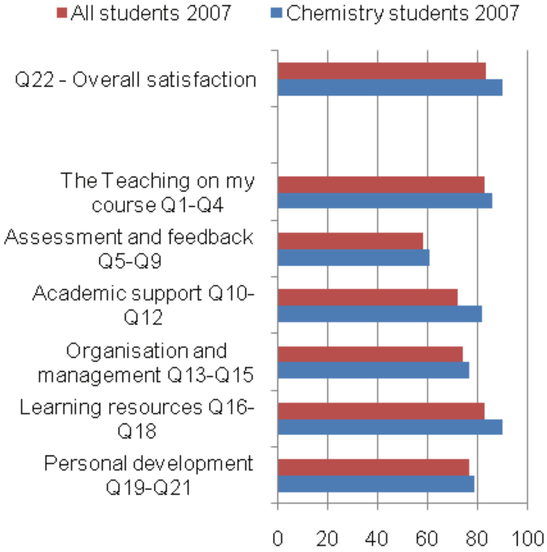

Figure 26 Comparison of NSS questionnaire responses between chemistry students in all the selected Groups of universities and all students in the same universities for 2007.

A more detailed overview of student satisfaction is found by grouping responses from the students in each of the Groups of departments, under the six dimensions (Figure 26), which shows that a higher than average level of satisfaction is found among chemistry students in all the categories investigated by the NSS Survey. However this masks some differences between the groups (Figure 27). (For a List of NSS Questionnaire Statements, see *Appendix 4: List of National Student Survey Questionnaire Statements*)

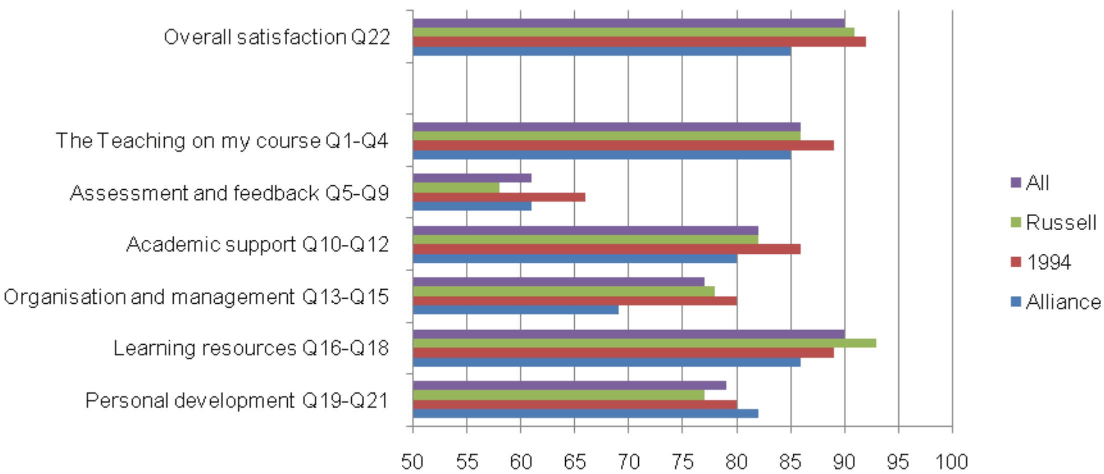

Figure 27 Group and combined percentage responses from chemistry students who 'Definitely agree' and 'Mostly agree' with statements in the National Student Survey questionnaire in 2007 (the results for 2006 are similar)

9. Student welfare

Most students, especially in Russell and 1994 Group departments[dot23], are assigned to a particular member of staff in their department as a Personal Tutor; and 70% of the students experiencing such a system have found it helpful[stu69].

Student Mentoring schemes seem to be used much less frequently, with about one third of departments overall having such a scheme in place[dot24]. Mentoring schemes seem to be less effective than personal tutor schemes on the whole[stu70], with fewer than 40% of the students expressing satisfaction with their experience. Nevertheless, one Director of Teaching reports: "We have low drop out because the students get support from a parenting system, in which a 2nd year looks after a 1st year"[dotint37].

Students are appreciative when staff get to know students as individuals, and are interested in their university careers. Describing one department, a student says: "Staff are very approachable. If there is not contact it is because in the early years students are nervous of approaching staff, not because staff are unwilling. Indeed they are more approachable than you might think at first; " and another: "If students are polite and respectful towards lecturers they will respond by being helpful." Students find that a social programme that incorporates both staff and students boosts good relations, and "it is easier to interact with members of staff if you have established a relationship through participating in tutorials."

Figure 28 seems to show there are few departments with policies to identify, and provide special support for, exceptionally able students. Less well-prepared students are better catered for, but less than half the departments make special provision for them[dot119].

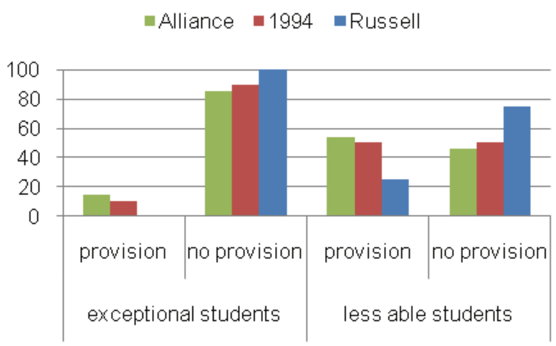

Figure 28 Special provision by departments for exceptional and less well prepared students

There is more confidence from the teaching staff that the less well prepared students are being sufficiently supported in undergraduate chemistry courses (Table 9)[sta52], than that the brightest students are being sufficiently challenged (Table 10)[sta53].

Every Russell and 1994 Group department has bursaries of up to £1000 available for students; many of them are awarded automatically to students who perform well at A Level, and continue to do well through their course. By contrast, only about half the Alliance Group departments offer bursaries of similar value[dot14ii]. It would seem that take up is very

Table 9 Staff perception of support for the less well prepared students

	All	Russell	1994	Alliance
yes; the less well prepared students are being sufficiently supported	70%	73%	71%	65%
no; the less well prepared students are not being sufficiently supported	20%	20%	18%	19%
don't know	10%	7%	11%	16%

Table 10 Staff perception of the level of challenge presented to the exceptional students

	All	Russell	1994	Alliance
yes; the brightest students are being sufficiently challenged	50%	46%	51%	56%
no; the brightest students are not being sufficiently challenged	39%	42%	35%	37%
don't know	11%	12%	14%	7%

variable, ranging from 0-100%, but mostly between 10 and 20% of students[dot15]. From all the responses, only a couple of 1994 Group departments indicated that they offer full fees remission to any student[dot14i]. Overall, UK universities offered £96m in bursaries 2006-7 (121). The Higher Education Policy Institute (HEPI) considers that a national bursary scheme would be fairer to both students and HEIs than the present system in which each institution has developed its own scheme (122). Many departments have made special provision for students with a disability[dotint40] as the number of such students wishing to take chemistry degrees seems to be increasing (123).

10. Student workload

The distribution of teaching hours allocated to students (median values) in each year is shown in Figure 29-Figure 32 for all three Groups of departments, although making no distinction between MChem/MSci students and BSc students complicates Year 3. Overall students say their formal teaching workload rises from 20 hours in Year 1, through 24 hours in Years 2 and 3, to 30 hours in Year 4[stu8]. The last figure suggests that some students have included project work hours in their formal allocation. A HEPI survey of Year 1 and Year 2 undergraduates in English universities (124, 125) records physical science students as having an average of 17 scheduled teaching hours a week.

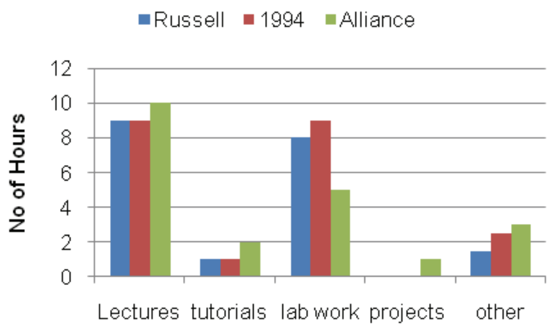

Figure 29 Distribution of allocated teaching hours in Year 1 (MChem/MSci and BSc students)

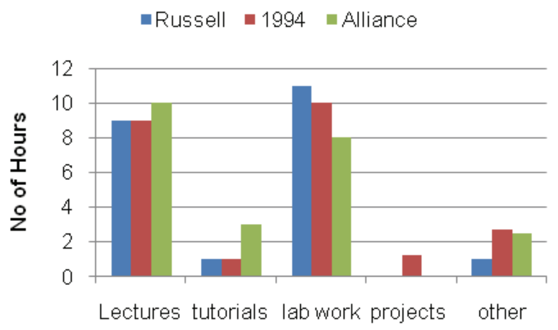

Figure 30 Distribution of allocated teaching hours in Year 2 (MChem/MSci and BSc students)

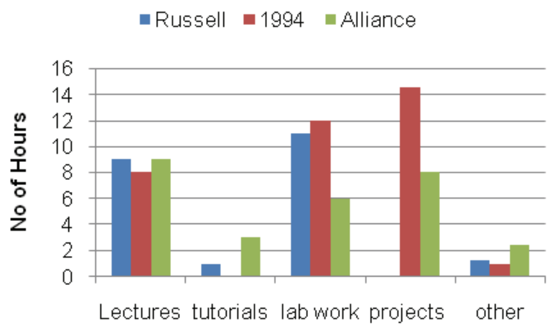

Figure 31 Distribution of allocated teaching hours in Year 3 (MChem/MSci and BSc students)

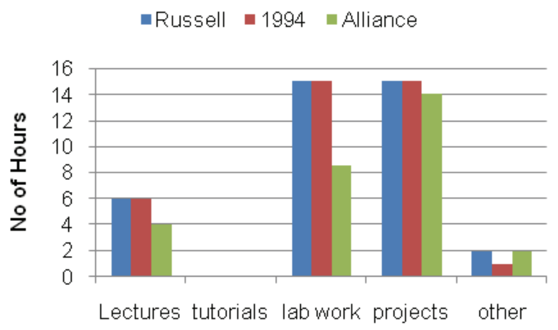

Figure 32 Distribution of allocated teaching hours in Year 4 (MChem/MSci students)

In almost two-thirds of departments, student attendance at some, or all, teaching events is compulsory – in particular laboratories and tutorials[dot36]. Attendance is monitored, at least occasionally, for some teaching events in every department whose Director of Teaching responded[dot37].

These data reveal that departments have a similar amount of lecturing time; tutorials are most prominent in Years 1 and 2; and in Year 4 departments concentrate on their laboratory-intensive project work[dot38].

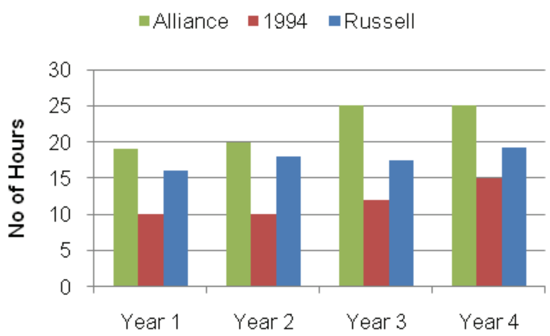

Figure 33 Staff expectation of students' weekly additional hours of independent study

In addition to the formal allocated teaching hours, staff also expect students to study independently. The weekly additional hours of independent study that staff expect from their students are shown in Figure 33. When asked, staff seem to suggest a round number of hours – 10, 15, or 20, of which 15 hours would seem to fit in best with the total of 40 hours for a normal student working week[sta57,dot39].

Students fail to live up to these expectations. The amount of coursework and private study outside formal teaching *they* record is fairly constant at 7-9 hours per week[stu9a,9b]; that is, students only seem to work half the number of hours that staff expect, outside the formal programme.

In both 2006 and 2007, physical science students responding to the HEPI report averaged 12 hours a week of private study, making a weekly workload of 27.5 hours. (124, 125) In both these years, HEPI investigators found female students overall were more industrious in private study and missed less of the formal teaching.

Although nearly 60% of staff think their department has about the correct balance between teaching and independent study, about one third believe that students have too much teaching and not enough independent study; few staff think students have too much independent study and not enough teaching[sta59]. Three quarters of the students also think this balance is about right[stu72]. There is a 3:2 split between students who prefer to do course-work on their own, and those whose choice is to work with other students, with virtually no difference between male and female students[stu73].

A principal aim of universities is to produce independent learners, but only about 20% of staff think students understand what is meant by this expression[sta58]. A student defines the term this way: "The objectives of independent learning are to acquire sourcing skills, to be able to learn on your own, to develop the ability to assimilate material, to see the need to go further. You will not become an independent learner if you are not enthusias-tic." Many students find that this skill only begins to develop in later years of the course when, in order to tackle research projects, posters and presentations they have to begin finding their own source material.

Figure 34 shows how the sources that students use change as their course progresses. A publisher's survey finds students are buying fewer books, but 91% say that they are important in their learning, and they tend to follow staff recommendations. First year students are the biggest purchasers of textbooks (126). Students find textbooks expensive, and are not able tell how useful they might be until after they have been purchased. So they come to rely more on the Web and, as their confidence increases, on the lecturing staff. Confidence in peer advice falls away when study becomes more specialised in the final year of the MChem/MSci[stu103].

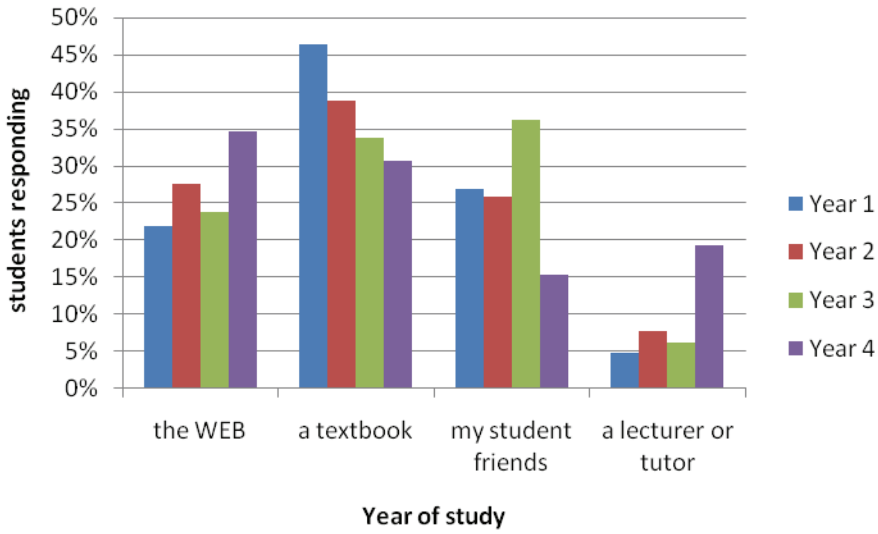

Figure 34 Students' changing sources of information with year of course

Overall, total study in Years 1, 2, 3, 4 increases steadily at 27, 31, 33, 37 hours per week[stu9], suggesting that Year 3 of the BSc and Year 4 of the MChem/MSci are the most demanding of student time. However, only about one third of students find this workload too heavy, even in Year 4; and interestingly a lower proportion of MChem/MSci students find it so than BSc students[stu13]. "You do have to work hard as a science student. It is not easy to balance academic work, family, friends and hobbies/ societies because of the demands of the course."

Only 30% of the students responding said they did any paid work during the semester[stu9c]. This is slightly below the value of 39% suggested in the 2006 HEPI report (124). The average amount per week is 10 hours, though this varies from 1-20 hours. Only one student admitted missing more than one hour a week of the formal teaching programme to do paid work[stu12]. Some choose to work during holiday periods, and others in advance of starting the course, sometimes taking a year out to earn funds. One student summed up the situation: "The extent and rigour of the formal teaching programme means that there is not much available time to do a part-time job as well." The HEPI report found no evidence that paid employment has more than a minor effect upon students' overall level of satisfaction, and any negative effect upon students' academic experiences is likely to be slight (124).

Nearly half the students do no academic work during the summer vacation; the remainder average 4-5 days. The Christmas vacation is more productive, averaging 7-10 days, and with exams looming, students say they work 11-19 days on average over the years in the Easter vacation, with the higher figures in Years 3 and 4[stu10]. These are student *estimates*, and the variation between individual students is very high.

11. Types of teaching

In recent years, a number of new types of teaching have been introduced into chemistry departments (127), and innovation seems certain to continue. Students find most of the teaching methods employed are effective in helping them to learn. Figure 35 shows there are few differences between the preferences of male and female students[stu19].

Tutorials are considered to be the most effective way of learning by far, by both male and female students. Practical work and problem classes are the next most effective. Female students seem to find workshops and problem classes generally more effective for

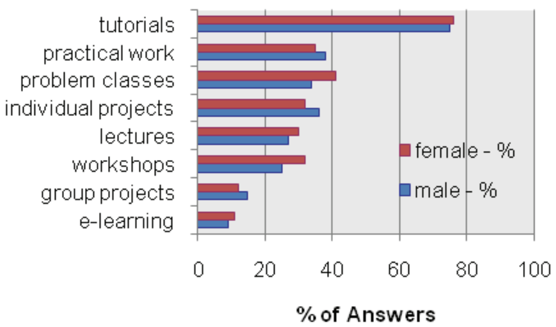

Figure 35 Student evaluation of which teaching methods are very effective

learning than male students do. Individual projects are thought to be much more effective than group projects. E-learning comes at the bottom of the list for effectiveness, and only 8% of the students surveyed by HEPI gave better e-learning and web-based facilities their top priority for university development resources (124).

Nevertheless, educational technology is increasingly being used in UK chemistry departments (127). By contrast, not many students overall find these teaching methods employed to be very enjoyable[stu20]. Figure 36 again shows there are small differences between the choice of male and female students.

Practical work easily heads the list, and male students seem to enjoy it more than female students, as they do tutorials and projects. Female students show a small preference over male students for lectures and problem classes, and for e-learning.

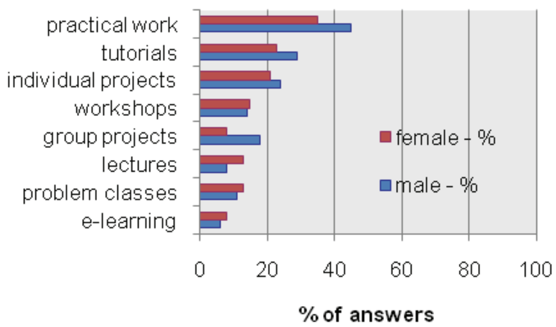

Figure 36 Student evaluation of which teaching methods are very enjoyable

Students are very reluctant on the whole to miss any part of the teaching programme, but consistently across all years participation in the laboratory programme is most highly valued, and attendance at lectures the most vulnerable[stu11].

11.1 Lectures

Lectures are still the principal way in which staff interact with students, although workshops and tutorials are generally used to back up lecture material[sta20]. Confirming the results of a Physical Sciences Centre survey of its own community (128), most staff allocate some

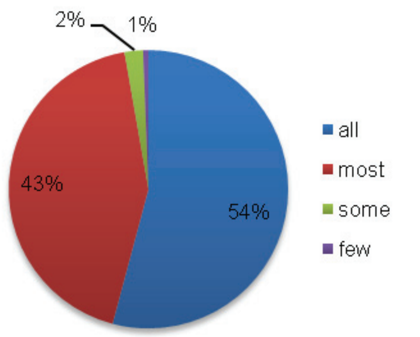

Figure 37 Percentage of lectures attended by students

additional work[sta21], and recommend some reading related to their lectures[sta22], but staff in the Russell Group of departments seem to do this less frequently. More than half the students responding attend all lectures (Figure 37), and very few students make do with minimum attendances[stu21]. So although lectures are low on the enjoyment scale, and only modest performers on the effectiveness scale, they still seem to attract a high proportion of the students most of the time.

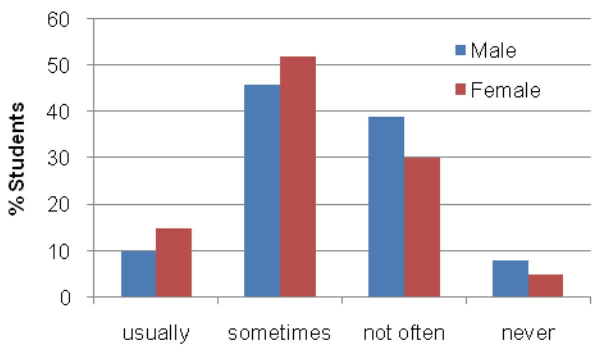

Figure 38 Gender differences in following up additional material given in lectures

However, regular follow-up of study material provided or referred to in lectures is quite rare, although about two thirds of these students would do so sometimes – female students somewhat more readily than male students (Figure 38)[stu25].

Although the majority of staff hand out lecture notes[sta18], and post their lecture notes on their VLE[sta19], they also expect their students to make full or partial notes on their lectures[sta17]. Students seem to prefer notes provided by the staff rather than making their own set, but more than half the students prefer skeleton notes to full lecture notes[stu22]. Students prefer to have a choice of lecture notes in both hard copy and electronic formats[stu24]. If only one form is available, printed notes are more popular. Handing out notes before, or during, lectures seem to be almost equally preferred[stu23], and almost all staff do one of these[sta18a]. Having the lecture first and the notes provided later is most unpopular.

Three quarters of the students think that attending a lecture is time well spent, rising to nearly 100% when those that think it is sometimes are included[stu26]. Despite the feeling of some staff that they are an old-fashioned method of teaching, most students recognise that they will get more out of going to a lecture rather than just using the information on the VLE.

11.2 Tutorials

Staff overwhelmingly think that students must be taught in small groups[sta23], but opinions on the optimum size for tutorials differ quite markedly[sta24] (Figure 39).

Few students experience tutorials in groups of more than 12[stu27a] (Figure 40). The median value for actual tutorial group size, as given by the Directors of Teaching, is 6 in the Russell and 1994 Groups of departments, but in the Alliance Group the median is more than twice as many[dot40]. This indicates that a 'tutorial' in many Alliance departments would be thought of as a workshop in the other Groups.

Discussion with students confirms that they rate tutorials very highly, believing that a manageable size group of students makes for good teaching. They are good for learning because they are more focused, everyone

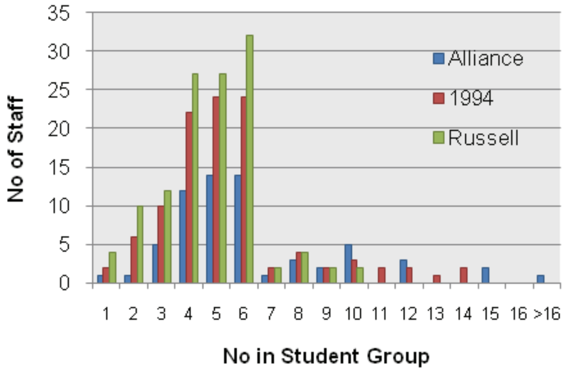

Figure 39 Staff preferences for the optimum size of a tutorial group

becomes involved, and time is used very efficiently. They provide students with a correct perspective of the subject, deepen their understanding and develop critical thinking.

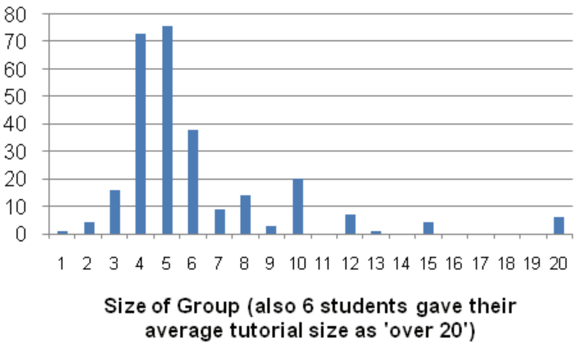

Figure 40 Actual size of tutorial groups as reported by students

"Missing tutorials is like shooting yourself in the foot; the more tutorials you attend, the better marks you are going to get." In 2006, nearly a third of the physical science students surveyed by HEPI placed reducing teaching group sizes at the top of their list of possible improvements (124). Most tutorials are based on previously set work[stu29a,sta25], but they also provide an opportunity to answer student questions based on coursework and lectures. Discussions on exercises and problems seem to feature in most tutorials, with a distinct emphasis on exercises[stu30,sta25a].

Several other types of small to medium size group teaching activities take place in most departments[sta26,dot41]. They include workshops (Figure 41 - median size 25)[stu27ai] and problem solving classes (median size 30 students)[stu27aii]. The most popular sizes for both these activities are groups of 20 or 30, although groups of 100 are not uncommon, and even groups of 150 and 200 are recorded.

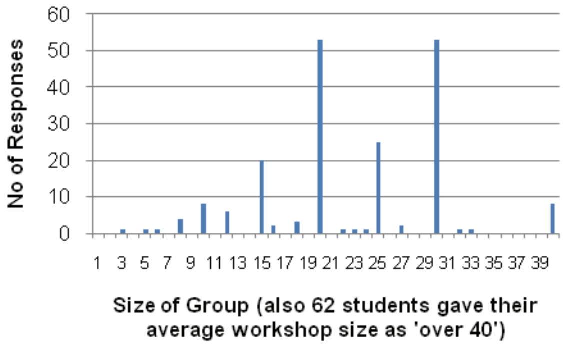

Figure 41 Actual size of groups in workshops as reported by students

Attendance at tutorials and workshops is high but significantly better at tutorials than workshops; and attendance at problem solving classes is notably lower still[stu28]. Greater importance seems to be attached to tutorials than to workshops and problem solving classes, in that students are much more frequently set specific work prior to tutorials in comparison with the other types of event[stu29]. Workshops and problem solving classes may be arranged more on a 'turn up if you want to' basis.

11.3 Workshops

Workshops seem to be a principal means of developing all varieties of transferable skills[sta30]. Problem solving, IT skills, technical and mathematical skills, and presentation and communication skills seem regularly to be developed through workshops (Figure 42). Work may be set beforehand[stu29b], but students are also given material to work on when they arrive. A typical workshop will have a ratio of about 20 students to 2 staff members.

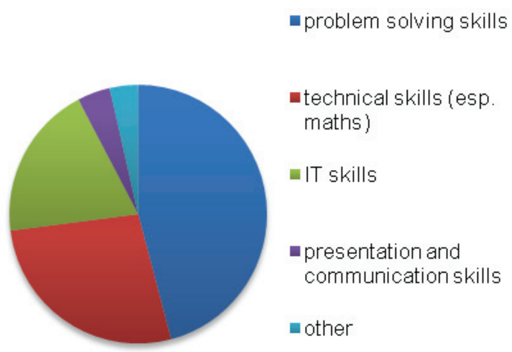

Figure 42 Distribution of skills developed in workshops

11.4 Problem Solving Classes

Problem solving classes seem to be a universally adopted feature of teaching in chemistry departments[sta26]; and a very high proportion of all staff are involved in giving them[sta27]. They are well liked by the students who attend, and seen as a very useful addition to the teaching programme. As with work-shops, "having several staff is an advantage, as one of them will usually be able to sort out your particular problem with different ways to explain things." Students can have course-related problems sorted out, as well as tackling set problems[stu29]. Staff believe that problem classes are effective at developing problem-solving ability[sta28], for the majority of their students, but fewer departments than might be expected have a specific strategy to develop the problem-solving abilities of students[dot50].

11.5 E-learning and educational technology

Educational technology is now widespread in chemistry teaching (127). The most common recent introduction of technological teaching equipment was the interactive whiteboard, with the virtual learning environment (VLE) also common[dot80]. As Figure 44 shows[stu105], students now have more experience of VLE teaching material[105e] and on-line library access[stu105f] than they do of experimental lecture demonstrations[105c]. Podcasts and personal response systems are now being tried in some departments, and video links to the laboratory, molecular modelling software, on-line assessment, radiomicrophones in the lecture theatre, and electronic discussion forums for projects and groupwork are other new introductions[dot80].

Considerable numbers of staff are using electronic means for supporting student learning, and are incorporating these methods and materials into their teaching on a regular basis[sta33]. Half the staff who responded regularly engage with a VLE[sta31]; an intranet, or on-line communication system appears to be used by most of the other staff who use e-learning (Figure 43).

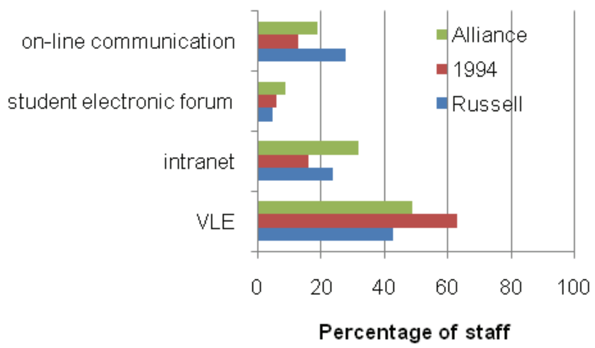

Figure 43 Percentage of staff using electronic teaching methods

Almost all staff direct students to e-resources (e.g. by providing a list of useful websites), expect them to find material from e-resources independently, or both[sta32]. E-Learning is scored quite low by students as an effective way of learning[stu19]; and even lower for enjoyment[stu20]. Students are most familiar with presentational software (most commonly PowerPoint)[stu105a], as a very high proportion of teaching staff use it regularly[dotint24]. Staff are gradually introducing wikis and blogs into their teaching[dot81a,dotint24]; but students are using wikis and blogs to a

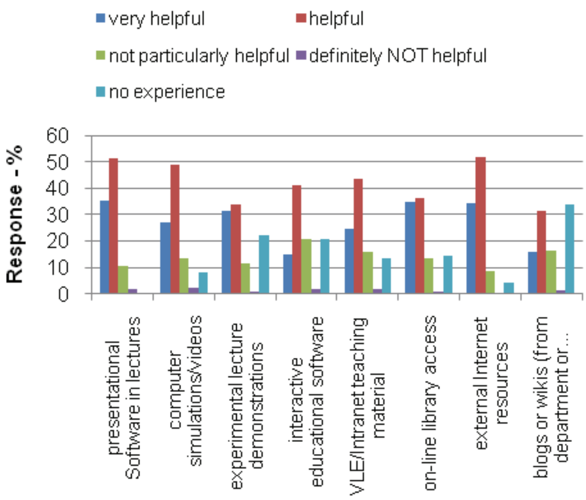

Figure 44 Students' preferences for educational technology, and their experience of using it

greater extent, and social networking sites like YouTube and Facebook, to assist their learning[dot81b]. Not all technological innovation is welcomed by staff[sta84], however, as seen from this quotation: "The student portal was useful for disseminating material but this has been replaced with a new system that is far too functional to the extent that it is useless. Technology does not equate to good teaching"[dotint25]. Almost half the staff responding are not convinced that presentational software has significantly improved their teaching[sta84a], or enhanced student learning[sta84b]. Less than one third of the staff definitely feel that the introduction of educational software has significantly improved their teaching or enhanced their students' learning[sta85]. Staff are not even sure about the value of virtual learning environments, even though almost every higher education institution has invested heavily in them[sta86].

Among the students experiencing these techniques[stu105], on-line library access, presentational software, and external Internet resources are deemed the most helpful, but interactive educational software and computer simulations on the Web are not held in high regard (Figure 44, Figure 45). Feedback indicates that not all students appreciate presentational software, and they regularly comment that not all staff use it to best advantage, and its indiscriminate use can be counter-productive[dotint25]. "How PowerPoint is used is critical, not too much material on a frame, and don't boom through slides too quickly for students to read and appreciate the information."

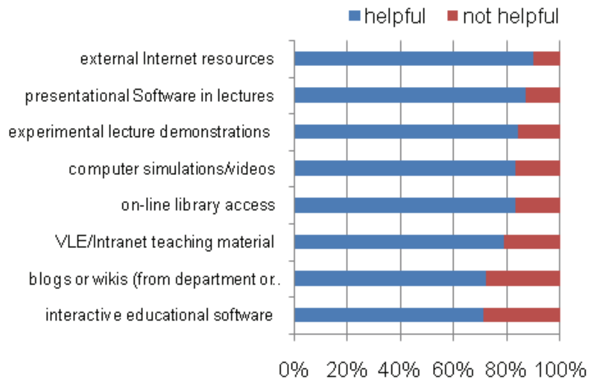

Figure 45 Students' perception of the relative helpfulness of electronic teaching methods they have experienced

Students find VLEs useful[stu105e], but they have to be kept up-to-date. Presentational software slide sequences, for example, must be made available for a second look by transferring them to the VLE, and it is useful to be able to access the VLE from home, the department or the library. "When practical experiments and the theory courses get out of synch, it is useful to be able to find corresponding information on the VLE." As one student remarked: "Teaching technology doesn't have to be high-tech – coloured cubes are effective for instant feedback from class."

11.6 Practical Work

In general, hours allocated to practical work increase steadily from Year 1 to Year 4[stu31] (Figure 46). There is a heavy emphasis on laboratory projects in Year 3 (BSc, and also MChem/MSci) and Year 4 (MChem/MSci)[dot38]. In addition, these students spend a considerable amount of time writing up notes, doing calculations and checking results outside the laboratory. The average student will spend 5 or 6 hours on these activities, more than half as much time as is usually spent in the laboratory[stu36]. Students complain that there is too much writing up.

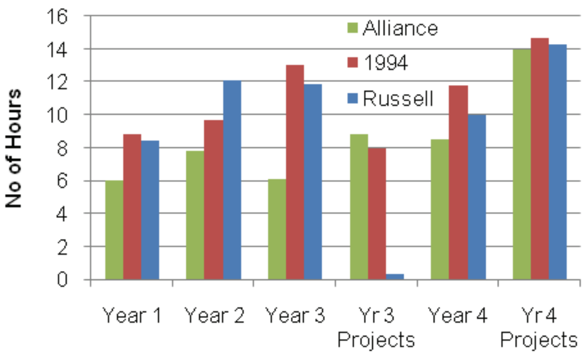

Figure 46 Median weekly allocation of student laboratory and project time by year and department Group

Students consider practical work essential or important to their degree[stu33], although MChem/MSci students rate practical work more highly than BSc students. A higher proportion of MChem/MSci students than BSc students consider that proficiency in practical work is essential when it comes to getting a job[stu35]. Three quarters of these students also find that practical work is either extremely useful or useful in understanding theoretical concepts[stu34]. The importance that students place on practical work is confirmed when more than two thirds of them – male and female, MChem/MSci and BSc – think that practical work assessments should contribute of the order of 15-20%, to their overall degree classification[stu45]. In most departments, the contribution is rather less than this. Most students also find that working in the laboratory is an informal environment, although students usually enjoy most, the practical work associated with the chemistry they like best.

Practical work is often specified as compulsory as it is an essential component of every chemistry degree, so students rarely choose to miss laboratory sessions[stu11,stu32]. Most laboratory work is strictly timetabled, and almost two thirds of the students responding prefer to have fixed hours for laboratory classes[stu38]. Similarly, a large majority of the experiments on offer in laboratory courses is allocated to students by staff[stu39], although in about half the Russell and 1994 Group departments students also have some choice in which practical activities they attempt[dot43].

Open-ended laboratory investigations are now a feature in almost all departments, and for many BSc students in Year 3 and MChem/MSci students in Year 4 all their practical work is open ended. Many departments also give their MChem/MSci students a taste of laboratory project work in Year 3[dot45]. Students' preference for more open ended experiments increases as their experience of laboratory techniques and procedures develops[stu42], as shown in Table 11.

Table 11 Student preference for different types of practical work by year

Students prefer:	Year 1	Year 2	Year 3	Year 4
practical work where the expected outcome is known:	47%	50%	33%	12%
practical work where they do not know the expected outcome, but the procedures are well known (e.g. instrumental analysis):	41%	43%	49%	48%
practical work where they do not know the outcome and procedures have to be devised (e.g. projects):	12%	7%	17%	40%

In teaching laboratories, most students are offered more than one form of instruction, and although a written laboratory text is the most common, the art of live demonstration is by no means dead[stu37]. Some pre-lab activities now seem to be carried out in all departments, whereas post-lab activities are not used quite as widely[dot44]. Much of the support offered to students in teaching laboratories is from postgraduate students, and the survey finds that over 70% of the responding students would usually or always expect to have their questions answered satisfactorily[stu41]. "PhD students are very helpful in the lab; the students who were doing the same experiments just a few years earlier can remember the sort of problems that can occur." However some students think that better demonstrator training is needed. The number of students supervised by each demonstrator shows a steady decrease from

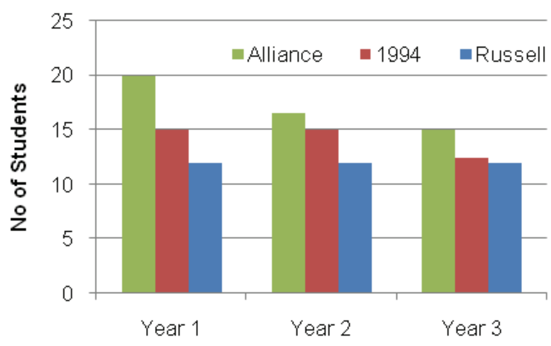

Figure 47 Average number of students supervised by a demonstrator in each year

Year 1 to Year 3 (Figure 47); and students doing projects in Year 3 and Year 4 are more closely supervised with sometimes only one or two students attached to a research worker[dot42].

When staff were asked about the efficacy of the time students currently spend in the laboratory they responded as shown in Table 12[sta29]:

Table 12 Staff perception of the efficacy of students' time in the laboratory

	All	Alliance	1994	Russell
too long for the learning achieved:	19%	3%	20%	25%
too little for them to become a competent practical worker:	81%	97%	80%	75%

The table shows a marked difference between the Alliance Group and the others. Alliance Group staff think that not enough time is spent in the laboratory to enable students to become competent laboratory workers, whereas staff from the other two Groups show less concern. There is an interesting correlation with the median hours of laboratory work shown in Figure 46, which shows that in almost every year, Alliance department students do significantly less laboratory work than their counterparts in Russell and 1994 Group departments.

More than two thirds of the students take a positive view of the time they have to spend in the laboratory, although BSc students are rather less positive than MChem/MSci students[stu40] (Table 13).

Of the remainder, only 10% feel that they leave the laboratory without becoming competent practical chemists. However, 28% of the BSc students think that they spend rather more time in the laboratory than is necessary for what they need to learn. Just 18% of the MChem/MSci students express this view.

A written report, either in the form of a laboratory notebook or a separate document, is the method most favoured for practical assessment, although testing students' ability to answer related questions is also used[stu41]. Other methods of assessing practical work included pre-lab tests and observation of laboratory skills, although this is quite rare[dot54]. Laboratory examinations are used by only very few departments[dot54]. Only about 60% of the

Table 13 Student perception of the efficacy of their time in the laboratory

	All	Russell	Non-Russell	BSc	MChem/MSci
well-spent:	69%	65%	73%	60%	73%
too long for the learning achieved	21%	26%	18%	28%	18%
not long enough to become a competent practical worker:	10%	10%	9%	12%	9%

students thought that the scores they achieved in practical work accurately reflected their skill as a laboratory worker[stu44].

11.7 Students working in groups

All departments have group work embedded in their programmes, with group activities in the laboratory a common feature. Joint presentations or poster preparation, group projects, and group problem-solving activities are also included in the teaching programme of most departments[dot49]. Other group activities practised in a few departments included focus groups and debates, data analysis, scientific writing, and specialist skills development.

More than three quarters of the students who have experienced group working find that it is an effective way of learning, interesting, and stimulating[stu46]. Most departments assess groupwork[dot54], but more than half the students who responded are not convinced that it is fairly assessed[stu46d]. "There is always the possibility of having to rely on other people who don't do the work, and getting a poorer score." Just over half the students think their department has correctly judged the amount of time they give to group working; of the remainder, the balance slightly favours more time working in groups[stu47].

11.8 Project Work

All departments include extensive project work in the final year of both BSc and MChem/MSci courses, but many departments also include project work earlier in their degree programmes. Both MChem/MSci and BSc projects are mostly laboratory based, but this can include the computer laboratory. However projects are considered an important component of the degree, and an allocation

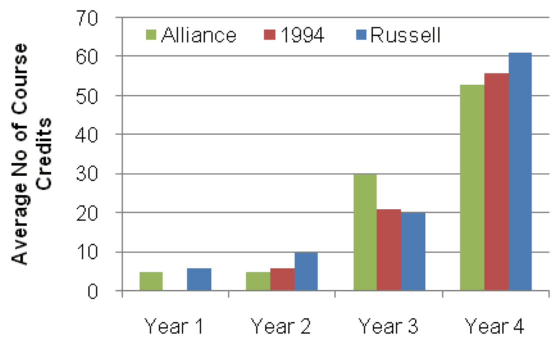

Figure 48 Course credits allocated to MChem/MSci project work

(overall median values) of 20 credits in Year 3 and 60 credits in Year 4 for MChem/MSci students[dot51] (Figure 48); 25 credits in Year 2 and 30 credits in Year 3 for BSc students[dot52] (Figure 49) – give a good indication of the norm.

Projects are generally popular[stu20], although students have suggested that short un-assessed projects, that give them a chance to practice skills needed later on would be useful, in addition to the sessions on research methodology that some departments provide.

Students are generally guided in project work by an individual supervisor, whom they meet with regularly for discussion of progress. They are often supported as well by an academic tutor, a postgraduate student or a postdoctoral worker for daily guidance. Some departments have developed a Project Preparation module to help students to identify a project and prepare a proposal[dotint6].

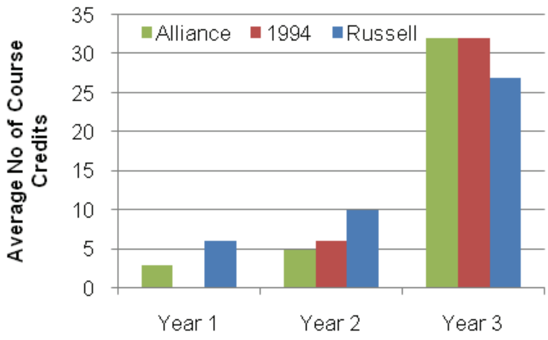

Figure 49 Course credits allocated to BSc project work

About three quarters of all staff responding believe that the quality of project work is reliably assessed[sta56], and it is clear that a great deal of effort goes into project assessment. The components of project work assessment generally include a report, a presentation (which may be oral, a poster, or both), and an oral examination; presentation or oral exam may be omitted for BSc projects. Some students find an oral exam very stressful. Laboratory performance may also be observed, and assessed through a supervisor's report. The student's report is usually the most heavily weighted component (40-50%), with other components usually scored 10-30%[dotint7]. Project reports are often assessed against a defined set of criteria to ensure comparability between projects, and may be double marked blind. At least two examiners (who may or may not include the supervisor) assess the report and conduct the viva. Presentation assessment may include other members of staff, who may not have been involved in the other parts of the assessment[dotint8].

Project work is mostly carried out by individual BSc students in Year 3 and individual MChem/MSci students in Year 4 (and frequently in Year 3 too), while in earlier years projects are more usually carried out in pairs or small groups[dot53]. Three quarters of staff think that the amount of project work their department offers to students is about right[sta54], and about two thirds of the students agree; almost all the remainder would like to see more[stu74]. Both BSc and MChem/MSci students seem to have similar opinions, suggesting that each group is satisfied with their different amounts of project work. Staff rely heavily on their own research work for devising projects[sta55], which is a strong argument for retaining staff interest in research even in the less research-intensive departments.

11.9 Learning outcomes

Chemistry learning outcomes should be informed by the National Chemistry Benchmarks[dotint4] (25) but the value of learning outcomes is a contentious issue in chemistry departments. For most university courses the provision of learning outcomes is obligatory, and Directors of Teaching confirm that chemistry staff are required to provide learning outcomes for all course components[dotint4]; but more than half the students claimed that if *more* and clearer learning outcomes were provided they would use them more regularly[stu17]. Although learning outcomes are embedded[sta15;stu14], and over two thirds of staff draw students' attention to them and emphasise their value[sta16], they are not universally convinced that they are worthwhile. On the whole they think that most students ignore them, and cannot, for example, state them when asked[dotint5].

Although a large majority of the students responding think it is worthwhile providing learning outcomes[stu16], only about one third are positive about using them to find out what they are expected to know and understand, although most of them use them sometimes[stu15]. Female students are slightly better users of learning outcomes than males. Students can find learning outcomes for modules useful for revision purposes[dotint5]. There seems to be no real conviction among staff either about the value of using learning outcomes when setting assessment, their most relevant context, but three quarters of them still do so at least sometimes[sta35]. Rather less than one third of the students are confidently aware of which learning outcomes are being assessed[stu18].

Table 14 Student perception of the effect of skills teaching on learning

enhanced learning?	All	BSc	MChem/ MSci	male	female	Russell	non-Russell
yes:	15%	6%	20%	16%	14%	13%	17%
to some extent:	58%	62%	56%	57%	59%	51%	63%
not really at all:	26%	32%	24%	27%	27%	36%	20%

11.10 Transferable skills

Chemistry has a wealth of situations where the development of skills can be exploited, and which help to make the learning of skills more meaningful for the students. So the separate teaching of transferable skills is not practised as frequently as teaching embedded in other course material[stu76, sta64]. However, there seem to be grounds for staff making their introduction of skills teaching into modules more explicit, as 40% of the students did not recognise that they had been provided with advice or training on how to develop transferable skills[stu75].

In some departments, if particular skills are needed, a skills workshop will be provided. Taught skills include how to write essays (websites and textbooks are recommended); how to write up a laboratory notebook and write a report of a practical exercise; how to use spreadsheets in order to calculate and display results; and how to calculate errors and assess their significance. Overall, just over three quarters of these students feel that they experience sufficient exposure within their courses to the transferable skills of communication, presentation, information handling, and IT, to meet their needs[stu77]. The odd one out is learning how to learn, which only half the students acknowledged. About half the students feel that they have developed transferable skills enough to help them do well in their degree course[stu79], but that means the other half feel that their skills are still not sufficient – or they do not know whether they are or not. Some feel the exercise of transferable skills is not encouraged enough, when for example, there is "no requirement for course work to be word processed until projects in the third year."

Students are only partially convinced that the inclusion of skills teaching has enhanced their learning experience, as Table 14 shows[stu78].

Staff agree with students that the shortfall in skills development comes in learning how to learn. They see both coursework and practical work as suitable vehicles for introducing practice in such skills[sta67]. Nearly two-thirds of staff believe that they are able to facilitate student learning of transferable skills, without the benefit of training; and a further quarter have been given help to do this[sta65]. Although the majority of staff think that transferable skills are better taught within the department, and embedded within teaching modules, more than a third see the value of having some skills taught (perhaps by specialists) from outside the department as well[sta66].

11.11 Mathematics

Many departments report that students experience difficulties[sta51] with quantitative chemistry because the level of mathematical skills of students on entry is low. There is a strong feeling that maths is not always taught at school to a suitable level for the study of science[dotint34]. Although there is a constant

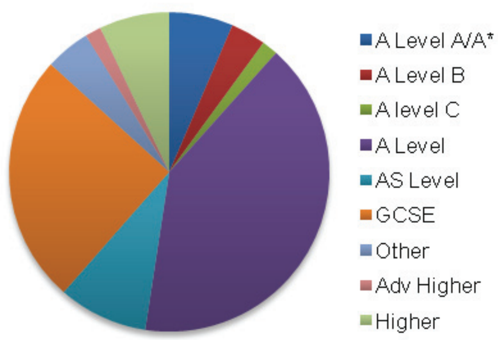

Figure 50 Maths qualifications gained by students at entry to chemistry departments

worry about the level of mathematical skill at entry, many departments only specify the minimum university entry of GCSE Grade C. Some of the Russell Group departments ask for AS Level maths; but only two of the universities who responded, neither of them in the Russell Group, asked for A Level maths[dot12].
Figure 50 shows that just over half the students responding had A Level Mathematics, with at least 6% scoring A or A* grades[stu65]. Most of the students with A Level (41%) did not give the grade they had obtained. 25% entered the course having only GCSE Mathematics. Staff complain that students are ill-prepared in mathematics when they start their courses[sta51], but more than half these students overall say that the maths they did at school or college prepared them very well for their chemistry courses[stu66]. The two groups of students who do not feel well prepared are those from the Russell Group departments and those on BSc courses.

Nearly 90% of staff consider that a mathematics component is a primary requirement for a modern chemistry course[sta69]. All departments responding to the survey provide courses for maths support in the first year; but for most departments this is the only year[dot66]. It is very rare for a department to offer maths after Year 2[stu80], but in some universities there is a student support centre at which voluntary maths workbooks and courses are available at any time[dot66]. Maths courses are not always assessed, and rarely contribute to degree classification.

For more than half the students the study of mathematics was compulsory at some stage in their degree course[stu81], and about 80% of the students think that the mathematics teaching they received was of at least some relevance to their chemistry course[stu82]. About one quarter of both MChem/MSci and BSc students find the maths too challenging[stu83], but the remainder are able to cope with the mathematics required. Two-thirds of mathematics courses for chemists are taught from within the departments, with only nine of the responding departments relying entirely on staff from outside their department[dot67].

11.12 Non-chemistry subjects (other than mathematics)

Most students have an option to take courses rated at 3 to 30 credits in a year; i.e. up to 25% of all study, outside their chemistry modules[dotint12], but this tradition seems not to be so well established in Alliance Group departments[sta60]. Some of these will usually be compulsory (especially in Scotland), or specific to particular degree programmes, but most students also have a choice, although often with recommendations or restrictions[stu84a,sta61,dotint13]. Alliance Group departments seem to be the most restricted in choice. In some universities it is a requirement to offer this possibility, but some departments discourage such studies because of problems with timetabling, and finding enough time to cover the chemistry syllabus[dotint12]. "Sometimes you find that the overall system is against you; e.g. if you want to study a language or go on an ERASMUS exchange. There can be stress because departments don't work together. You wonder how responsive are departments to student input?" Study of modules in subjects other than chemistry falls away after Year 1, but a few students from both BSc and MChem/MSci programmes persist with study of subjects outside chemistry right through their degree course[stu84].

In general students can study anything across the university[dotint14], provided it can fit into the students' timetables but many of the choices tend to be cognate to chemistry[stu84ai]. Among the most popular are biosciences, education (including school teaching experience), languages, business, and chemical engineering[dotint15] (See *Appendix 5: Choices of subject other than Chemistry and Mathematics*). Modules taught either in the evening, or by distance learning are popular.

Table 15 Level of student demand for the opportunity to study subject modules outside chemistry

Would you have liked more opportunity to	All	male	female	BSc	MChem /MSci
yes:	42%	39%	46%	51%	38%
no:	58%	61%	54%	49%	62%

Three quarters of the students responding found these non-chemistry modules to be either very valuable or useful, and very few students seriously resented having to do them[stu84b]. Almost three-quarters of the staff also consider these studies to be useful, with few considering them as a waste of time, and more than 10% of respondents considering them essential[sta62].

Nevertheless there seems to be an unfulfilled demand for opportunities to study subjects outside chemistry within a chemistry degree course[stu85], slightly more among BSc students than MChem/MSci students, and among female students rather than male students, as Table 15 shows.

12. Assessment

A very wide variety of summative assessment techniques is used in all departments[dot54] including marked coursework (such as essays/ reports, problems and laboratory exercises), short answer tests, long written examinations, oral examinations, oral presentations, projects, and posters. Objective/multiple choice tests and computer assessment are rarely used for summative assessment (although they are frequently used for formative and indicative assessment). So it is not surprising to find that when students arrive in a chemistry department, nearly two-thirds of them find that assessment at university is quite different from the types of assessment they experienced at school[stu57]. "Assessment was different from school, in that the teachers effectively show you how to pass A level, but you have to learn and work out what is needed in the university." Nevertheless, students generally find the variety of methods to be good, and that a broad assessment regime avoids bias.

The staff perception of student motivation is that it is dominated by their desire to score well in coursework and examinations. This view is held by more than three-quarters of the university teaching staff among our respondents[sta39].

Although a large majority of students think that the amount of assessment is about right in their department: "You need regular assessment to maintain regular progress", about a quarter still believe they are being over-assessed[stu48]. This figure rises to a third of the students from the Russell Group of departments, and students studying for the BSc degree.

In the view of students, departments seem to be largely able to present them with assessment appropriate to the teaching they provide[stu49], although male students are more confident about this than female students. Just over half the students surveyed also feel that the methods of assessment being used in their department are accurately able to reflect their level of ability[stu50], although MChem/MSci students are rather more confident than BSc students. However, nearly one third think that the assessment scores that they achieve misrepresent their true ability. The teaching staff are slightly more confident, with about two thirds of them (64%) thinking that their assessment regime does reveal genuine student abilities[sta40]. However this leaves about a quarter (22%) who are unsure, and a substantial number (14%) who think that it does not. The nearest equivalent in the NSS questionnaire is the statement: "Assessment arrangements and marking have been fair," to which 78% of the 2007 and 2008 chemistry students in the three Groups definitely or mostly agreed (108), showing a good correlation. They were slightly less positive with the statement: "The criteria used in marking have been clear in advance," for which our survey had no equivalent, with 65% in agreement.

Few students would like to see more weight put on to the scores attained in examinations in determining overall performance, but nearly half the responding students (especially those studying for a BSc) would like to see more weight accorded to continuous assessment[stu51]. The remainder, again about half, feel that their department has the correct balance between formal examinations and continuous assessment. Even where the proportion of credit given to coursework is low, students appreciate the feedback, and see it as formative assessment, and so worth doing.

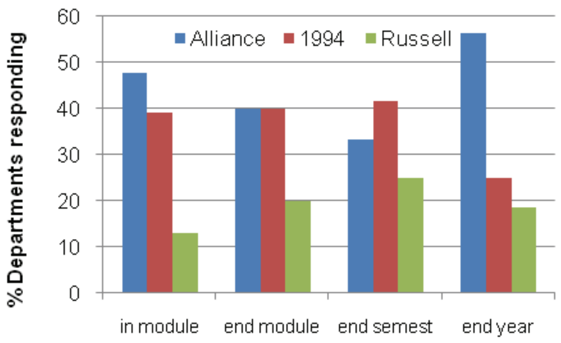

Figure 51 Departments' times for assessing students

The practice of setting formative assessment seems to be widespread[stu52,dot56], but nearly half the students say that their formative exercises and tests are not set in the same style as their summative assessments[dot57], or don't know whether or not the two are related[stu53].

covered in lectures but not likely to come up in examinations[stu56], although more than three quarters of the students who responded do hold this view to some extent. For a non-assessed tutorial not many students would do work beforehand, but they would go along to the tutorial and pick up the ideas there instead.

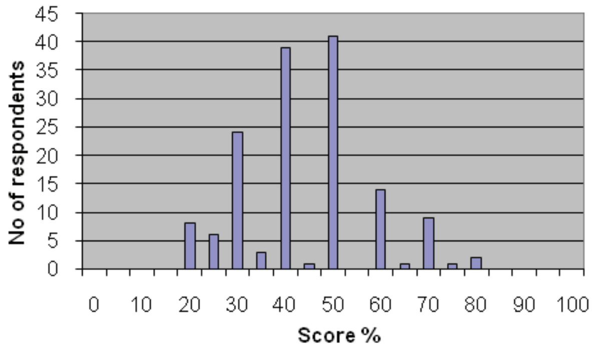

Figure 52 Staff estimate of the percentage of departmental examinations based on recall

There seems to be no set time for assessing students[dot55]. Coursework and module assessment can take place at different times during the semester, as Figure 51 shows.

Table 16 Staff views on the relationship between assessment and the development of independent learning

	Is assessment the main mechanism for determining the extent to which students have become independent learners?	
Do you think assessment is an effective tool in developing independent learning?	Yes	no
yes	44%	6%
no	19%	14%
don't know	12%	5%

A high proportion of the coursework that is set seems to be marked by staff[stu54], but about half the students say they would usually do coursework that is set even if it were not assessed[stu55]. Similarly less than 20% of students would admit to completely ignoring topics

More than 20% of responding staff would claim that their examinations were now mostly based on the understanding and application of concepts[sta38]. However, Figure 52 shows that where the examination is based on a mixture of both recall and understanding and application of concepts, a substantial proportion – typically between 35 and 65% - is still based on recall[sta38a]. Departments in all three groups seem to be offering their students a similar mix of examination questions.

An interesting cross correlation of two questions from the staff questionnaire is shown in Table 16[sta41,42].

There is clearly much uncertainty about peer assessment among students[stu58], with almost half the sample unable to give either a positive or negative view about its fairness, helpfulness or accuracy. Among students with definite views, more (3:2) would agree that it is fair and helpful, but more than twice as many would judge it to be an inaccurate form of assessment as would be confident about its accuracy. While there is a general agreement among staff that this form of assessment is helpful[sta43b], and about two-thirds of staff consider it to be fair[sta43a], there is less conviction that students can make an accurate assessment of the quality of the work of their peers[sta43c]. Staff from the Alliance Group, who seem to have the greatest experience of peer assessment[sta43], also show the greatest concern about its accuracy.

13. Feedback

13.1 Feedback on teaching

Once staff are in post, most Directors of Teaching consider that their departmental monitoring procedure is fair and fit for purpose[dot29]. Observation of teaching is part of almost every department's approach to monitoring teaching quality[dot28]; and about half our respondents had either had a teaching mentor[sta8], or been a mentor themselves[sta9]. Correlations of mentoring with age suggest that younger members of staff are now being provided with mentors from among the older and more experienced staff. However younger members of staff are also starting to engage in mentoring. It is also clear that most members of staff discuss styles and techniques of teaching with their colleagues[sta10].

Almost all departments have a policy and procedure to collect feedback from students[dot60], and a regular formal review of student feedback on teaching[dot63], as well as a student complaints procedure[dot61]. Most departments have a Staff-Student committee[dot62], and many also have student representatives on a departmental teaching committee[stu94]. Almost 90% of the students are aware that these facilities exist. Although almost half the students do not know whether their departments involve students in module development[stu95], just under half the DoTs say their departments do involve students in this way[dot64]. A majority of the Directors of Teaching believe that this diversity of student input has some (or in four departments quite a lot) of influence on staff teaching[dot65], whereas only just over half the students believe that that the comments they make on teachers and teaching methods have any effect in bringing about change for the better[stu96]. In one department, open meetings of the Staff-student committee are held to reassure students that their input is being taken seriously. The Year 4 students are most confident that a student voice has been heard and acted upon[stu96]. "Staff-Student Committee really does seem to work, even though it can take quite a while to get results."

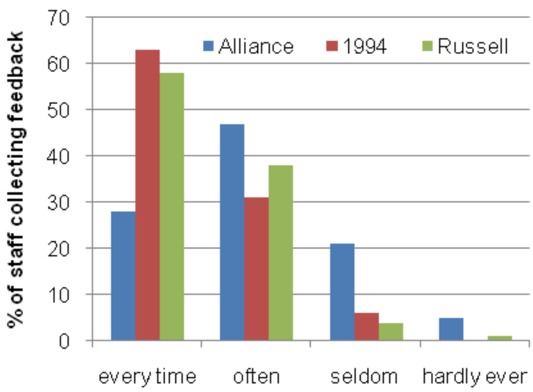

Figure 53 Staff collection of feedback from students

A habit of staff collecting regular feedback from students about the quality of teaching is generally well established[sta44], though perhaps not so strongly in the Alliance Group of departments (Figure 53); and almost 90% of staff find their student feedback is helpful in improving their teaching for next year's presentation[sta45]. Some however would prefer higher quality feedback and not just tickbox responses. Paper forms, used by about 80% of staff, are still the most popular, and effective, way of obtaining student feedback[sta44a]; students would agree. Some departments employ optical character readers to process them for large classes. The major problem with electronic systems, used by nearly half the staff (mainly in the Russell and 1994 departments), is summed up by this comment: "We recently switched to electronic – response rate plummeted; we will return to paper next year." A few staff prefer to make direct enquiries of their students, but only about half the respondents discuss with their students any feedback they obtain from them[sta46].

13.2 Feedback to students

Staff and students agree that written, detailed, individual feedback given to students during the course or module, is definitely the sort that is most appreciated[sta47,stu59]. Of course: "The quality of feedback depends on who is doing the marking;" and "It is not very useful if it only gives a score, so you do not know how you have gone wrong." Oral feedback is also acceptable, but an overview of group performance, and feedback that is delayed until the end of the course or module is not liked. Over half the students surveyed say they receive little or no feedback, with 10% or fewer receiving regular feedback on all their study modules[stu60]. Although return of feedback is not up to student expectations, three quarters of the students are happy with what they receive. Three quarters of the respondents find that it helps their learning[stu61]. They would however, like to see improvement in the rate of return, since only a quarter of the students, or less, expect to have their work returned promptly, which is of course the most useful form of feedback[stu62]. "Delay in returning scripts does not help students to improve their next assignment."

These responses can be compared with the responses to the NSS Assessment and Feedback section. The relative dissatisfaction shown, elaborated in Figure 54, has parallels in the findings from our questionnaires.

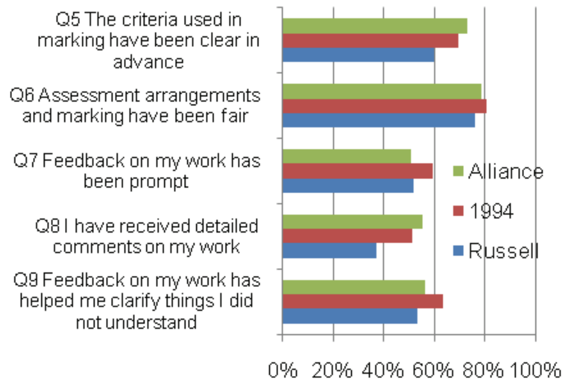

Figure 54 Student responses to NSS statements in the Assessment and Feedback section (the results from 2006 and 2007 have been combined)

About one third of the staff provide students with written model answers to coursework[sta36]; and about 20% return marked examination scripts from the exams that they set[sta37] – most frequently to first year students, and decreasingly in the later years of the course[sta37a].

14. Chemistry teaching staff

14.1 Developing teaching skills

Staff are increasingly expected to have high quality teaching skills. For almost half the staff in post, a course of teaching skills was obligatory when they joined the university[sta7]. Correlation with age distribution shows that a higher proportion of younger members of staff have attended courses, suggesting that this has become the accepted procedure for newly appointed staff[dot27]. Not all staff are complimentary about such courses. Opinion is almost equally split between those who consider them valuable and of little value. Very few staff thought of them as having high value, or of not being valuable at all[sta7a].

Initial training in teaching skills is almost entirely the responsibility of the universities rather than the departments[dot25,26]. Courses are over-whelmingly generic in nature[sta7b], possibly accounting for some of their unpopularity and perceived lack of value. A least one university employs the strategy that if there is a group of staff from one school, the course can be modified to meet more subject-specific needs[dotint39]. The HEA Physical Sciences Centre (3) provides, and supports, courses specifically directed to the needs of newly appointed science staff; and also meets the needs of established staff, along with other providers, through its workshops.

Higher education teaching qualifications do not appear to be common in Russell and 1994 Group departments, but considerable numbers of Alliance group staff seem to have them[dot4]. A few departments have indicated that they have a policy that all staff (or all newly-appointed staff) are required to obtain such a qualification.

Most universities have an ongoing teaching development programme for academic staff[dot76], and about half the individual chemistry departments arrange their own teaching development activities[dot77]. More than two thirds of the staff responding thought that their university has a policy of encouraging attendance at teaching development activities[sta77], but encouragement within the department is rather less positive[sta77]. Nearly 60% of the staff who replied have spent some time at a teaching development event in the previous year[sta76] but overall, the number of regular attenders is rather smaller than this[dot78]. In general, about three quarters of the staff who participate seem to get some value out of attendance at teaching development activities[sta79]. Staff from the Alliance Group of departments seem to be more highly satisfied with the quality of such events. Again about three quarters of these staff are using (or intending to use) some of the material or ideas they picked up at these events in their teaching[sta76a], and a similar proportion have passed on something of what they learned to colleagues[sta76b]. However overall, only about 10% of all chemistry staff seem to participate regularly in this type of activity, and in some departments no-one at all.

Not many teaching staff keep up with current research in chemistry education[sta87], around 15% in all, with by far the highest proportion in Alliance Group departments, and twice as many women as men, *pro rata*. Staff have been actively engaged in chemistry education research in just under half the departments[dot79], but only about a quarter of all staff have ever undertaken research or scholarship relating to undergraduate teaching[sta88]. Staff from the Alliance Group seem to be noticeably more active in this area than their colleagues in the Russell and 1994 Groups, and again the female staff are more engaged than their male colleagues. Rather fewer staff have gone on to have anything published relating to chemistry education[sta89]. Cross tabulating with the age profile of staff shows that those currently in mid-career are the ones most likely to have pursued chemistry education research at some time.

About three quarters of the staff feel they have few problems with introducing an innovative teaching method[sta82], and a similar proportion already has experience of producing and introducing teaching material that differs from that they have encountered previously[sta83]. Figure 55 shows the main reasons given by staff for making a change in their methods of teaching[sta83a]. Two other responses given are noteworthy – a desire to generate new, better ways of communicating the material; and an interest in teaching a difficult topic in a simple way.

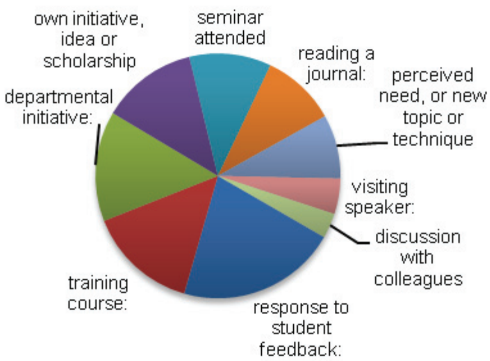

Figure 55 Staff reasons for changing their methods of teaching

Nevertheless, a high proportion of traditional teaching methods (around 80% in the Russell and 1994 Groups) is still to be found in all departments[sta80]. Changes from traditional teaching methods are most noticeable in the Alliance Group of departments. It is, therefore, not surprising that well over half the staff are not convinced that new teaching methods are necessary for the current student cohort[sta81].

More than one third of the students responding think that their academic staff give a high priority to teaching[stu100]. Students on the MChem/MSci courses, and in the non-Russell Group departments, rate them even higher. Only about 10% of the students across all courses and departments, reckon that staff give little or no priority to their teaching.
In the majority view of students, poor teaching is very uncommon in chemistry departments, and just under a third of these students consider that their teaching has been excellent overall[stu104]. However, about 20% of students in years 3 and 4 rate their teaching as only satisfactory. Quite a lot more excellent teaching is reported by MChem/MSci students than by BSc students, of whom a quarter rate their teaching overall satisfactory or poor. In the 2007 HEPI report, training for lecturing staff was given quite a high priority (125) suggesting that teaching in chemistry departments is of higher than usual quality.

14.2 Teaching commitments

It seems that staff are usually consulted about their amount of teaching and the topics they prefer to teach, but that teaching methods are more frequently left for the member of staff to decide for themselves[sta12]. Younger members of staff are less likely to be consulted over their teaching load and the topics they are asked to teach. Two-thirds of departments have a norm for a staff teaching load, a practice most common in the Alliance Group departments and least used in the 1994 Group[dot31].

Hours that staff are expected to teach vary widely between institutions and from semester to semester. The highest teaching loads seem to occur in the Alliance Group departments, and the lowest in the 1994 Group[dot31]. As well as lectures, academic staff make a major contribution to teaching in workshops, seminars, and tutorials[sta13,dot33]. Very little of this work seems to be passed on to post-doctoral or postgraduate members of the departments[dot5,33,34]; part-time staff are not commonly used either[dot6]. Lecturing staff are also heavily involved in laboratory supervision, but almost all departments also rely on substantial support from postgraduate students[dot34].

In about two thirds of departments there is a variation in the teaching hours allocated to strongly research-oriented staff and to less strongly research-oriented staff[dot32]. This is most marked in Russell and Alliance Group departments.

As well as a weekly teaching load, staff also engage in a considerable amount of informal student contact[sta14]. Staff in several departments operate an open door policy towards students, which has become a recognised part of the feedback system. However: “Even if staff have an open door policy, students don’t always take advantage of it.”

15. Preparing students for employment

The main responsibility for providing careers advice, and training in employability skills, rests with university careers services rather than departments, but about two thirds of departments do also provide their students with career guidance[dot82] as recommended (130). Time spent in industry can also develop these skills, if students have a suitable placement. Providing careers advice does not figure regularly on the teaching programme of many of the staff, but most of them appear to do this occasionally[sta90].

Just about one third of the students say they chose their course principally for its employment prospects[stu106], irrespective of whether they were male or female, or BSc or MChem/MSci students. Some students want to use the skills they have acquired as chemistry undergraduates, but not in a chemistry-based job.

More than two thirds of this student sample overall hopes to move from a first degree to a higher degree, almost all in chemistry or a chemistry related subject[stu97]. By the time they reach their final year just over 50% have made this a firm choice. Overall more than 80% of students who have chosen career paths (two third of the whole group), intend to go into a career directly using chemistry knowledge and skills[stu98]; more than three quarters of these students on both the BSc and MChem/MSci courses think their courses are providing them with the knowledge and skills that will be useful in their expected careers[stu99].

Although 60% of staff do think it is necessary in teaching their courses to take into account that students will go into different areas of employment, about one third feel this is not their responsibility[sta75]. Although almost three quarters of departments expect students to keep an academic portfolio (PDP or personal log)[dot86], just over half the staff in Russell and 1994 Group support their students in keeping these records, rising to 80% in Alliance Group departments[sta91]. So it is not surprising that four times as many non-Russell Group students keep them, as do Russell Group students[stu108]. Students are not enthusiastic about PDPs: “They are never used within the university, and it is most unlikely that any employer would choose to look at them as they have their own interviewing and testing regime.” Fewer than two thirds of the students think that a particular effort is made by their departments to prepare them for employment[stu107]. Some students feel departments should offer more help, especially for those not considering science-based jobs. However, since the whole of a degree course is directed towards preparing students for a career, and most of them enter employment, this may only indicate the absence of explicit activities directed towards the mechanics of getting a job. Nevertheless, students seem to think that considerably more effort is made to prepare them for employment if they are studying for MChem/MSci degrees than for BSc degrees; and if they are students studying in non-Russell Group departments rather than Russell Group departments (Table 17).

Table 17 Student responses to the Question: "Would you consider that a particular effort is made within your course to prepare you for employment?"

	BSc	MChem/MSci	Russell	non-Russell
yes	49%	60%	41%	70%
no	51%	40%	59%	30%

Many departments say they offer help to students with writing a job application, drawing up a *curriculum vitae*, and preparing for an interview, but this is not uniform as Figure 56 shows[dot83]. Alliance Group departments seem to do this more often than departments in the other two Groups.

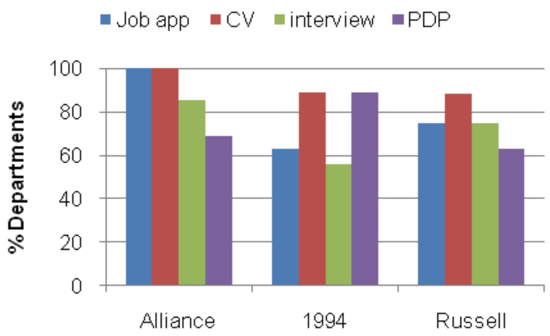

Figure 56 Departments providing help towards student employability

However, the proportion of students taking up their offer seems to be small, to judge by Table 18[stu109].

BSc students and students in Russell Group departments are much less likely to encounter study material related to employment – such as, aspects of business studies, chemical legislation, entrepreneurship, and patents and intellectual property rights – than MChem/MSci students and those from non-Russell departments[dot84], with overall two thirds of the students receiving nothing of this type[stu111]. Staff from other university departments may be used in teaching courses in this area[stu111a]; but

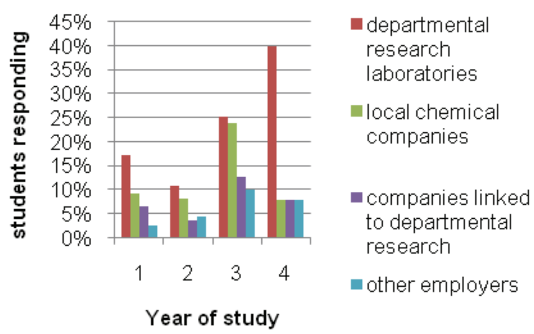

Figure 57 Opportunities for students to visit potential employers by year of course

students are generally not sure whether the lecturers who give these courses are experts in these fields or not[stu111ai]. The reason for omitting such studies is only very rarely because they have been considered for the curriculum and rejected, but more usually because they have never been considered for inclusion[dot85]. Departments inform their

Table 18 Students provided with help towards employability by year of course

This year are you given help with:	All	Year 1	Year 2	Year 3	Year 4
writing a job application:	19%	6%	15%	17%	15%
preparing a curriculum vitae:	30%	10%	29%	24%	15%
attending an interview:	19%	6%	14%	18%	12%
none of these:	64%	86%	32%	42%	59%

Table 19 Opportunities for students to visit potential employers by year of course

	Year 1	Year 2	Year 3	Year 4
departmental research laboratories:	13 (15%)	12 (10%)	20 (20%)	15 (35%)
local chemical companies:	7 (8%)	9 (8%)	19 (19%)	5 (12%)
companies linked to departmental research:	5 (6%)	4 (3%)	10 (10%)	3 (7%)
other employers:	2 (2%)	5 (4%)	8 (8%)	3 (7%)
none of these:	60 (69%)	89 (75%)	42 (42%)	17 (40%)

students about health and safety regulations, but usually only the legal requirement for working in their own departments[stu110]. There are similarly few opportunities arranged for students to visit chemical companies, other employers, or the departmental research laboratories[stu112] (Table 19 and Figure 57).

Students become more familiar with the research work of the departmental staff as they move from Year 1 to Year 4[stu101], probably as they embark on project work. In later years 80% of them appreciate that this research has directly enhanced the teaching and learning they have experienced (Figure 58)[stu102]. Better knowledge of the departmental research activities is shown by MChem/MSci students and those in the Russell Group departments.

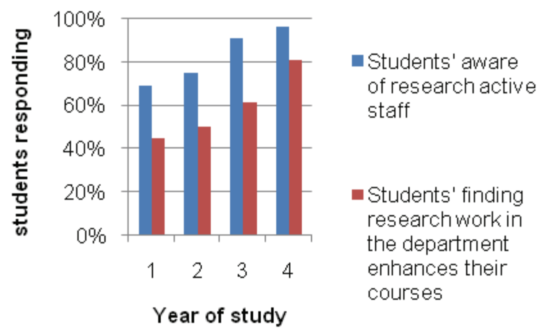

Figure 58 Students' developing perceptions of departmental staff research with year of course

16. Work placement and foreign exchange

Currently a very high proportion of students is given the option of taking a BSc or MSci/ MChem[dot20i] with an industrial placement scheme[stu88]; the number of departments not offering it is small and decreasing, although it is slightly less common in Russell Group departments. Some departments use a year in industry to distinguish between their MChem/ MSci and BSc programmes. Industrial placements are not as frequently found associated with the BSc programmes, with only two-thirds of departments giving BSc students this opportunity; but this includes almost all the Alliance Group of departments that only offer BSc courses[dot20ii]. Nearly two thirds of those students not offered the opportunity to work in industry would have liked to have been given such a chance[stu88a]. Placement schemes in Europe are not common. (61)

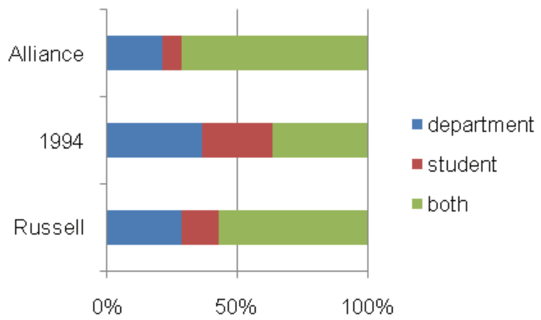

Figure 59 Agencies for arrangement of work placement

Every department responding believes that work placement is a good way to prepare students for employment[dot94], and it certainly gets the enthusiastic support of almost 90% of the students who participate as well[stu116]. For the majority of students work placement is optional, although it is obligatory for some courses – especially MChem/MSci with titles like *Chemistry with a Year in Industry*[dot88]. When students are given the option the take-up is very variable, running from 10-50% of the students in Russell Group departments, and 5-80% in 1994 and Alliance Group departments[dot89].

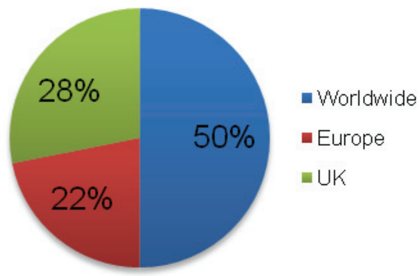

Figure 60 Location of work placement opportunities

A year is the usual time to spend on this component of the course, but periods of 6 weeks, 2-3 months and 6 months are also offered by a few departments[dot87]. Any student can intercalate a year; i.e. take a year out, and work in industry, but this is not an official placement and carries no credit[dotint27].

For many students their work placement is arranged by the department (Figure 59)[stu114], and students also seem to have a wide choice of location, with only about a quarter of these students who have the opportunity to accept placements being limited to the UK

(Figure 60)[stu115]. The pie chart shows the proportion of departments offering worldwide opportunities for work placement, and those restricting their students to Europe or the UK[dot91]. Although departments have many contacts with the placement providers, one third of Russell Group departments and over 40% of 1994 and Alliance Group departments say they have difficulty in finding enough places for their students[dot92]. Most departments will encourage students to apply for those placements that they think will be the most suitable, according to their chemical interests; but the final selection of candidates is usually done by the employer through competitive interview[dot90,dotint28].

Sometimes departments only allow the 'better' students to take up work placements so that their students will create a good impression. However, the better students are not necessarily the ones most likely to take up work placement, nor the ones who will gain the best advantage from time in industry. Students who are well motivated, well organised, and the most independent benefit the most[dotint27].

The majority of work placements form a component of the degree assessment scheme[dot93]; whether it does, or not, there can still be problems: "In MChem, where the industry project makes a high contribution to the year's score, a difficult project can cause problems leading to a poor overall result. However, a successful BSc industry project that doesn't count towards the final score can be frustrating and disappointing." Almost all departments expect both students[dot95] and employer[dot96] to provide a report on the work placement; the few exceptions are for unassessed BSc students. For MChem/MSci students, these reports form part of the assessment scheme for the degree[dot97]. In all departments the content of these reports is reviewed, and in most departments the reviews are used to improve the work placement system for the next group of students[dot98].

Students spending a year in industry generally report very favourably on their experiences. Work placement is popular because students like the opportunity to earn some money, while students (especially those who are thinking of a career in industry) value getting some work experience too. It has the additional advantages of putting their degree in context, improving their employability, and helping their skills development[dotint26]. "Placement year is especially good for making you into an independent learner;" and "Placement tells you how valuable you are in a working environment." The main objections are from students who wish to get into employment, or go on to postgraduate study, more quickly[dotint26].

Rather more departments offer industrial placement than foreign exchange schemes, and students seem to be much clearer about them[stu113]. One of the reasons could be that many more students are automatically provided with information about work placement as receive information about foreign exchange schemes[stu113c]. Foreign exchange seems to be a less systematic and voluntary system, except for those departments who offer degrees entitled *Chemistry with a year abroad*, *Chemistry with a European Language*, or something similar. Proportionately nearly three times as many students have taken up industrial placements (or intend to do so) as have taken a foreign exchange opportunity[stu113b], and twice the proportion want a work placement as want a place as an exchange student[stu113e]. Work placement also seems to attract more course credit[stu113d], especially for MChem/MSci students.

Although student exchange schemes are well established, few chemistry students take up this option, with 0-5% being the departmental norm[dot101]. They are apprehensive that their degree class will be affected, and that they will not be able to cope with the language difference[dotint29]. So the English-speaking destinations (Australia, USA, Canada) tend to be much more popular than continental Europe. All Russell Group departments have an option for their students to spend time in a different country, as do three quarters of 1994 Group, and more than half Alliance Group departments[dot99]. There is a more variation in the length of time students spend on exchange than the usual year on work placement[dot100]. Most participants speak positively of a year abroad[dotint30]. Considerably more exchange students from overseas come to spend time in UK departments.

Most departments (or universities) have arrangements with corresponding departments in a number of other universities, and they usually direct their students to these particular locations[dot102]. Three quarters of the departments have contacts around the world, the remainder are limited to European contacts[dot103]. Every department that responded gave credit for academic or project work done abroad[dot104], but almost a quarter of the departments did not require a separate report on the time spent away from the department[dot105]. Those that did, used the review to improve the experience for subsequent students – especially if it had been unsatisfactory[dot106].

17. Input from employers/employees

There is a diverse approach to obtaining feedback from employers, with some departments having Industrial Liaison Groups, or regular meetings with employers; others rely on informal contact through their industrial placement schemes. Some staff feel that any employer input will be of limited value, because the job of the department is to "teach students chemistry and leave generic skills which apply to the entire workforce to the employer." Just over half the students are aware of links between their department and employers of chemistry graduates, with students in non-Russell departments being somewhat better informed[stu117].

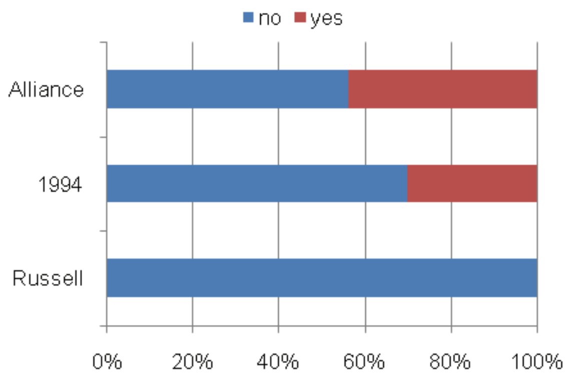

Figure 61 Departments with an established procedure to obtain regular feedback from employers

Figure 61 shows the proportion of departments with an established procedure to obtain regular feedback from employers of their graduates[dot107]. As can be seen, this is considered to be a fairly low priority; and departments are only slightly better at maintaining contact with their graduates[dot108].

About a third of the students responding are aware of recent graduates returning to their department to talk to undergraduates about the jobs they are doing; but about the same proportion are convinced that they do not[stu118]. This practice seems to be better established in the Russell Group of departments than in the non-Russell Group.

Overall, Directors of Teaching are not wholly convinced that their departments engage effectively with employers (Figure 62)[dot113]. Employers are invited to visit many of the departments to give guest lectures about their careers or companies[dot111], but fewer

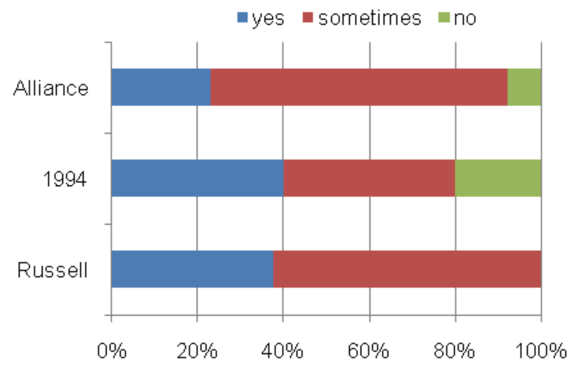

Figure 62 DoTs' opinion of the effectiveness of their department's engagement with employers

departments invite employers to contribute to programme planning[dot112].

About half the students in the Russell Group are aware of employers visiting their departments, but in the non-Russell Group the proportion is considerably lower[stu119]. Only about one quarter of the students who responded have had an opportunity to meet with employers who are linked with departmental research[stu120].

More than three quarters of departments use industrial staff to contribute to teaching on their programmes[dot114]. Students benefit by being introduced to aspects of modern industrial development, and through case studies, they see real applications of the techniques they are being taught. Staff are alerted to important recent trends affecting industry, and are able to obtain material for their teaching that would otherwise be hard to find[dotint33].

Some departments have designed new courses in conjunction with employers (many of whom were their former graduates), or found them very valuable in setting up a placement programme.

Departments are convinced that employers are satisfied with their graduates, in that they keep on employing them, often ask if there are any more available, come into the department to help in teaching, and give good feedback about the graduates in their organisations[dotint32].

MChem/MSci students and students from Russell Group departments are more confident that employers are satisfied with the graduates from their departments, or with graduate chemists in general, but 40% or more of the students responding did not know whether employers were satisfied or not[stu121].

Good interaction with industry not only exposes students and staff to an industrial perspective, but can facilitate placement schemes, provide opportunities in collaboration for staff, and may even result in obtaining research funding. Industry sees that there are recruitment advantages through familiarising students with their working practices[dotint33].

18. The chemistry graduate

The number of graduates in physical sciences in the UK has remained at about twelve thousand over the last six years. However, as the number of students graduating has increased from just over two hundred thousand to over two hundred and sixty thousand, the physical sciences percentage of the graduate output has fallen from 5.7% to 4.6%. The numbers of graduates in chemistry over this same period are shown in Figure 63.

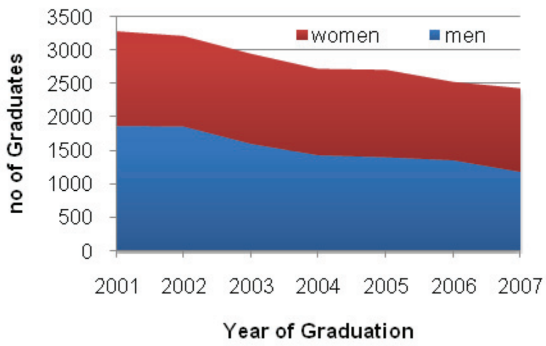

Figure 63 Chemistry graduates from UK universities 2001-2007 showing gender proportions

This shows that chemistry is providing a decreasing proportion of the output of physical science graduates. The proportion of women chemistry graduates has risen over this relatively short period from 43% to 51%, while the proportion of women graduates overall has stayed around 56%. This change is a continuation of a trend; in the three-year period 1995-1997 the proportion of women chemistry graduates was 37% (with the overall percentage of women graduates about 51%). When compared to other subjects the percentage of female graduates is higher in chemistry than in physics and mathematics but is lower than in biology, English and French. (15)

The employment prospects for chemistry graduates are extremely good in comparison with graduates from other non-vocational degree programmes. The investigation by PricewaterhouseCoopers, commissioned by the RSC and the Institute of Physics, confirms that studying chemistry is a better economic option than many alternative subjects. The lifetime earnings of a chemistry graduate will be on average 30% more than those without a degree; and at least 12% higher than graduates in subjects including psychology, biological sciences, linguistics and history. Only medicine and law graduates will earn significantly more. (131, 132) It is not clear if students are aware of these economic factors when choosing a university degree. This survey also showed that although it costs more to educate a chemist, the state also benefits, recouping the extra cost of laboratory-based teaching several times over through taxation.

The chemical industry is a major employer in the UK, and across the world. Many positions in industry, and some other spheres of employment, prefer graduates with higher degrees, so it is not surprising to find that, on completing their first degree, a larger number of chemistry graduates choose to continue their studies than from any other academic discipline. The distribution of chemistry graduates on leaving university is shown in Figure 64 (15).

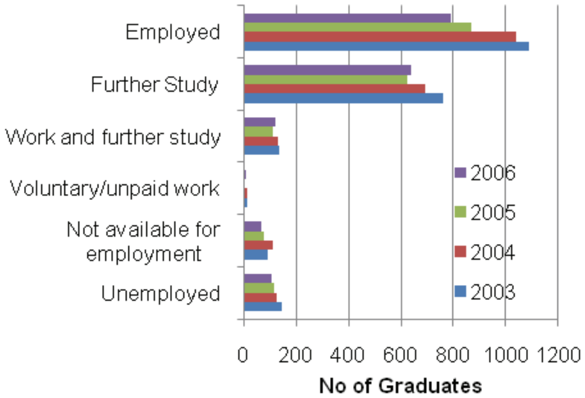

Figure 64 First Destinations of UK Chemistry Graduates 2003-2006, showing the high proportion continuing in study

Figure 65 is the corresponding chart showing the most recent overall destinations for graduates (102). This also shows the low level

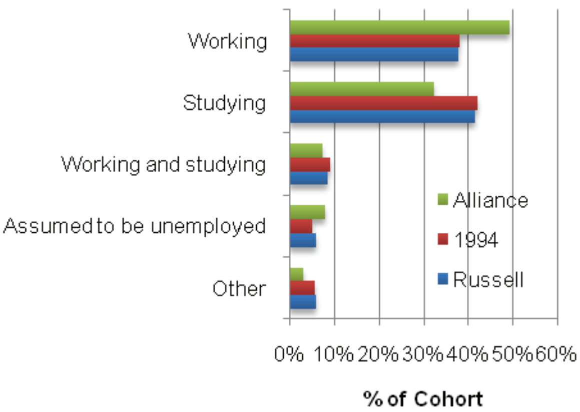

Figure 65 Destination of recent chemistry graduates (2007 data for Russell and 1994 department, but some 2006 data also included for Alliance departments).

of unemployment among recently qualified chemistry graduates. A higher proportion of graduates from Alliance Group departments would appear to enter employment directly on graduating with a first degree, rather than continuing study for a higher degree.

The majority of first degree chemistry graduates from universities enter UK employment in industry or commerce (Figure 66). The major employers of the graduates working in science-based industries are in the oil, mining, chemical and allied industries. Of those first degree graduates entering commerce the majority work in finance. A further breakdown by occupation is shown in Figure 67. (15) Only 7% of chemistry graduates are unemployed, and just 14% are in non-graduate jobs; 79% occupy graduate roles or are studying. (Good University Guide 2008)

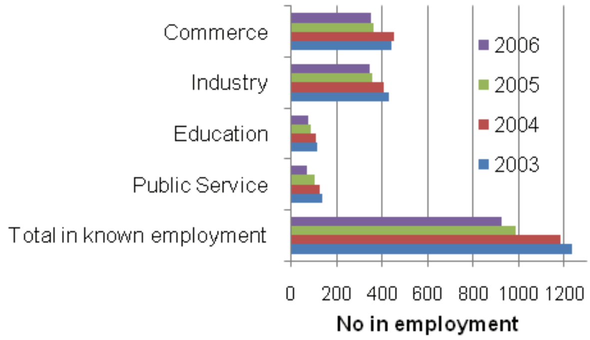

Figure 66 Fields of Employment for First Degree University Chemistry Graduates 2003-2006

In Figure 67, elementary occupations indicate occupations that require knowledge and experience necessary to perform mostly routine and technical tasks; and personal service occupations indicate caring, leisure, and other services for individuals.

The wide range of prospects for chemistry graduates is shown in the more detailed analysis of UK employment from 2005 and 2006 (Figure 68). The distribution among the occupations is fairly similar for the two years. Responses from over 80% of the cohorts from the two years (2100 men and 1875 women) are included on the chart. (133, 134)

As shown by Figure 68, a degree in the chemical sciences is seen to prepare graduates for a very wide range of professional and managerial careers across all fields of employment.

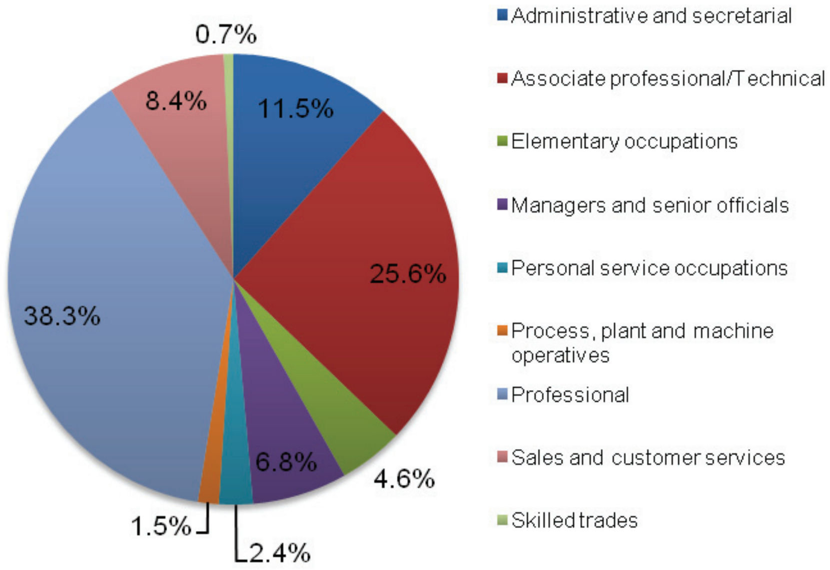

Figure 67 Types of work entered by Chemistry Graduates, aggregated over 2003-2006

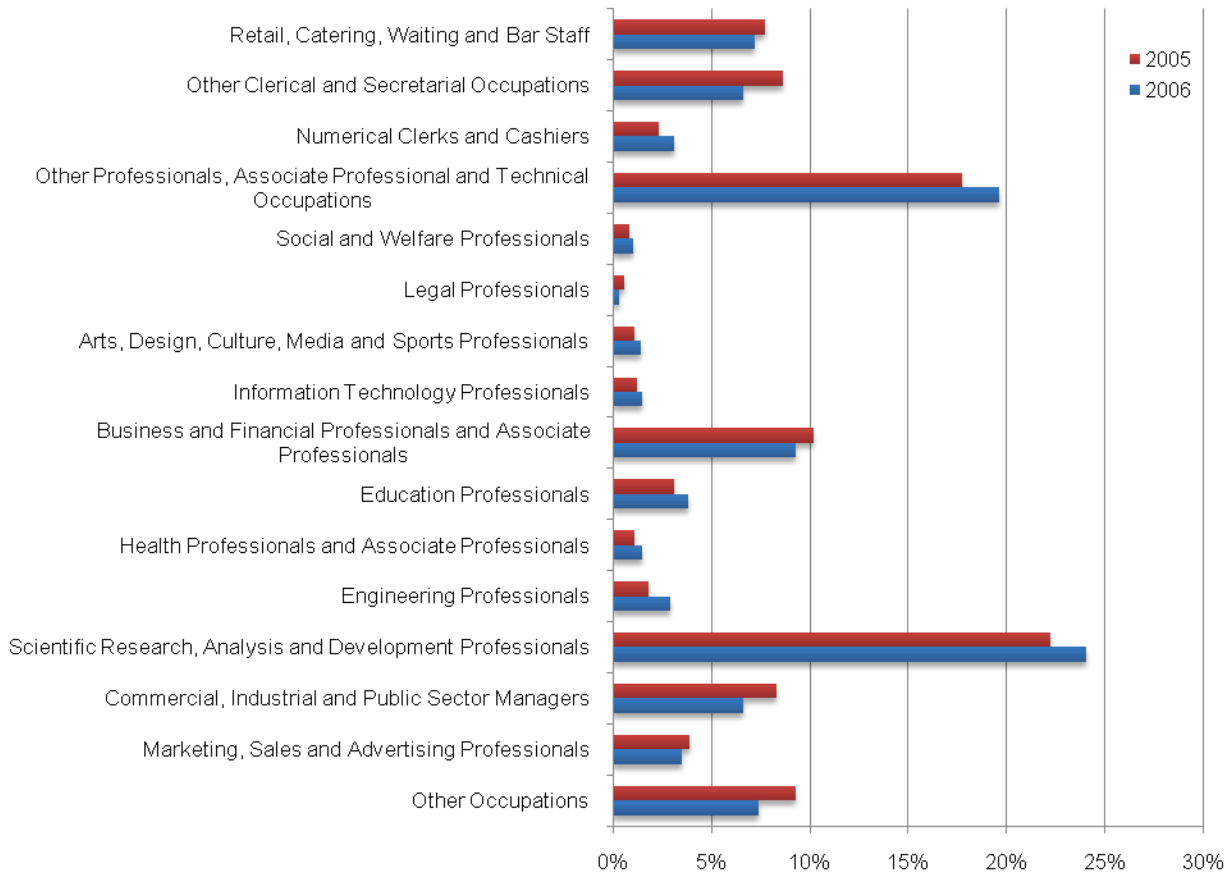

Figure 68 Further breakdown of occupations in the categories 'Employed' and 'Work and further study' from Figure 64 for 2005 and 2006

19. Conclusions

This report provides a comprehensive snapshot of the learning experiences of full-time chemistry undergraduates in a UK university in 2008. It also provides a rich overview of many aspects of teaching and learning in the discipline.

We offer the report to all interested stake-holders, which we anticipate will include Heads of Chemistry Departments, Directors of Teaching, academic staff engaged in teaching chemistry (including those in cognate departments), employers of chemistry graduates, administrators, planners, members of the Royal Society of Chemistry, teachers, careers advisors, parents, and current and potential students. We hope that the information that it offers will provide encouragement to all engaged with education in chemistry at HE level, and incentives to develop further what is already clearly seen to be a high quality product.

If there is any surprise in the finding of the study, it lies in the absence of unexpected revelations about the state of the discipline. The questionnaires and the interviews generally told us what we expected and hoped to hear – that the teaching and learning experience of chemistry undergraduates in the UK is positive and effective. It is not static and is building on a solid basis of educational experience. There is evidence that it is developing through the elaboration of the curriculum, through innovation in approaches to teaching, through the imaginative use of technology, and through the extension of the learning environment, all for the benefit of present and future students.

The prospects for students entering a chemistry department in the UK are shown to be sound, and we trust they will continue to improve.

All the supporting documents – the questionnaires, the Staff and Student Survey Analyses, and the tabulated responses, may be accessed through the HEA Physical Sciences Centre website -

<www.heacademy.ac.uk/physsci/home/projects/subjectreviews/chemistry>

- for anyone who wishes to explore the collected data in depth, and assistance is available from the Centre.

20. References

All URLs checked, January 2009

1. Higher Education Academy <www.heacademy.ac.uk/>
2. National Subject Profiles <www.heacademy.ac.uk/ourwork/networks/NSP>
3. Higher Education Academy Physical Sciences Centre <www.heacademy.ac.uk/physsci>
4. Staff Questionnaire: *Review of the Student Learning Experience in Chemistry, Staff Survey* (via www.heacademy.ac.uk/physsci>
5. Student Questionnaire: *Review of the Student Learning Experience in Chemistry, Student Survey* (via www.heacademy.ac.uk/physsci>
6. DoTs Questionnaire: *Questionnaire for Directors of Teaching, Review of the Student Learning Experience in Undergraduate Chemistry*, HEA Physical Sciences Centre (via www.heacademy.ac.uk/physsci>
7. *RSC Recognised and Accredited Degree Courses*, RSC, 2009 <www.rsc.org/Membership/join/AccreditedCourses/index.asp>; *The Recognition and Accreditation of Degree Courses*, RSC, August 2001 (Original) <www.rsc.org/images/accredcriteria_tcm18-35049.pdf>; *Consultation - Accreditation of Degree Programmes* (Revised criteria), RSC, 2007 <www.rsc.org/Membership/join/AccreditedCourses/accreditationconsultation.asp>; *Accreditation of Degree Programmes: Draft for Consultation*, RSC, May 2008 <www.rsc.org/images/Accreditation%20Consultation%20May08_tcm18-121330.pdf>
8. The Royal Society of Chemistry (RSC) <www.rsc.org/; http://www.rsc.org/AboutUs/index.asp>
9. The Russell Group <www.russellgroup.ac.uk/>
10. 1994 Group <www.1994group.ac.uk/>
11. University Alliance <www.university-alliance.ac.uk/>
12. 'dot' references refer to question numbers in the *Survey of Directors of Teaching in Chemistry and Allied Departments, Review of the Student Learning Experience in Undergraduate Chemistry,* HEA Physical Sciences Centre. 'dotint' references point to the free response questions.
13. 'stu' references refer to question numbers in the *Chemistry Student Survey Analysis, Review of the Student Learning Experience in Undergraduate Chemistry*, HEA Physical Sciences Centre
14. 'sta' references refer to question numbers in the *Chemistry Staff Survey Analysis, Review of the Student Learning Experience in Undergraduate Chemistry*, HEA Physical Sciences Centre
15. *Statistics of Chemistry Education*, RSC, 2009 <www.rsc.org/Education/Statistics/index.asp>; *Digest of Statistics of Chemistry Education*, RSC, 2007 <www.rsc.org/images/Summary%20of%20the%20latest%20statistics_tcm18-102763.pdf>

16. Professor Dame Julia Higgins, *Good Practice for Success*, RSC Policy Bulletin 10, October 2008 <www.rsc.org/images/Bulletin10_tcm18-134605.pdf>
17. *Good Practice in University Departments*, Caroline Fox and Sean McWhinnie, RSC/Athena, December 2004 <www.rsc.org/ScienceAndTechnology/Policy/Documents/GoodPracticeinUCD.asp>
18. Research Assessment Exercise 2008 <www.rae.ac.uk/aboutus/>
19. HESA file 25750 23-Jan-08 <www.iop.org/activity/policy/Statistics/file_25750.doc>
20. *NEW INQUIRY STUDENTS AND UNIVERSITIES*, Innovation, Universities, Science and Skills Committee, No. 82 (07-08), October 2008 <www.parliament.uk/parliamentary_committees/ius/ius_301008.cfm>
21. *The age of the molecule*, Ed. Nina Hall, RSC 1999 (ISBN 0-85404-945-2)
22. *Subject benchmark Statement: Chemistry 2007*, QAA, 2007 <www.qaa.ac.uk/academicinfrastructure/benchmark/honours/chemistryfinal.pdf>
23. *Undergraduate Honours Programmes*, University of Bristol, School of Chemistry <www.chm.bris.ac.uk/Ugrad/undergd.htm>
24. The Quality Assurance Agency for Higher Education (QAA) <www.qaa.ac.uk/>
25. *Subject benchmark Statements Chemistry* 2000 <www.qaa.ac.uk/academicinfrastructure/benchmark/honours/chemistry.asp>
26. Terry Mitchell, *The "Budapest" Cycle Level Descriptors for Chemistry*, ECTN Association, 2005 <ectn-assoc.cpe.fr/archives/lib/2005/N03/200503_BudapestDescriptors.pdf>
27. *Chemical Science – highlights from the last 50 years*, RSC, 2002
28. *Chemistry 2000*, Eds. Cath O'Driscoll and Elizabeth Palmer, RSC, 1999
29. *Cutting edge chemistry*, Compiler: Ted Lister, RSC, 2000, (ISBN 0-85404-914-2)
30. *The World's Ten Best-Selling Drugs*, Matthew Herper and Peter Kang, Forbes, March 2006 <www.forbes.com/2006/03/21/pfizer-merck-amgen-cx_mh_pk_0321topdrugs.html>
31. *All Nobel Laureates in Chemistry*, Nobel Foundation, 2008 <nobelprize.org/nobel_prizes/chemistry/laureates/>
32. Cogent Sector Skills Council: The Sector Skills Council (SSC) for the Chemicals and Pharmaceuticals, Oil and Gas, Nuclear, Petroleum and Polymer Industries <www.cogent-ssc.com>
33. Chemical Industries Association <www.cia.org.uk; http://www.cia.org.uk/newsite/about_cia/about_cia.htm>
34. Paul Anastas and John Warner, *Green Chemistry: Theory and Practice,* Oxford University Press: New York, 1998; *Twelve Principles of Green Chemistry* <www.epa.gov/greenchemistry/pubs/principles.html>
35. *Meeting industry's need for chemistry graduates*, RSC Policy Bulletin issue No 4, October 2006 <www.rsc.org/images/Policy%20Bulletin%204%20final_tcm18-62864.pdf>
36. *Cogent Sector: Annual Business Inquiry Trend Data, 1997-2006, FACTS AND FIGURES REFERENCE*, Cogent Sector Skills Council, 2007 <www.cogent-ssc.com/research/Publications/publications/ABI_TRENDS.pdf>
37. Cogent Corporate Factsheet, Cogent Sector Skills Council, June 2008 <www.cogent-ssc.com/research/Publications/factsheets/Corporate_Factsheet.pdf>
38. Labour Force Survey January 2006-December 2006. Source of data (in part) for Cogent Factsheets
39. *Facts and Figures: UK Chemical Industry*, Chemical Industries Association, January 2006 <www.cia.org.uk/newsite/industry_glance/facts_leaflet_2006.pdf>
40. Cogent Chemicals Industry Factsheet, Cogent Sector Skills Council, June 2008 <www.cogent-ssc.com/research/Publications/factsheets/Chemicals_Factsheet_AW_Chemicals_Factsheet.pdf>

41. Cogent Pharmaceuticals Industry Factsheet, Cogent Sector Skills Council, June 2008 <www.cogent-ssc.com/research/Publications/factsheets/Pharmaceuticals_Factsheet.pdf>
42. Cogent Nuclear Industry Factsheet, Cogent Sector Skills Council, June 2008 <www.cogent-ssc.com/research/Publications/factsheets/Nuclear_Factsheet.pdf>
43. Cogent Oil and Gas Industry Factsheet, Cogent Sector Skills Council, June 2008 <www.cogent-ssc.com/research/Publications/factsheets/Oil_and_Gas_Factsheet.pdf>
44. Oil and Gas UK, 2009 <www.oilandgas.org.uk/index.cfm>
45. Cogent Petroleum Industry Factsheet, Cogent Sector Skills Council, June 2008 <www.cogent-ssc.com/research/Publications/factsheets/Petrol_Factsheet.pdf>
46. UK Petroleum Industry Association (UKPIA), 2008 <www.ukpia.com/industry_information.aspx>
47. Cogent Polymers Industry Factsheet, Cogent Sector Skills Council, June 2008 <www.cogent-ssc.com/research/Publications/factsheets/Polymers_Factsheet_.pdf>
48. British Plastics Federation, 2008 <www.bpf.co.uk>
49. *Degrees of decline? Core science and mathematics degree courses in the UK 1998-2007*, University and College Union, November 2006 <www.ucu.org.uk/media/pdf/7/h/degreesofdecline_nov06_1.pdf>
50. Heads of Chemistry UK (HCUK) <www.rsc.org/Education/HCUK/index.asp>
51. MChem – the first decade, RSC, 2003 <www.rsc.org/education/teachers/learnnet/mchem.htm>
52. *Types of Review*, Quality Assurance Agency for Higher Education, 2008 <www.qaa.ac.uk/reviews/default.asp>
53. *Report on Quality Assessment 1992-1995*, Ref. M 18/95, HEFCE, November 1995 <www.hefce.ac.uk/pubs/hefce/1997/m1_97.htm>
54. *Higher Education in the Learning Society*, Summary Report from the National Committee of Inquiry in Higher Education (the Dearing Report), 1997 <www.leeds.ac.uk/educol/ncihe/sumrep.htm>
55. *Computers in Teaching Initiative 1989-1999*, CTISS, University of Oxford, 1999 (ISBN 0 9531683 2 8)
56. Chemistry Video Consortium, School of Chemistry, University of Southampton, 2007 <www.soton.ac.uk/chemistry/services/services3_1.html>
57. The eLABorate Project, University of York <www.york.ac.uk/depts/chem/staff/elaborate/elab.html>
58. R B Moyes and T L Overton, *Project Improve: an FDTL project for chemistry*, Phys. Educ. 34(2), March 1999, 80-83
59. *Quality Assessment of Chemistry 1993-94*, QO 2/95 Subject Overview Report – Chemistry, QAA, 1995 <www.qaa.ac.uk/reviews/reports/subjectlevel/qo2_95_textonly.htm>
60. *The Bologna Declaration on the European space for higher education: an explanation* <ec.europa.eu/education/policies/educ/bologna/bologna.pdf>
61. *Review of Chemistry Programmes - In Denmark and in the United Kingdom*, The Danish Evaluation Institute, 2006
62. *The Bologna Process*, House of Commons Education and Skill Committee, 2007 <www.publications.parliament.uk/pa/cm200607/cmselect/cmeduski/205/205.pdf>
63. *Developing University Chemistry Provision*, RSC (A.D.Ashmore), 2005 <www.rsc.org/images/DevelopingUniChemProvision_tcm18-41925.pdf>
64. *The Bologna Process and UK's integrated Masters programmes*, Europe Note, E/05/12, Europe Unit, 2005 <www.europeunit.ac.uk/resources/E-05-12.doc>
65. Mastering Bologna, *Education in Chemistry*, 45 (4), 98-99, 2008 <www.rsc.org/Education/CFOF/DevelopingHECurr/MasteringBologna.asp>

66. European Chemistry Thematic Network (ECTN) <ectn-assoc.cpe.fr/network/index.htm>
67. EChem Test <ectn-assoc.cpe.fr/echemtest/>
68. ECTN Association (ECTNA) <ectn-assoc.cpe.fr/>
69. Eurobachelor® <ectn-assoc.cpe.fr/chemistry-eurolabels/cel/3_ceb01_Introduction.htm>
70. Euromaster® <ectn-assoc.cpe.fr/chemistry_eurolabels/cel/5_cem01_Introduction.htm>
71. European Association for Chemical and Molecular Sciences (EuCheMS) <www.euchems.org/>
72. EuCheMS Division of Chemical Education <www.euchems.org/Divisions/DivCEd/index.asp>
73. European Conference on Research in Chemical Education (ECRICE) <www.gate2biotech.com/th-ecrice-european-conference-on-research-in-chemical-education/>
74. European Variety in Chemistry Education <www.heacademy.ac.uk/physsci/events/detail/2009/eurovariety_2009>
75. EuCheMS Division of Chemical Education publications <www.euchems.org/Divisions/DivCEd/Publications.asp>
76. ProChemE <www.euchems.org/GovernanceStructure/ProChemE.asp>
77. European Chemist (EurChem) <www.rsc.org/Education/Qualifications/EurChem.asp>
78. Wendy Crocker, *Supporting and influencing education*, RSC Policy Bulletin, Issue No 9, June 2008 <www.rsc.org/images/Bulletin9_tcm18-127193.pdf>
79. *Chemistry: the Next Generation*, RSC, 2009 <www.rsc.org/Education/CFOF/CTNG/index.asp>
80. *Chemistry for our Future*, RSC, 2009 <www.rsc.org/Education/CFOF/index.asp>
81. Melanie Washington, *Chemistry for our Future*, RSC Policy Bulletin, Issue No 8, February 2008; Josephine Tunney, *ibid*, Issue No 4, Autumn 2006 <www.rsc.org/images/PolicyBulletin8web_tcm18-111585.pdf http://www.rsc.org/images/Policy%20Bulletin%204%20final_tcm18-62864.pdf>
82. *Education in Chemistry*, Ed Kathryn Roberts, RSC <www.rsc.org/education/eic/>
83. LearnNet <www.rsc.org/Education/Teachers/Resources/LearnNet.asp>
84. *Chemical Education Research and Practice* (CERP) Ed. Stephen Breuer <www.rsc.org/Publishing/Journals/RP/Index.asp>
85. Variety in Chemistry Education (2008) <www.heacademy.ac.uk/physsci/events/detail/vice_2008>; <www.heacademy.ac.uk/physsci/events/detail/2009/eurovariety_2009>
86. *Undergraduate skills record*, Ed. Kristy MacDonald, RSC, 2005 <www.rsc.org/Education/HEstudents/usr/index.asp>
87. David Barr, *Challenges for accreditation*, RSC Policy Bulletin, Issue No 7, October 2007 <www.rsc.org/images/PolicyBulletinIssue7_tcm18-105735.pdf>
88. Higher Education Academy Subject Centres <www.heacademy.ac.uk/ourwork/networks/subjectcentres>
89. *A degree of concern? UK first degrees in science, technology and mathematics*, The Royal Society, October 2006 <www.royalsoc.ac.uk/displaypagedoc.asp?id=23118>
90. *Performance in higher education estates. Estate Management Statistics Annual Report 2006*, Higher Education Funding Council for England (HEFCE), April 2007 <www.hefce.ac.uk/pubs/hefce/2007/07_08>
91. National Teaching Fellowship Scheme, HEA, 2008 <www.heacademy.ac.uk/ourwork/professional/ntfs>
92. Centres for Excellence in Teaching and Learning (CETLs), HEFCE, June 2007 <www.hefce.ac.uk/learning/tinits/cetl>
93. Bristol ChemLabS, School of Chemistry University of Bristol <www.chemlabs.bris.ac.uk/>
94. Centre for Effective Learning in Science (CELS), Nottingham Trent University <www.ntu.ac.uk/cels/>
95. The Joint Council for Qualifications (JCQ) <www.jcq.org.uk>
96. AS and A-level data from Joint Council for Qualifications <www.jcq.org.uk/national_results/alevels/>

97. GCSE data from Joint Council for Qualifications <www.jcq.org.uk/national_results/gcses/>
98. *Chemistry Higher, 2008*, BBC News, 2009 <news.bbc.co.uk/1/shared/bsp/hi/education/08/exam_results/higher/html/chemistry.stm>
99. *Educating the UK's future scientists*, Fred Campbell and Richard Van Noorden, Chemistry World, 5(10), 10-11, 2008
100. *Widening Participation in the Physical Sciences: An investigation into Factors Influencing the Uptake of Physics and Chemistry*, Paul Taylor, Centre for Education and Industry, University of Warwick, 2003 <www.heacademy.ac.uk/assets/ps/documents/projects/completed/widening_participation_in_chemistry.pdf>
101. Tariff tables, UCAS <www.ucas.com/students/ucas_tariff/tarifftables/>
102. *National Student Survey*, HEFCE, 2008 <hefce.ac.uk/learning/nss>
2007 Teaching Quality Information data, National Student Survey, HEFCE, 2007 <www.hefce.ac.uk/learning/nss/data/2007/>
Also: National Student Survey 2006, National Student Survey 2005
103. *Search, review and compare subjects at unis and colleges in the UK*, Unistats, 2008 <www.unistats.com/>
104. *Mathematics and Science in Secondary Schools. The Deployment of Teachers and Support Staff to Deliver the Curriculum*, Research Report RR708, Helen Moor, Megan Jones, Fiona Johnson, Kerry Martin and Elizabeth Cowell (NFER) and Chris Bojke (PharMerit), Department for Education and Skills. 2006 (ISBN 1 84478 656 0) <www.dfes.gov.uk/research/data/uploadfiles/RR708.pdf>
105. Colin Osborne, *Who teaches our children chemistry?* RSC Policy Bulletin, Issue No 3, Spring 2006 <www.rsc.org/images/Sience%20Policy%20Bulletin%203_tcm18-53129.pdf>
106. Alan Smithers and Pamela Robinson, *Chemistry Teachers*, RSC, March 2004, (ISBN 0-85404-379-9) <www.rsc.org/images/2004ChemistryTeachersSupply_tcm18-12551.pdf>
107. Jon Turney, *Influencing the Future: A-Level Chemistry*, National Science Learning Centre, York, October 2006
108. *Science Education NOW: A Renewed Pedagogy for the Future of Europe*, European Commission Directorate-General for Research, Science, Economy and Society, EUR 22845, 2007 <www.eirma.org/documents/EU/report-rocard-on-science-education.pdf>
109. Colin Osborne, *Surely that's banned*, RSC Policy Bulletin, Issue No 5, January 2007 <www.rsc.org/images/Policy%20Bulletin%20Issue%205_tcm18-76030.pdf; Conference report http://www.rsc.org/images/report%20final%20for%20print_tcm18-41416.pdf>
110. Consortium of Local Education Authorities for the Provision of Science Services (CLEAPSS) <www.cleapss.org.uk/>
111. Colin Osborne, *Labs, resources and budgets*, RSC Bulletin, Issue 2, January 2006 <www.rsc.org/images/Final%20Science%20Policy%20Bulletin%202_tcm18-46476.pdf>
112. *Laboratories, Resources and Budgets*, A report for the RSC on provision for Science in Secondary Schools, RSC/CLEAPSS, April 2004, ISBN 0-85404-384-5 <www.rsc.org/images/2004Laboratories_tcm18-12553.pdf>
113. Higher Education Statistics Agency (HESA), file 25748 23-Jan-08 <www.iop.org/activity/policy/Statistics/file_25748.doc>
114. UK University & Colleges Admissions Service (UCAS) <www.ucas.co.uk>
115. *Provisional final figures for 2008 entry*, Table 7, UCAS, 2008 <www.ucas.ac.uk/website/news/media_releases/2008/2008-10-15> (Also 2007, 2006)
116. Polly Curtis, *University entrants hit record high*, The Guardian, Thursday August 21 2008.
117. HESA Statistics on Qualifications obtained (from their Table 14) <www.hesa.ac.uk/index.php?option=com_datatables&Itemid=121&task=show_category&catdex=3>
118. HESA Data obtained privately, Copy of 28300_data

119. Paula Surridge, *The National Student Survey 2005: Summary Report*, November 2006 <www.hefce.ac.uk/pubs/rdreports/2006/rd22_06/rd22_06.pdf>
120. *National Student Survey Briefing note for students' unions*, October 2005
121. *Your starter for £1000*, Education Guardian Higher, 25 March, 2008
122. Juliet Chester and Bahram Bekhradnia, *Financial support in English universities: a national bursary scheme*, Higher Education Policy Institute, September 2008 <www.hepi.ac.uk/downloads/37NationalBursarysummary.pdf>
123. *Supporting Students with Disabilities in the Physical Sciences*, Conference Report, Nottingham Trent University, June 2004 <www.heacademy.ac.uk/assets/ps/documents/workshop_reports/workshop_reports/2004/jun_2004/supporting_students_with_disabilities_in_the_physical_sciences_jun_2004.pdf>
124. Bahram Bekhradnia, Carolyn Whitnall and Tom Sastry, *The academic experience of students in English universities*, Higher Education Policy Institute, October 2006 <www.hepi.ac.uk/downloads/27Academicexperienceofstudents.pdf>
125. Tom Sastry, and Bahram Bekhradnia, *The academic experience of students in English universities*, Higher Education Policy Institute, September 2007 <www.hepi.ac.uk/downloads/33TheacademicexperienceofstudentsinEnglishuniversities2007.pdf>
126. Philip Carpenter, Adrian Bullock and Jane Potter, *Textbooks in Teaching and Learning: The Views of Students and Their Teachers*, Brookes eJournal of Learning and Teaching, Volume 2, Issue 1, October 2006 <bejlt.brookes.ac.uk/article/textbooks_in_teaching_and_learning/>
127. Jonny Woodward, *The education revolution*, Chemistry World, 4 (1), 60-63
128. *Surveying the Communities Questionnaire Responses*, LTSN Physical Sciences Subject Centre, 2002
129. *Chemistry*, in *Learning and teaching innovation in UK higher education, Retrospective 1989-1999*, CTISS, 1999, (ISBN 0-9531683-2-8)
130. Geoff Mason, *Change and diversity: The challenges facing chemistry higher education*, RSC/CIHE, March 1998, (ISBN 0-85404-915-0) <www.rsc.org/education/teachers/learnnet/pdf/LearnNet/rsc/ChngDiv_select.pdf>
131. *The Economic Benefits of Higher Education Qualifications*, Pricewaterhouse Coopers LLP, January 2005 <www.rsc.org/images/EconomicBenefitsHigherEducationQualifications_tcm18-12647.pdf>
132. RSC *The economic benefits of a chemistry degree*, RSC Policy Bulletin Issue 2, January 2006 <www.rsc.org/ScienceAndTechnology/Policy/Bulletins/Issue2/ChemDegree.asp>
133. *Chemistry – 2006 graduates*, Prospects; the UK's official graduate careers website, 2008 <www.prospects.ac.uk/cms/ShowPage/Home_page/What_do_graduates_do__2008/charts_and_tables_pages/p!eaLjjjF?subject_id=7>
134. *Higher Education Data for the Chemicals Industry A Report Prepared for the CIA*, (Charts 4, 7), Cogent Sector Skills Council, October 2007 <www.cogent-ssc.com/research/Publications/publications/HE_Education_Data_Report_CIA_October_07.pdf>
135. Recognised and Accredited Courses, RSC, 2009 <www.rsc.org/Education/SchoolStudents/RecogniseAccredit.asp>
136. H W Kroto, J R Heath, S C O'Brien, R F Curl, and R E Smalley, C_{60}: *Buckminsterfullerene*, Nature 318, 162-163 (1985)
137. *The green fluorescent protein: discovery, expression and development*, The Royal Swedish Academy of Sciences, 2008 <nobelprize.org/nobel_prizes/chemistry/laureates/2008/chemadv08.pdf>
138. Sandy Leitch, *Prosperity for all in the Global Economy: World Class Skills* (The Leitch Report), December 2006 <www.hm-treasury.gov.uk/d/leitch_finalreport051206.pdf>
139. *Skills Needs Assessment*, Sector Skills Agreement Publications, Cogent Sector Skills Council, 2005 <www.cogent-ssc.com/research/SSA_publications_Index.php>

140. *Sustaining the skills pipeline*, ABPI, November 2005 <www.abpi.org.uk/publications/pdfs/2005-STEM-Ed-skills-TF-Report.pdf>
141. Association of the British Pharmaceutical Industry (ABPI) <www.abpi.org.uk/statistics/intro.asp>

21. Glossary of terms

1994 Group. Mainly members of the 1994 Group of smaller research-led British universities established to promote excellence in research and teaching. See Appendix 1.
Accredited course. A 4-year (minimum) integrated masters (MChem or MSci) degree of a high standard in terms of intellectual challenge and content that meets specific criteria after review of the formally submitted course details to the Royal Society of Chemistry. Accredited courses satisfy the academic requirements in subject knowledge, abilities and skills for the award of Chartered Chemist (CChem).
Alliance Group. Mainly members of the University Alliance, previously the Alliance of Non-Aligned Universities, formed 2006, a mixture of pre and post 1992 universities, with a balanced portfolio of research, teaching, enterprise and innovation, representing the middle sector. See Appendix 1.
Assessment. May be summative (carries marks which count towards an outcome), formative (does not carry marks but is designed to help students assess their progress) or diagnostic (does not carry marks but is designed to determine whether or not a student already has the required knowledge).
Benchmark. A set of statements through which the academic community can describe the nature and characteristics of programmes in a specific subject or subject area. They also represent general expectations about standards for the award of qualifications at a given level in terms of the attributes and capabilities that those possessing qualifications should have demonstrated.
Bologna process. Started in 1999 with the aim of achieving greater convergence and mobility of students between European countries. Includes a framework of three cycles: first cycle: typically 180–240 ECTS credits, usually awarding a Bachelors degree. Second cycle: typically 90–120 ECTS credits (a minimum of 60 on second-cycle level), usually awarding a Masters degree. Third cycle: Doctoral degree.
BSc. Bachelor of Science. The traditional chemistry degree usually requiring 3 years of study (4 years in Scotland).
CELS. Centre for Effective Learning in Science. The CETL at Nottingham Trent University.
CERP. Chemical Education Research and Practice. The RSC electronic journal for chemistry teachers and researchers in higher education.
CETL. Centre for Excellence in Teaching and Learning. An initiative funded in England by the Higher Education Funding Council for England to provide, within an institution, a focus for development of a particular aspect of teaching and learning.
CChem. Chartered Chemist. An award for which chemistry graduates who have obtained an RSC accredited degree and are RSC members are eligible once they have gained several years of chemistry related work experience. As in other professions, achieving chartered status indicates to the wider community a high level of subject specific knowledge and professional competence.
ChemLabS. Chemical Laboratory Sciences. The CETL at the University of Bristol.

CIA. Chemical Industries Association. The CIA is the UK's leading trade association for the chemical and chemistry-using industries, representing members both nationally and internationally.
CLEAPSS. Consortium of Local Education Authorities for the Provision of Science Services. An advisory service providing support in science and technology for a consortium of local authorities and their schools.
COGENT. Sector Skills Council (SSC) for Chemicals, Nuclear, Oil and Gas, Petroleum and Polymer Processing Industries.
Contact hours (Student). Direct face-to-face or online contact time between teaching staff and students, usually formally timetabled, as represented by hours of lectures, practicals, tutorials, seminars etc. Contact hours (teaching) for a student may include some time spent in activities partially supported by non-academic (technical and other support) staff, or activities involving more than one teacher. Contact time should be seen in the context of the total expected study time (notional learning time) for a student usually being about 40 hours per week during a semester.
Contact hours (Staff) The time during which a member of staff is directly teaching students or facilitating student work, either face-to- face or online, and does not normally include preparation or assessment time.
CTI. Computers in Teaching Initiative. An early attempt to coordinate the development and introduction of computer-based teaching materials into higher education.
CTISS. Computers in Teaching Initiative Support Service. Established in 1989 to support the CTI Centres, and to promote C&IT and the use of learning technologies to the wider academic community.
CVC. Chemistry Video Consortium. A group of chemistry staff who produced a set of digital videos of practical procedures in the 1990s.
DoT. Director of Teaching. (Also Director of Studies, Director of Undergraduate Studies). The member of staff in the department responsible for the course curriculum, the undergraduate teaching programme, and often for overseeing curriculum development.
DTI. Department of Trade and Industry.
ECRICE. European Conference on Research in Chemical Education. A biennial conference since 1992 organised by the Division of Chemical Education of EuCheMS.
ECTN (ECTNA). European Chemistry Thematic Network, and European Chemistry Thematic Network Association. See Section 5.4.4.
ECTS. European Credit Transfer and Accumulation System. A standard, awarding credit points for successfully completed studies, that allows comparison of study attainment and performance of students in higher education across the European Union and other collaborating European countries. One academic year corresponds to 60 ECTS-credit points, equivalent to 1500-1800 hours of study
eLABorate. A TLTP project run by chemistry staff at the University of York, which produced computerised simulations of laboratory experiments.
EuCheMS. European Association of Chemical and Molecular Sciences (formerly FECS; Federation of European Chemical Societies). See Section 5.4.4
Eurobachelor; Euromaster. The Eurobach-elor® is a flexible and open framework for a first cycle qualification in chemistry developed by ECTN to promote international recognition of the degree qualification and to document the willingness of the institution to participate fully in the European Higher Education Area. The Euromaster® is a similar framework for a second cycle qualification in chemistry.
Eur.Chem. European Chemist. A designation administered through ProChemE, indicating a high level of professional competence in the practice of chemistry, to assist chemists who are moving employment in different member states of the EC.
FDTL. Fund for the Development of Teaching and Learning.
FE. Further education. Post- compulsory education, including any level of education from basic training up to but not including Higher National and Foundation Degree.
Fine chemical. A chemical substance that is manufactured in limited quantities to a high specification, particularly by the pharmaceutical and agrochemical industries, for use directly or in research; e.g. diazepam (Valium).

Green chemistry. An approach to chemical manufacture that incorporates some of the twelve principles of green chemistry: Prevent waste, design safer chemicals and products, design less hazardous chemical syntheses, use renewable feedstocks, use catalysts not stoichiometric reagents, avoid chemical derivatives, maximise atom economy, use safer solvents and reaction conditions, increase energy efficiency, design chemicals and products to degrade after use, analyse in real time to prevent pollution, minimise the potential for accidents.

GVA. Gross Value Added. GVA represents the amount that individual businesses, industries or sectors contribute to the economy. The difference between the value of goods and services produced and the cost of raw materials and other inputs that are used up in production. GVA consists of labour costs (e.g. wages and salaries) and an operating surplus (or loss). Productivity can be defined as GVA per employee.

HCUK. Heads of Chemistry UK. The collective body of heads of university chemistry departments in the UK – an independent body that represents the interest of UK Higher Education Institutions engaged in chemical education and research. Formerly Higher Education Chemistry Council (HECC).

Heavy chemical. A chemical substance that is produced in bulk, usually for use by other industries; e.g. sulfuric acid.

HEA. Higher Education Academy. Formed in October 2004 to work with the higher education community to enhance all aspects of the student experience.

HEA Physical Science Centre. The Centre overseeing educational development at university level in chemistry, physics, astronomy and forensic science.

HECC. Higher Education Chemistry Conference (now Heads of Chemistry UK – HCUK).

HEFCE. Higher Education Funding Council for England. A public body of the Department for Innovation, Universities and Skills which promotes and funds teaching and research in Universities and Colleges of Higher/Further Education in England.

HEI. Higher Education Institution. An institution such as a university, community or technical college that awards academic degrees.

HEPI. Higher Education Policy Institute. Established in November 2002, with the aim of ensuring that higher education policy development in the UK is informed by research and by the experience of others.

HESA. Higher Education Statistics Agency. HESA is the central source for the collection and publication of higher education statistics in the UK.

Industrial placement. A (usually) credit-bearing part of a degree programme spent in industry, or a research establishment. It most frequently lasts a year (although periods from a few weeks upwards are known), and is usually supervised by an academic and an industrial supervisor. A placement student is usually paid by the employer. Sometimes called a sandwich placement.

Lectures. Timetabled teaching often of large numbers of students and usually lasting for about 50 minutes. The activities which take place in a 'lecture' often involve much more than listening by students, and increasingly involve interaction between the lecturer and the students and/or between the students.

LTSN. Learning and Teaching Support Network. A forerunner of the HEA Subject Centres network.

MChem/MSci. Undergraduate integrated Master of Science degrees. The MSci is an undergraduate academic degree qualification awarded after typically four years studying a science discipline at an HEI (5 years in Scotland); MChem is a degree of equal academic standing specifically awarded to students of the chemical sciences.

Notional learning time. This is the estimated learning time taken by the 'average' student to achieve the specified learning outcomes of a module or programme at a university. The most widely used notional learning time per credit in the UK is ten hours. For credit-based HEIs the total notional learning time is therefore 1200 hours for a 120 credit full time undergraduate year and 1800 hours for a 180 credit full time postgraduate year.

NSS. National Student Survey. The analysis of an annual questionnaire sent to final year students in all HEIs since 2005, to gather information about student satisfaction with many aspects of teaching on their courses.

PBL. Problem-based (or project-based) learning. Student-centred instruction in which students collaboratively solve problems (or work on projects), often including reflection of the experience. Students are usually encouraged to take responsibility for group-work and organise and direct the learning process with support from a facilitator or tutor.
Postgraduate students. Students enrolled on programmes leading to higher degrees, diplomas and certificates, and professional qualifications, including part-time and full-time students. Includes taught and research degree students.
Practical work. Can be 'wet' (for example, laboratory work) or 'dry' (for example, computer simulations and/or paper-based data interpretation exercises). Usually associated with a formal schedule which students must follow in early years of a course, but may use a more open-ended investigative approach later
ProChemE. The EuCheMS standing committee on educational, professional and ethical issues;
Project. A final year project is a substantial piece of work, in which students work on a research question, usually in a laboratory context (although this may be a computer laboratory), often while attached to a research team. Usually carries a substantial number of credits and involves the writing of a dissertation. Other shorter projects may be taken at other times during the course, possibly also in a library context.
Project *Improve*. An FDTL-funded chemistry consortium of more than 30 departments, running from October 1996 to September 1999, which set out to disseminate good teaching practice. A pioneer activity in university chemistry education.
QAA. Quality Assurance Agency for Higher Education. An independent body funded by UK Higher Education stakeholders, whose remit is to ensure the quality of education delivered in UK Universities and other institutions of Higher Education.
RAE. Research Assessment Exercise. The RAE is an exercise that has been undertaken approximately every five years since 1992 on behalf of the four UK higher education funding councils to evaluate the quality of research undertaken by British HEIs.
Recognised course. A 3-year (minimum) BSc honours degree that contains more than 50% chemical science and so satisfies the requirements for Associate Membership of the Royal Society of Chemistry. Recognition covers chemical science in the widest sense, extending for example, to forensic science, biochemistry, and pharmacy courses.
RSC. Royal Society of Chemistry. The RSC is the largest organisation in Europe for advancing the chemical sciences, with a worldwide network of members and an international publishing business. Its activities span education, conferences, science policy and the promotion of chemistry to the public.
Russell Group. An association of 20 research-intensive universities of the United Kingdom, formed in 1994. See Appendix 1.
SEMTA. Science, Engineering and Manufacturing Technologies Alliance. An industry owned and led SSC, SEMTA aims to increase the impact of skilled people throughout the aerospace, automotive, bioscience, electrical, electronics, engineered metal products, maintenance, marine, mathematics, mechanical and metals sectors.
SIVS. Strategically Important and Vulnerable Subjects, as defined by HEFCE.
SMEs. Small/medium-sized enterprises. Usually considered as organisations employing fewer than 50 (small) or fewer than 250 (medium) people though different countries use different numbers. An SME can also be defined by its turnover.
SSC. Sector Skills Council. SSCs are state-sponsored, employer-led organisations that cover specific economic sectors in the UK. They have four key goals: to reduce skills gaps and shortages; to improve productivity; to boost the skills of their sector workforces and to improve learning supply. There are currently 25 SSCs covering about 85% of the British workforce. They are licensed by the Government to provide employers in their sector with the opportunity for coherent leadership and strategic action to meet their skills needs.
Tariff. This term derives from the terminology used by UCAS. The UCAS Tariff was introduced in 2002–03 and establishes agreed equivalences between different types of qualifications (for example, A-levels,

Baccalaureates, Scottish Higher or other qualifications) and measures achievement for entry to higher education in a numerical format. This allows comparisons between students with different types and volumes of achievement. However, the tariff system does not include all qualifications.

Tariff points. This term is taken from UCAS terminology. For example:
A level tariff: Grade A=120; B=100; C=80; D=60; E=40
Advanced Scottish Highers tariff: Grade A=120; B=100; C=80; D=72
Scottish Highers tariff: Grade A=72; B=60; C=48; D=42

TLTP. Teaching and Learning Technology Programme. An early attempt to encourage the introduction of technology into teaching at university level.

TQA. Teaching Quality Assessment. A review of teaching carried out by QAA in chemistry (and other) departments in 1993/4.

Turnover. Total sales and work done. The sum of value of sales of goods produced, goods purchased and resold without further processing, work done, and industrial and non-industrial services rendered.

Tutorials. The format and academic content of a tutorial is variable, but usually involves the teaching of a small group of students by an academic. They are less formally structured than a lecture and may involve academic discussions, professional and personal development activities, pastoral support or skills development. Some larger workshops or problem-solving classes are sometimes also considered as tutorials.

UCAS. Universities and Colleges Admissions Service. UCAS is an institution that collects and distributes information for applications to almost all full-time undergraduate degree programmes at British universities and colleges. It provides a central service through which prospective students apply for undergraduate study.

Undergraduate (UG) students. All full-time and part-time students registered on specified first degree programmes as reported by the universities, such as a bachelor's degree (BSc) or an undergraduate integrated Master's degree (MSci, MChem).

UK education systems. The education systems in the four countries comprising the UK are diverging and features of one are not necessarily seen in others. The arrangements for tuition fees and student funding differ in the institutions of each of the UK countries. For example, National Teaching Fellowships and CETLs operate in England only, and prior to university, Scottish school pupils study Highers and Advanced Highers rather than A levels.

VLE. Virtual Learning Environment. A university-provided electronic means of supporting student learning and communicating with students.

Appendix I: Grouping of University Chemistry Departments

(showing RSC Accreditation/Recognition of Courses; and Departments offering courses that specify a year on industry placement, or abroad.) (135)

Mostly University Alliance, with others offering BSc:

Aston	– RSC Recognised (2M – 2 integrated Masters 'MChem/MSci' courses; 7B – 7 Bachelors 'BSc' courses)
Glamorgan, Pontypridd	– RSC Recognised (5B)
Huddersfield	– RSC Accredited (1M) and Recognised (11B 3M)
Keele	– RSC Recognised (4)
Kingston	– RSC Recognised (5M 9B) - Year in industry
Liverpool John Moores	– RSC Recognised (10B)
London Metropolitan	– RSC Recognised (9B)
Manchester Metropolitan	– RSC Accredited (2M) and Recognised (9B) - Year abroad, Year in industry
Northumbria	– RSC Accredited (2M - Applied) and Recognised (5B) - Year in industry
Nottingham Trent	– RSC Accredited (2M) and Recognised (7B) - Year in industry
Plymouth	– RSC Recognised (2B – Analytical, Applied)
Robert Gordon	– RSC Recognised (1B – Forensic with chemistry option)
Sunderland	– RSC Recognised (1B)
Surrey	– RSC Recognised (1M 2B) - Year in industry
Sussex	– RSC Recognised (2B) - Year abroad, Year in industry
Teesside	– RSC Recognised (1B - applied)
West of Scotland (Paisley)	– RSC Recognised (6B)

Mostly 1994 Group, with others offering MChem/MSci:

Aberdeen	– RSC Accredited (6M) and Recognised (8B)
Bangor	– RSC Accredited (1M) and Recognised (11B) - Year abroad, Year in industry
Bath	– RSC Accredited (6M) and Recognised (13B) - Year abroad, Year in industry
Durham	– RSC Accredited (4M) and Recognised (1M 2B) - Year abroad, Year in industry
East Anglia	– RSC Accredited (6M) and Recognised (8B) - Year abroad, Year in industry
Heriot-Watt	– RSC Accredited (15M) and Recognised (11B) - Year abroad, Year in industry
Hull	– RSC Accredited (10M) and Recognised (6B) - Year in industry
Leicester	– RSC Accredited (9M) and Recognised (9B) - Year abroad, Year in industry
Loughborough	– RSC Accredited (4M) and Recognised (6B)
Queen Mary, London	– No 'Chemistry' only Pharm Chem & Biochem – Recognised (6B)
Reading	– RSC Accredited (4M) and Recognised (5B) - Year abroad, Year in industry
St Andrews	– RSC Accredited (5M) and Recognised (17M 2B) - Year abroad, Year in industry
Strathclyde	– RSC Accredited (4M) and Recognised (7B)
York	– RSC Accredited (12M) and Recognised (4B) - Year abroad, Year in industry

Russell

Birmingham	– RSC Accredited (1M) and Recognised (16MB) - Year abroad
Bristol	– RSC Accredited (4M) and Recognised (7B) - Year abroad, Year in industry
Cambridge	– RSC Accredited (1M – Nat Sci Chemistry)
Cardiff	– RSC Accredited (3M) and Recognised (5B) - Year abroad, Year in industry
Edinburgh	– RSC Accredited (12M) and Recognised (6B) - Year abroad, Year in industry
Glasgow	– RSC Accredited (4M) and Recognised (11BM) - Year abroad, Year in industry
Imperial	– RSC Accredited (7M) and Recognised (5B) - Year abroad, Year in industry
Leeds	– RSC Accredited (8M) and Recognised (14B) - Year abroad, Year in industry
Liverpool	– RSC Accredited (5M) - Year in industry
Manchester	– RSC Accredited (9M) and Recognised (1M 7B) - Year abroad, Year in industry
Newcastle	– RSC Accredited (6M) and Recognised (8B)- Year abroad, Year in industry
Nottingham	– RSC Accredited (7M) and Recognised (4B) - Year abroad, Year in industry
Oxford	– RSC Accredited (1M)
Queen's University, Belfast	– RSC Accredited (1M) and Recognised (9B) - Year abroad, Year in industry
Sheffield	– RSC Accredited (7M) and Recognised (6M 8B) - Year abroad, Year in industry
Southampton	– RSC Accredited (4M) and Recognised (3B)
University College London	– RSC Accredited (3M) and Recognised (4B)
Warwick	– RSC Accredited (9M) and Recognised (7B) - Year abroad, Year in industry

Appendix 2: Names of Departments in Universities teaching Chemistry

Department of …
Biological and Biomedical Sciences
Glasgow Caledonian
Chemical and Forensic Sciences
Bradford
Chemical Engineering and Applied Chemistry
Aston
Chemical Process Engineering
Sheffield
Chemistry
Aberdeen, Bath, Birmingham, Cambridge, Durham, Glasgow, Heriot Watt, Hull, Imperial, Oxford, Leicester, Liverpool, Loughborough, Reading, Sheffield, Southampton, Surrey, University College London, Warwick, York
Chemistry and Analytical Sciences
Open
Chemistry and Biochemistry
Sussex
Health and Human Sciences
London Metropolitan
Pure and Applied Chemistry
Northumbria, Strathclyde

Faculty of …
Health, Sport and Science
Glamorgan

School of …
Applied Sciences
Huddersfield
Biological and Chemical Sciences
Queen Mary College, London
Biology, Chemistry and Health Sciences
Manchester Metropolitan
Biomedical Science
Nottingham Trent
Chemical and Pharmaceutical Sciences
Dublin Institute of Technology
Chemical Sciences and Pharmacy
East Anglia
Chemistry
Bangor, Birmingham, Bristol, Cardiff, Edinburgh, Leeds, Manchester, Newcastle, Nottingham, St Andrews, Southampton,
Chemistry and Chemical Engineering
Queens University Belfast
Earth, Ocean and Environmental Sciences
Plymouth
Engineering and Science
West of Scotland
Health, Natural and Social Sciences, Chemistry and Biomedical Sciences
Sunderland
Pharmacy and Chemistry
Kingston, Liverpool John Moores
Physical and Geographical Sciences
Keele
Physical Sciences
Kent
Science and Technology
Nottingham Trent, Teesside

Appendix 3: Names of Degree Courses followed by students responding to the questionnaire

Analytical Chemistry and Toxicology 1
Applied Chemistry and Chemical Engineering . 2
Biochemistry 7
Biological and Medicinal Chemistry 3
Biomedical and Molecular Science 1
Chemical Physics 2
Chemistry 192
Chemistry with a Year Abroad/in Europe 8
Chemistry with a Year in Industry/Industrial Experience/Option 21
Chemistry and Law 1
Chemistry Management and Industry/with Industrial Management 3
Chemistry with a European Language 1
Chemistry with Analytical Chemistry 1
Chemistry with Analytical Chemistry and Toxicology 8
Chemistry with Analytical Science 1
Chemistry with Archaeology 1
Chemistry with Biomolecular and Medicinal Chemistry 2
Chemistry with Business 1
Chemistry with Computing 1
Chemistry with Drug Discovery 3
Chemistry with Forensic Science/Analysis 11
Chemistry with Forensic Science and Toxicology 8
Chemistry with Materials 1
Chemistry with Medicinal Chemistry 3
Chemistry with Molecular Medicine 5
Chemistry with Nanotechnology 1
Chemistry with Pharmaceutical Chemistry/ Science 2
Chemistry with Pharmacology 2
Chemistry with Professional Education 1
Chemistry with Teaching 1
Chemistry with Toxicology and Industrial Option 1
Chemistry: Resources and the Environment 1
Forensic and Analytical Chemistry 5
Forensic Chemistry/Science 3
Marine Chemistry 2
Medicinal and Pharmaceutical Chemistry 2
Medicinal Chemistry 7
Molecular Science 1
Pharmaceutical Science 7
Other 3
Total Students 327

Appendix 3a: Other popular courses offered by departments

Analytical Chemistry
Applied Chemistry
Chemistry with Biochemistry
Chemistry with Biology
Chemistry with Biomedical Chemistry
Chemistry with Bioscience
Chemistry with Biotechnology
Chemistry with Chemical Biology
Chemistry with Computer-aided Chemistry
Chemistry with Fine Chemicals Processing
Chemistry with French
Chemistry with Geology
Chemistry with Human Nutrition
Chemistry with Information Technology
Chemistry with Life Science
Chemistry with Management
Chemistry with Mathematics
Chemistry with Modern Languages
Chemistry with Molecular Physics
Chemistry with Offshore Industry
Chemistry with Physics
Chemistry with Sports Science
Environmental Chemistry
Environmental Science
Natural Sciences
Pharmaceutical and Chemical Science

Appendix 4: List of National Student Survey Questionnaire Statements

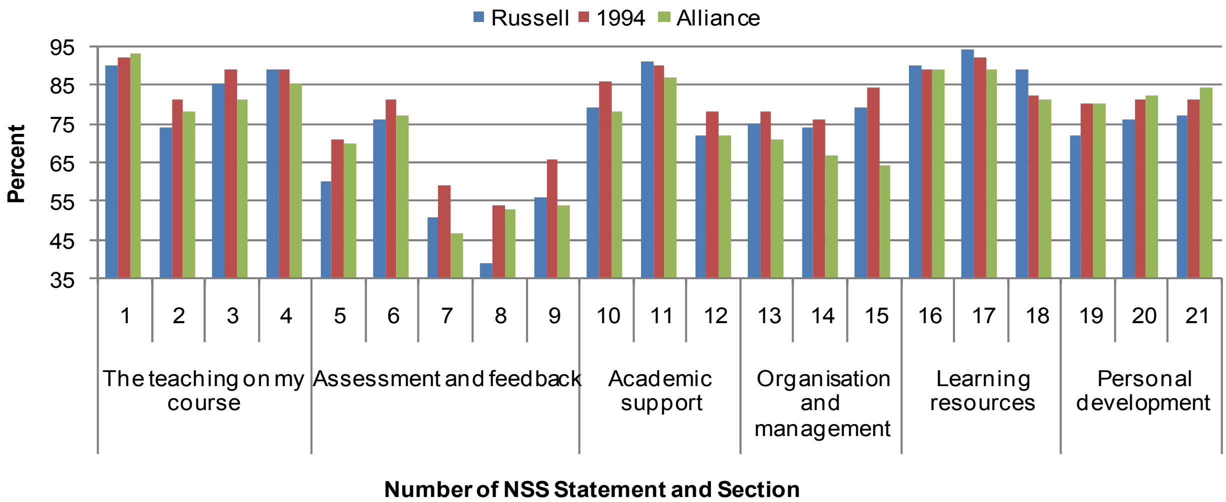

Figure 69 The combined 'Strongly agree' and Agree' responses by chemistry students in each departmental Group to the NSS questions in 2007.

The teaching on my course
1. Staff are good at explaining things.
2. Staff have made the subject interesting.
3. Staff are enthusiastic about what they are teaching.
4. The course is intellectually stimulating .

Assessment and feedback
5. The criteria used in marking have been clear in advance.
6. Assessment arrangements and marking have been fair.
7. Feedback on my work has been prompt.
8. I have received detailed comments on my work.
9. Feedback on my work has helped me clarify things I did not understand .

Academic support
10. I have received sufficient advice and support with my studies.
11. I have been able to contact staff when I needed to.
12. Good advice was available when I needed to make study choices .

Organisation and management
13. The timetable works efficiently as far as my activities are concerned.
14. Any changes in the course or teaching have been communicated effectively.
15. The course is well organised and is running smoothly.

Learning resources
16. The library resources and services are good enough for my needs.
17. I have been able to access general IT resources when I needed to.
18. I have been able to access specialised equipment, facilities, or rooms when I needed to.

Personal development
19. The course has helped me to present myself with confidence.
20. My communication skills have improved.
21. As a result of the course, I feel confident in tackling unfamiliar problems.
22. Overall, I am satisfied with the quality of the course.

Appendix 5: Choices of Subjects other than Chemistry and Mathematics

Subject	***No of students***
Arts foundation course	1
Physical Sciences	
Astronomy	2
Physics	11
Biosciences	
Anatomy	2
Biochemistry	22
Biological Chemistry	1
Biomedical Engineering	1
Cell biology	5
Genetics	1
Health	1
Immunology	2
Microbiology	8
Molecular Biology	3
Pathology	2
Pharmacology	13
Physiology	10
Business Studies	
Business	3
Economics	1
Finance	1
Management	2
Marketing	1
Social and Business Psychology	1
Statistics	2
Tax	1
Chemical Engineering	3
Colouration	1
Computing	1
Earth & Environmental Sciences	
Coastal processes	2
Earth History and Evolution	1
Environment	1
Environmental Geoscience	2
Geography - Physical processes	1
Geology	10
Oceanography	2
Sedimentary dynamics	2
Education	1
Forensic Sciences	6
Criminology	3
History, Philosophy and allied subjects	
Archaeology	1
Chemistry in context	1
History	3
History and Philosophy of Chemistry	1
Music and Western Civilisation	1
Philosophy	1
Philosophy of mathematics	1
Science in context	1
Materials	2
Modern Languages	
French	9
German	6
Italian	3
Spanish	4
Presentation skills	2
Scientific Programming	1
Tourism	1

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