Skills

*Skills required by new*

# CHEMISTRY

*graduates and their development in degree programmes*

development

The Higher Education Academy
UK Physical Sciences Centre

# Skills required by new chemistry graduates and their development in degree programmes

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in collaboration with and the financial support of the

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# 1. Aim of Study

This report is the outcome of a survey of recent graduates of chemistry programmes across the UK. The aim of the survey was to identify which areas of the chemistry curriculum including generic skills are particularly useful for new graduates and to evaluate how well they are developed within undergraduate chemistry degrees.

# 2. Scope of Survey

The survey focused on the 2007 graduate cohort, ie about two and half years after graduation. Such graduates have had sufficient time to gain some understanding of the skills requirements of their employment (or further study), whilst retaining a reasonably up-to-date knowledge of their chemistry degree programmes. Another factor influencing the choice of this cohort was that the longer the time after graduation, the more difficult it becomes to contact graduates. The sample covered BSc and MChem/MSci graduates, including those who had completed a year of industrial or international experience as part of their programme. It included 'Chemistry with' degree graduates (but not joint 'Chemistry and' degree graduates) and both UK and international students. Nine universities in England, Scotland and Wales were surveyed, including both pre-1992 (Russell Group and non-Russell Group) and post-1992 institutions. The survey was undertaken between November 2009 and June 2010.

Parallel surveys of physics and forensic science graduates were carried out, the other disciplines supported by the HEA UK Physical Sciences Centre. The results of these surveys are reported separately (HEA UK Physical Sciences Centre, 2010a, 2010b), although reference to some of the results is made in this report.

This report is concerned with the combined results for all the universities surveyed, rather than university-specific results and inter-university comparisons, although these will be made available to the individual universities concerned.

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# 3. Background

Although several reports have discussed the graduate skills required by employers, eg QAA (2003) and CIHE (2008), relatively little has been reported on the knowledge and skills which graduates have found of value when they enter into employment or further study. The UUK/CBI report entitled *Future fit: Preparing graduates for the world of work* (2009) recommended that universities should obtain regular feedback from former students/alumni on how well the universities are fostering employability skills in their students.

One very limited internal survey carried out 15 years ago in a major pharmaceutical company asked chemistry graduates which areas of training not received from university would, with hindsight, have been useful in preparing them for work. The results, in order, were: presentation skills, teamwork, IT/access to PCs, time management, interpersonal skills, experimental write-up and industrial experience/contact.

The lack of evidence of the skills needed by graduates is a major gap in this important pedagogic area. For example, their views should be very pertinent to development of subject benchmark statements. Graduates are also in a unique position to comment on whether these skills are being developed within degree programmes. Their views, including results and comments that are university-specific, can feed directly into curriculum development.

In order to gather some of this evidence, a pilot survey of chemistry graduates was carried out in 2008 by the HEA UK Physical Sciences Centre on behalf of the Royal Society of Chemistry Education Division. This unpublished study of 2006 graduates from three universities allowed the development of an effective survey methodology. Results indicated that some generic skills were considered very useful by graduates, but were relatively poorly developed within degree programmes. Results from this pilot survey will be referred to in this report.

*... relatively little has been reported on the knowledge and skills which graduates have found of value when they enter into employment or further study*

# 4. Methodology

## 4.1 Survey

The survey questionnaire aimed to determine which areas of knowledge and skills developed in the degree programmes had been of most use since graduation and how well they had been developed within the degree programmes.

The areas chosen, given in Table 1, were based on the *QAA Subject benchmark statement Chemistry* (2007), the *RSC Accreditation of Degree Programmes* (2009), and the *CIHE Student Employability Profiles* (2006).

**Table 1 : Areas of knowledge and skills included in the survey questionnaire**

| | | |
|---|---|---|
| A | Chemical terminology | Chemical knowledge/ skills |
| B | Fundamental chemical principles | |
| C | Principles of thermodynamics | |
| D | Kinetics of chemical change | |
| E | Inorganic compounds and reactions | |
| F | Organic compounds and reactions | |
| G | Analytical techniques | |
| H | Safe handling of chemical materials | |
| I | Manipulative practical skills | |
| J | Skills with chemical instrumentation | |
| K | Planning and design of experiments | Generic skills |
| L | Interpretation of experimental data | |
| M | Numeracy and computational skills | |
| N | Report writing skills | |
| O | Oral presentation skills | |
| P | Information retrieval skills | |
| Q | Problem-solving skills | |
| R | Team-working skills | |
| S | Time management and organisational skills | |
| T | Independent learning ability required for continuing professional development | |

In this report, the first ten listed, A to J, are referred to as the 'chemical knowledge/skills' and the final ten, K to T, as the 'generic skills', although it is appreciated that the experimental skills, K and L, can be considered as an intermediate group.

An additional question asked the graduates to choose which five areas of knowledge/skills out of the 20 listed above, they wished, in retrospect, they had been given the opportunity to develop more fully within their undergraduate degrees.

Other questions gathered evidence on the graduates' careers since graduation and their general views (in open form answers) on how their degree programmes might be modified and developed.

## 4.2 Contacting the graduates and response rates

Graduates are contacted each year by all UK universities about six months after graduation in order to collect the Destinations of Leavers in Higher Education (DLHE) data for the Higher Education Statistics Agency (HESA). Normally these data are collected and held by the university Careers Services. Hence all universities have databases of graduates containing contact information, with some or all of postal addresses, telephone numbers and e-mail addresses. Some universities update this information, often via their Alumni Offices. Collection of the DLHE data is by postal survey, followed by telephone surveying, the latter being the main source of data. E-mailing is used to a small extent.

In 2006, HESA sponsored a longitudinal survey of the 2003 graduate cohort (HESA, 2007). The survey covered 20% of graduates from all subject areas at all UK universities who had responded to the initial DLHE survey. The survey involved e-mailing twice (inviting graduates to use an online survey form), followed by two postal surveys, followed by up to seven attempts to contact by telephone. Overall a 40% response rate was achieved.

Our approach was similar to this HESA survey. An initial postal survey (with a covering letter signed by a member of staff of the university Chemistry Department or at one university a member of the Careers Service ), was followed by two e-mails and then several attempts at telephone contact. However, constraints of data protection legislation resulted in only four out of the nine collaborating universities being able to provide telephone contact information, which severely reduced the overall response rate. Graduates could, if they wished, fill in the survey form online in response to postal, e-mail or telephone contact. As an incentive, the names of all graduates completing the survey were included in a prize draw for each university.

For the four universities where telephone surveying was possible, the response rate was 54%, whereas for the five universities where only postal and e-mail contact was possible, the response rate was 16%. Completed survey forms were obtained from a total of 196 graduates, an overall response rate of 36%.

The graduates were clearly informed that although their names were requested in the survey form, this was only to track who had completed the survey, and any information shared by the HE Academy UK Physical Sciences Centre, including with their university, would be completely anonymous. Graduate contact information was collected from the collaborating universities on the basis that the universities would not be identified in any external reports and that the results collected for their graduates would be made available to them, but without graduates' names.

# 5. Results

## 5.1 Activities since graduating

Figure 1 gives the main activities of the chemistry graduates at the time of the survey, with physics and forensic science data included for comparison. The main differences are in the percentages undertaking study as their main activity, illustrating the high uptake of PhD study in chemistry and physics. Of those chemistry graduates engaged in study, either as their main activity or otherwise, 40 were undertaking PhDs (20% of the total number of graduates), 8 Masters degrees, 7 postgraduate certificates in education, 4 medical or dentistry degrees, 4 financial courses and 1 a law degree. Of the 133 graduates in employment as their main activity (68%), 15 were secondary science teachers and 6 were in financial occupations.

Figure 2 gives the results for the question: ***To what extent have your activities since graduating involved a knowledge of chemistry***? The figure also includes the results from the respective question in the physics and forensic science surveys and, separately, for the 133 chemistry graduates who indicated employment as their current main activity.

Comparing the three subjects, it is clear that the chemistry graduates had a far higher subject involvement in their activities than the physics or forensic science graduates. This is partly distorted by the number of the chemistry graduates undertaking PhDs; if only the graduates in employment are considered, then the subject involvement drops with just over 50% selecting 'Large extent/Very large extent'. Only 20% of graduates in employment indicated no involvement of chemistry in their activities since graduation, and only 16% of all graduates.

*... the chemistry graduates had a far higher subject involvement in their activities than the physics or forensic science graduates*

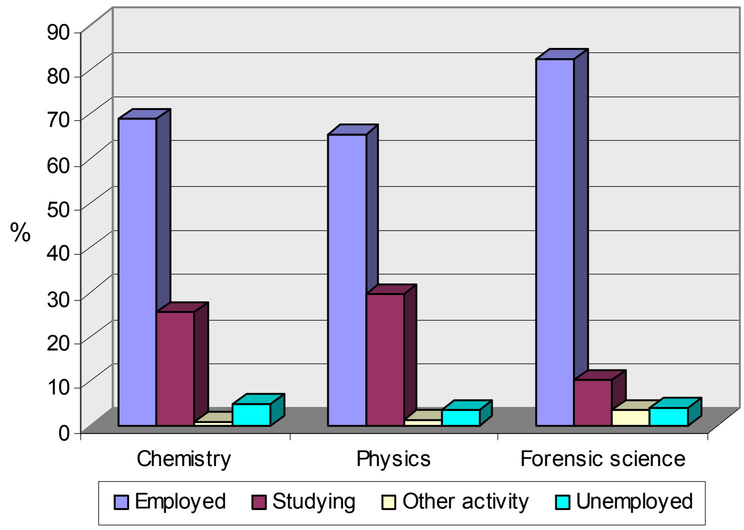


**Figure 1: Current activity**

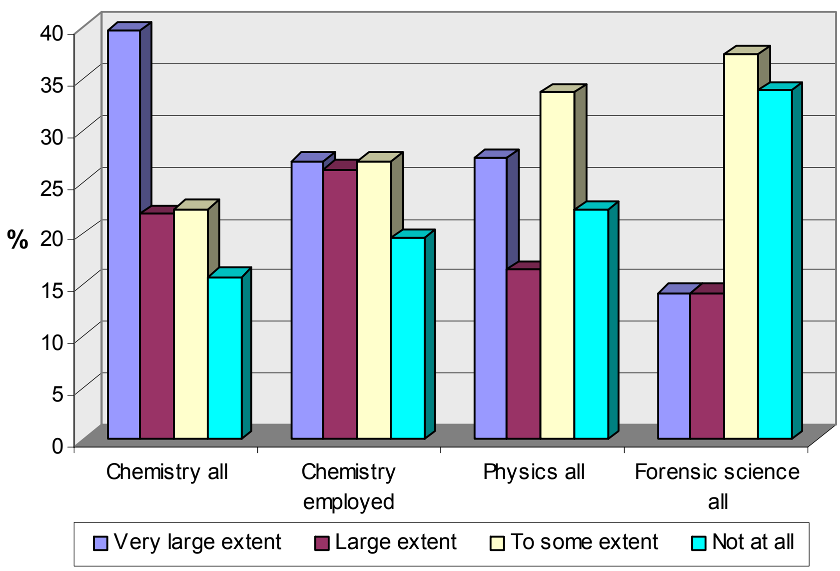


**Figure 2: Involvement of subject in activities since graduation**

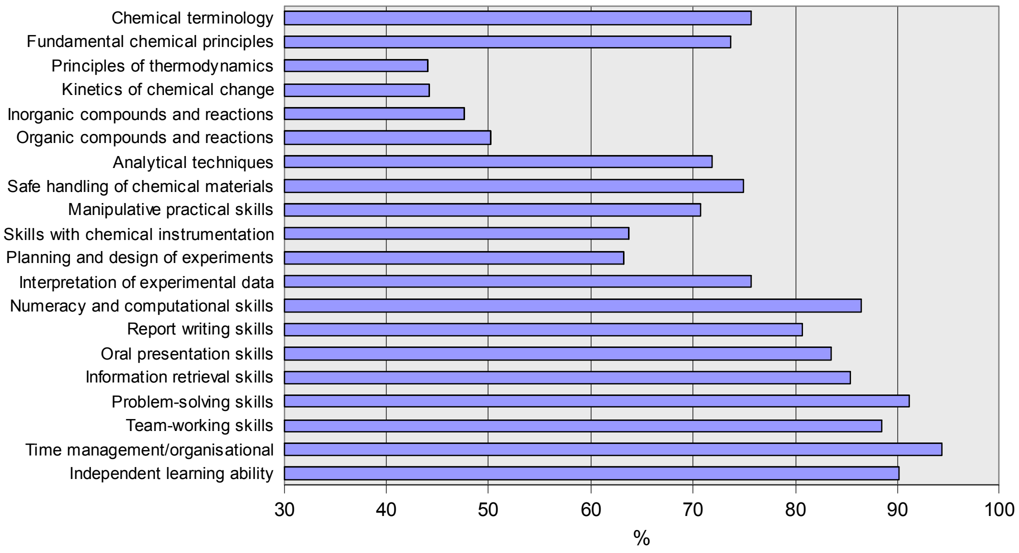


**Figure 3: Percentage of all graduates selecting 'Useful/Very useful'**

## 5.2 Knowledge/skills used since graduating

Figure 3 gives the results for the question: ***With respect to your career since completing your undergraduate degree, whether working, training or undertaking other activities, please indicate the value of the areas of knowledge or skills listed.*** Respondents could select one of: 'No use', 'Little use', 'Useful' or 'Very useful'. The percentage of graduates selecting 'Useful' and 'Very useful' is given.

It can be seen that the generic skills generally tend to be scored at a higher level of usefulness than the chemical knowledge/skills. This is not surprising in that generic skills are needed by all the graduates, whereas chemistry knowledge/skills are not. For the chemical knowledge/skills, other than the basic chemical terminology and principles, areas of analytical chemistry were considered to be of most use. There is little difference between the generic skills with all, except the two experimental skills, having over 80% of graduates selecting 'Useful/Very useful'. These results are closely in line with those obtained in the pilot survey of 2006 graduates carried out the year previously. The results for subject knowledge/skills compared with generic skills follow a similar pattern to those obtained in the parallel survey for physics graduates.

To give an idea of the spread of the results, the data from three universities are shown in Figure 4. University A is a Russell Group university, University B is a non-Russell Group pre-1992 university and University C is a post-1992 university. The main point to note is that the same general trends are seen for these three universities (and this is indeed the case for all nine universities). The differences seen probably relate to the types of activities undertaken by the graduates, for example, a higher proportion of graduates from Universities B and C were working in analytical laboratories compared with University A.

On breaking down the data according to activities undertaken since graduation, some interesting, if not unexpected, trends are seen. Figure 5 gives the results for the 133 graduates who had indicated that employment was currently their main activity. The data are split

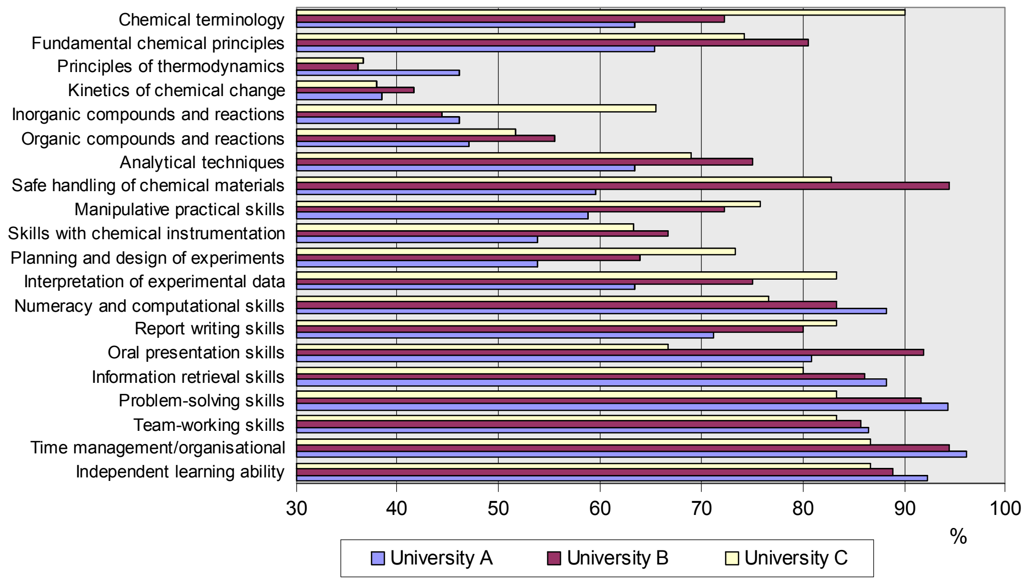


**Figure 4: Percentage of graduates from three universities selecting 'Useful/Very useful'**

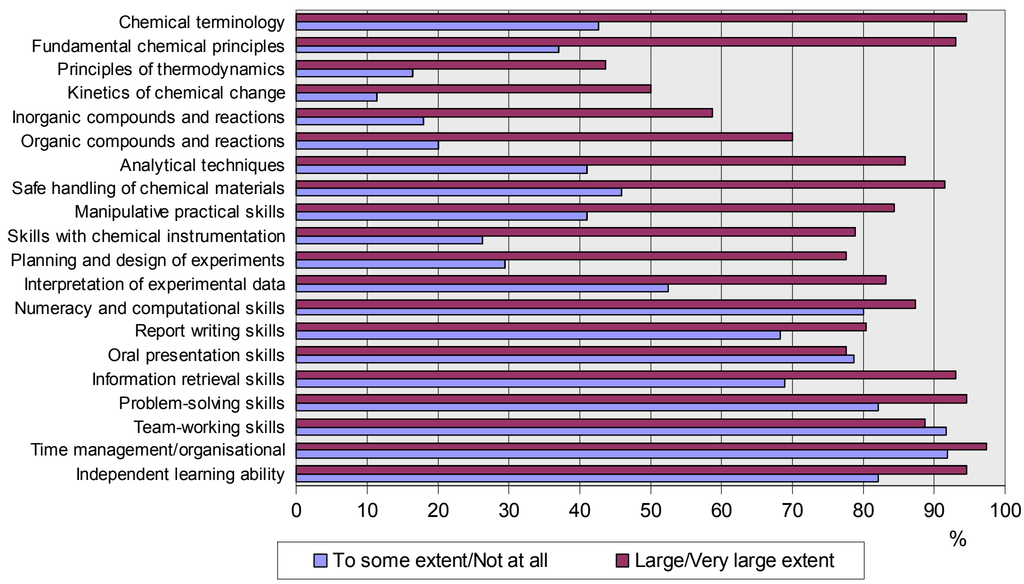


**Figure 5: Percentage of employed graduates selecting 'Useful/Very useful' with respect to chemistry in their activities**

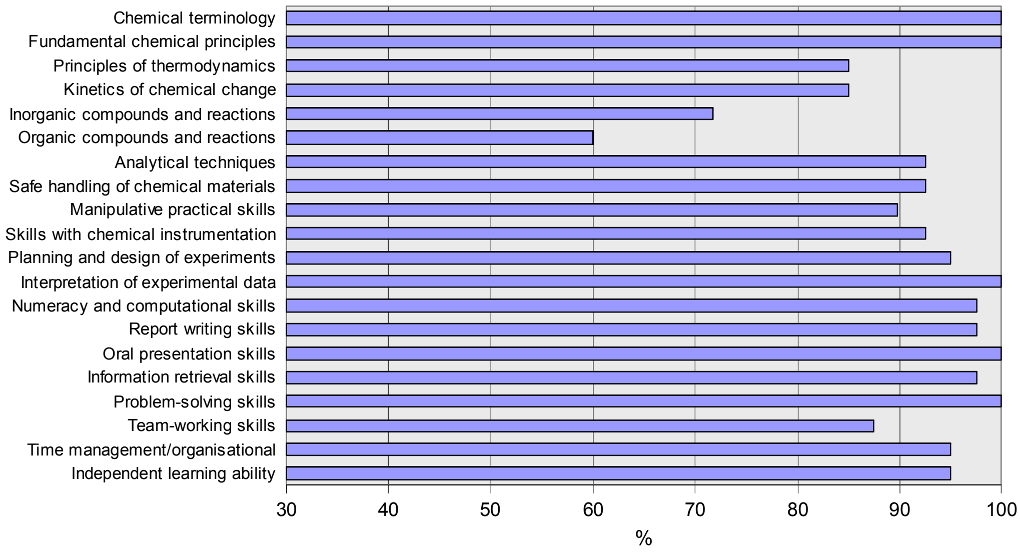


**Figure 6: Percentage of graduates undertaking PhDs selecting 'Useful/Very useful'**

according to whether their activities since graduation involved a knowledge of chemistry 'To some extent/Not at all' or to a 'Large/Very large extent'. Note that the scale in this case runs from 0 to 100% rather than 30 to 100%, as in the other figures.

Not surprisingly, those graduates whose employment required little or no knowledge of chemistry gave relatively low scores for the chemical knowledge/skills. It is seen that the generic skills (other than experimental skills) are given similar high scores by both groups, indicating again the relative importance of these skills, even for graduates in employment which has a high chemistry content.

The results for the 40 PhD students (Figure 6) show a similar pattern to the employed graduates who have a 'Large/Very large extent' involvement of chemistry knowledge in their activities, although 'Principles of thermodynamics' and 'Kinetics of chemical change' are scored more highly. The low scores for 'Inorganic compounds and reactions' and 'Organic compounds and reactions' possibly reflect the division of these subject areas in PhD research. Once again the generic skills are seen to have a high level of usefulness, although team-working skills are marked rather lower than others, perhaps indicative of the individual nature of much postgraduate research. From these results it can be seen that the curricula of chemistry degree programmes, as set out in this list of knowledge/skills, match very well the usage by PhD students. This was commented on by some graduates in answers to the open form questions, see below.

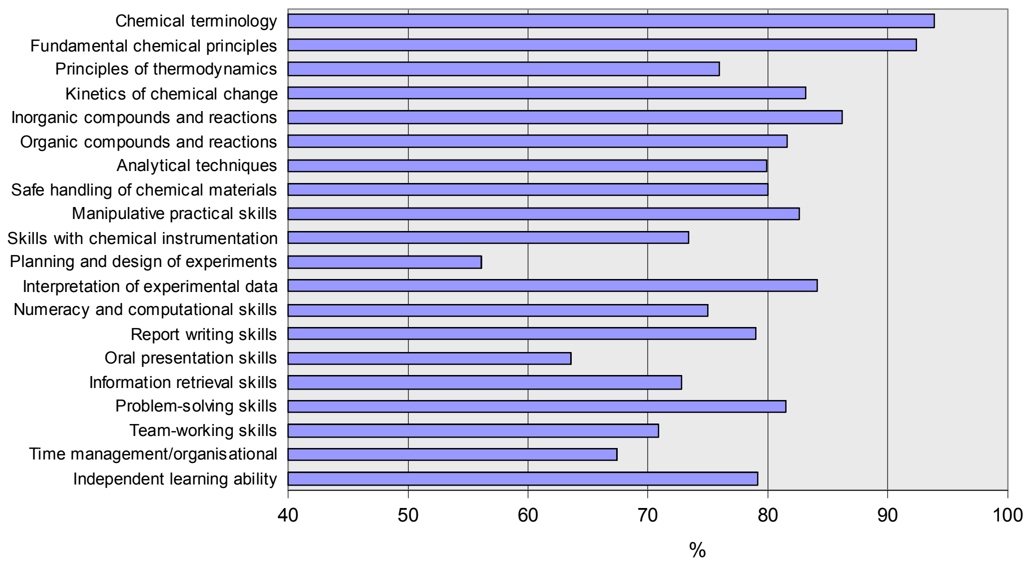


**Figure 7: Percentage of all graduates selecting 'Well/Very well' for development in their degree**

## 5.3 Knowledge/skills development in the degree programme

Figure 7 gives results to the question: ***With respect to your undergraduate degree (including work placement when included), please indicate how well the course assisted you in developing the knowledge and skills listed.*** Respondents could select one of: 'Not at all', 'To some extent', 'Well' or 'Very well'. The percentage of graduates selecting 'Well' and 'Very well' is given.

These results are again closely in line with the results obtained in the pilot survey of 2006 graduates carried out the year previously. It is reassuring to note that for all of the areas of knowledge/skills, more than 50% of graduates considered they had developed them 'Well/ Very well' within their degree programmes and this rose to more than 70% for the chemical knowledge/skills. The generic skills scored less well than the chemical knowledge/skills and this is further illustrated when three universities are considered individually.

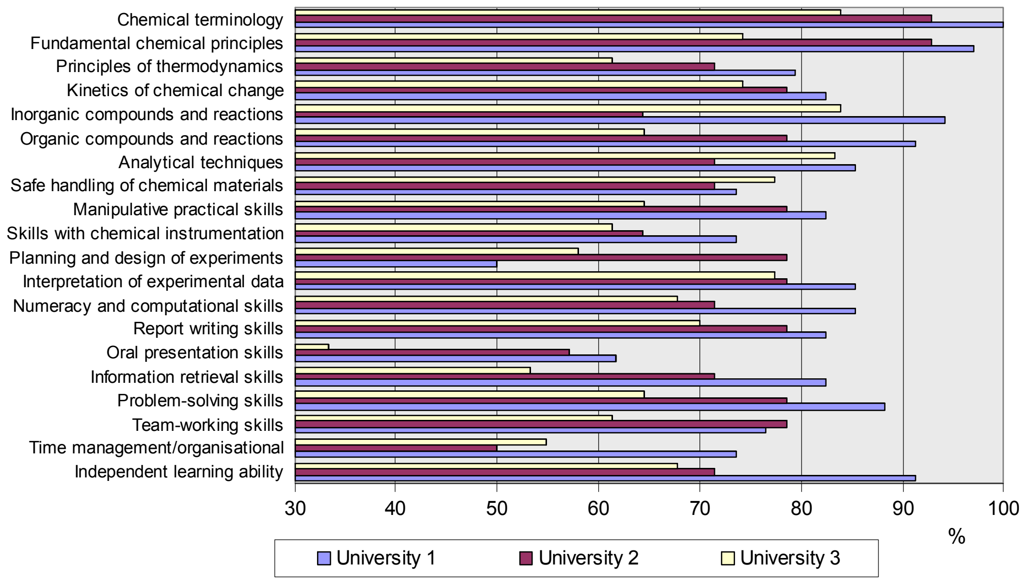


**Figure 8: Percentage of graduates from three universities selecting 'Well/Very well' for development in their degree**

The three universities shown in Figure 8 were selected to show the spread of results (they are not the same universities as A, B and C in Figure 4). Note the scale here runs from 30% to 100%, rather than 40% to 100% as in the other development figures. University 1 scores significantly higher than Universities 2 and 3 (p = 1% and 1%, Student's t-test, testing for 5% and 1% significance levels) and University 2 scores significantly higher than University 3 (p = 5%). Some significant differences are also found when considering the other six universities. However, as mentioned above, this report is concerned with the overall results for all universities rather than university-specific results, although these will be made available to the individual universities concerned.

In order to investigate whether the type of degree programme undertaken affected the graduates' scores for skills development, results were analysed for:

- BSc degrees (normally 3 years in England and Wales, 4 years in Scotland, and includes a few part-time students), 78 graduates
- MChem/MSci degrees without an industrial placement (normally 4 years in England and Wales, 5 years in Scotland), 48 graduates, including 6 with international study
- MChem/MSci degrees with an industrial placement (normally 4 years in England and Wales, 5 years in Scotland, and includes two BSc degrees with industrial placement), 32 graduates.

One university which had no MChem/MSci or placement students was excluded from this analysis.

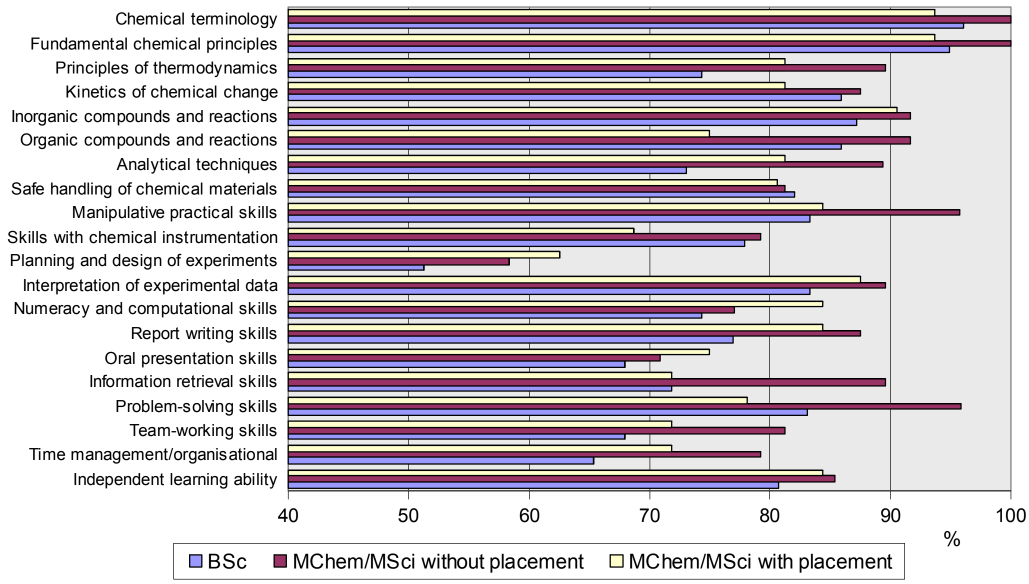


**Figure 9: Percentage of graduates selecting 'Well/Very well' for development in their degree with respect to type of degree**

Figure 9 compares the results for the three types of degree. The scores for the MChem/ MSci degrees without placement are significantly higher than the BSc degrees for both the chemical knowledge/skills (p = 1%) and for the generic skills (p = 1%). Although it might be expected that the extra year at university would lead to an increase in chemical knowledge/skills development, it also appears to provide an increase in generic skills development and, in particular, of information retrieval, time management, team-working and problem-solving skills.

When the MChem/MSci degrees with placement are compared with the BSc degrees, the scores for the chemical knowledge/skills are not significantly different, but are higher for the generic skills (p = 1%) for the degrees with placements. This is as might be expected, ie that the placement year allows generic skills development without necessarily increasing the general knowledge of chemistry, although possibly increasing it in specific areas involved with the placement.

When the MChem/MSci degrees without placement are compared with the degrees with placement, the scores are higher for chemical knowledge/skills (p =1%) for degrees without placement, but are not significantly different for the generic skills. This demonstrates the value of a university-based extra year.

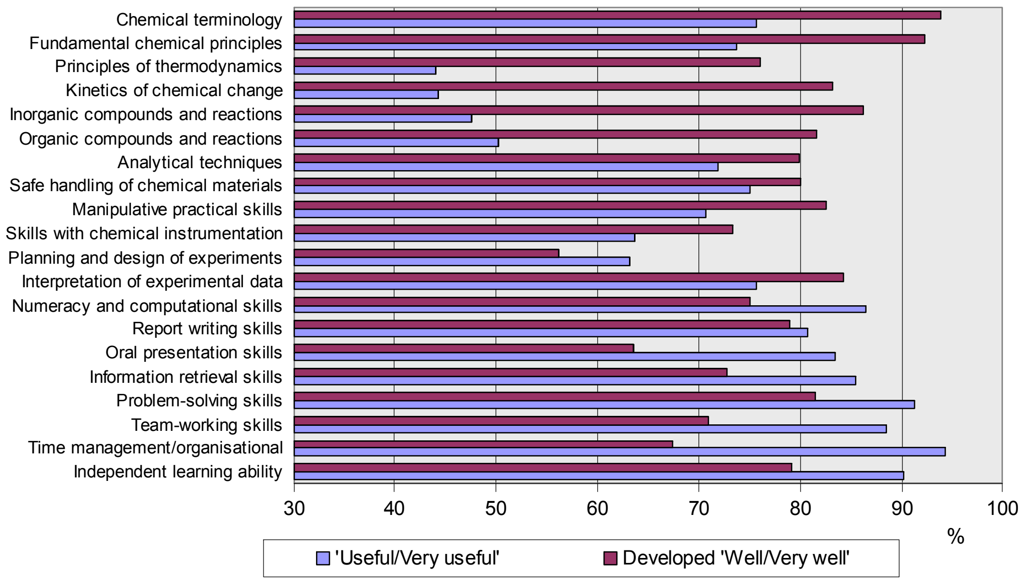


**Figure 10: Use versus development for all graduates**

## 5.4 Use versus development

In order to ascertain how well the skills usage by graduates relates to their development in their degree programmes, 'Use' and 'Development' data are plotted together in Figure 10. This shows that with respect to usage, the generic skills are less well developed than the chemical knowledge/skills within the degree programmes.

This is illustrated more clearly in Figure 11 where the differences between 'Use' and 'Development' data, as given in Figure 10, are plotted as so-called 'Development deficits'. A positive 'Development deficit' indicates that the area of knowledge/skill has been developed to a low level relative to usage, a negative value that it has been developed to a high level relative to usage. Although a rather crude measure, this does highlight well the apparent deficit in development for most of the generic skills.

In Figure 12 'Development deficit' results are broken down for the 133 employed graduates according to the extent their activities since graduation involved a knowledge of chemistry. Note that the scale here runs from -80% to 30%. For those graduates who have had relatively little or no involvement of chemistry in their activities since graduation, only 'Time management and organisational skills', 'Oral presentation skills' and 'Team-working skills' have positive 'Development deficits'. For those graduates with a high level of chemistry in their activities, in addition to generic skills, some analytical and experimental skills also have positive 'Development deficits'.

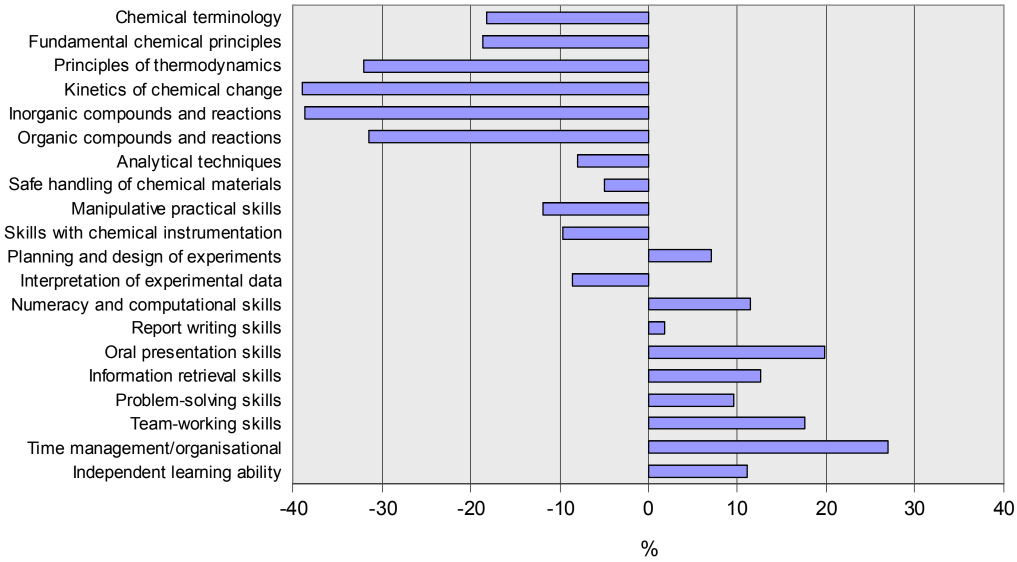


**Figure 11: 'Development deficits' for all graduates**

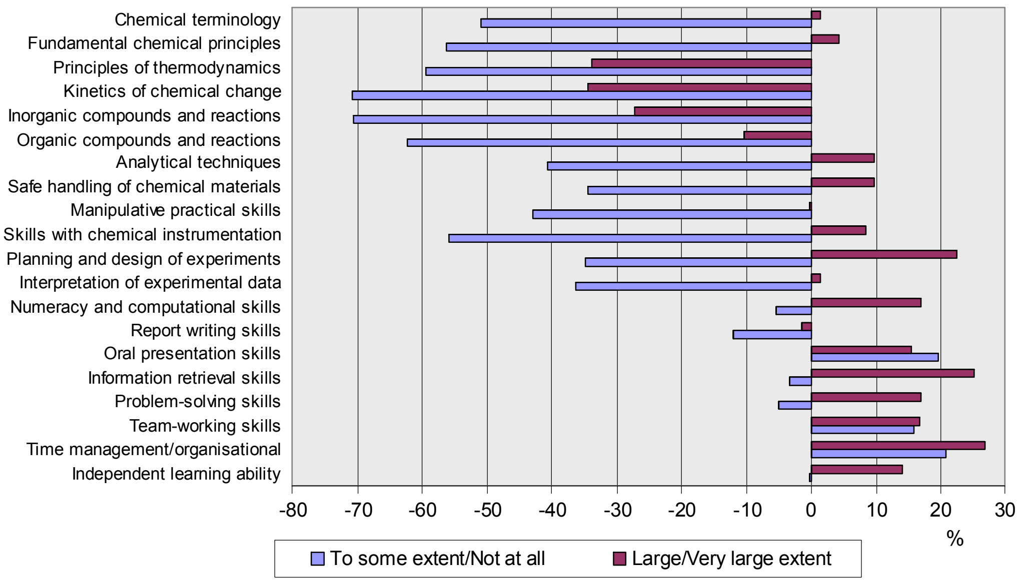


**Figure 12: 'Development deficits' for employed graduates with respect to chemistry in their activities**

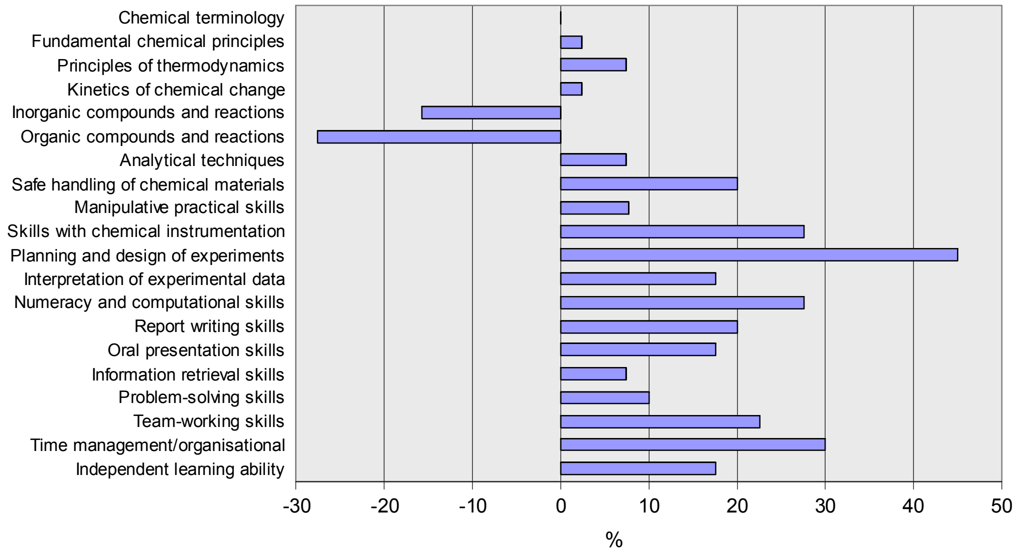


**Figure 13: 'Development deficits' for graduates undertaking PhDs**

The 'Development deficit' results for the 40 PhD students are shown in Figures 13, with the scale running from -30% to 50%. High positive 'Development deficits' are seen here for some analytical and experimental skills as well as for the generic skills, with 'Planning and design of experiments' having the highest value.

## 5.5 Knowledge/skills graduates would have liked more opportunity to develop within their degree

The analysis in the previous section has identified areas of knowledge/skills, particularly generic skills, where their use after graduation appears to be relatively high compared with their development within degree programmes. However, it does not necessarily follow that graduates would have liked to have developed these more within their chemistry degree programmes; they may, for example, consider the development of some of these skills to be more suited to extra-curricular activities. To address this point, the following question was asked:

***Of the 20 areas of knowledge/skills listed above, please indicate the FIVE which, in retrospect, you wish you had been given more opportunity to develop within your undergraduate degree.***

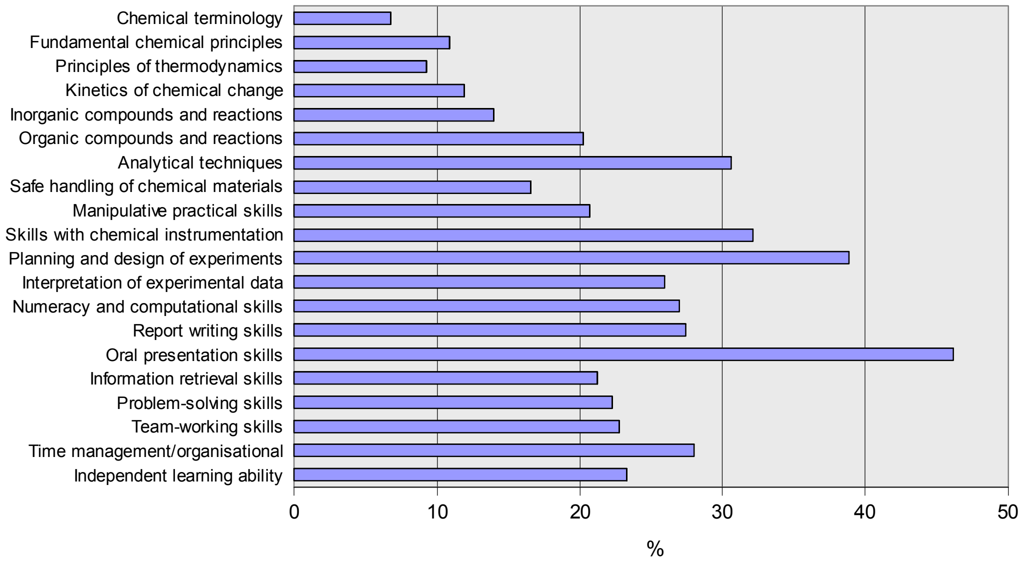


**Figure 14: Percentage of all graduates indicating they would have liked more opportunity to develop the areas of knowledge/skills in their degree**

The results for all graduates are given in Figure 14. It is seen that 'Oral presentation skills' have the highest score, being selected by 46% of graduates. It scored highest for six out of the nine universities when considered individually, and was in the top five for the other three universities. The other areas of knowledge/ skills which scored above average were, in order: 'Planning and design of experiments', 'Skills with chemical instrumentation', 'Analytical techniques', 'Time management and organisational skills', 'Report writing skills', 'Numeracy and computational skills', 'Interpretation of experimental data' and 'Independent learning ability'. When compared with 'Development deficits' (see Figure 11), these results are in broad agreement for most of the chemical knowledge/skills, but there are major differences for some of the generic skills, with 'Team-working skills' and 'Problem-solving skills', seen as lower priority in answer to this question.

*'Oral presentation skills' have the highest score, being selected by 46% of graduates*

It is interesting to note that in the parallel surveys carried out in physics and forensic science, 'Oral presentation skills' scored highest for this question in the physics survey (selected by nearly 60% of graduates) and was in the top five for forensic science survey (selected by about 30% of graduates).

In Figure 15 results are broken down for the 133 employed graduates according to the extent their activities since graduation involved a knowledge of chemistry. Again 'Oral presentation skills' scored highest for both groups. Some of the other generic skills scored highly for those graduates with little or no chemical involvement in their activities. Analytical and experimental skills scored highly for those with a high level of chemical involvement in their activities, in line with the 'Development deficit' results in Figure 12.

The results for the graduates taking PhDs are shown in Figure 16. 'Planning and design of experiments' scores highest, followed by 'Oral presentation skills'. When compared with the 'Development deficit' data in Figure 13, there is a similar pattern, although 'Oral presentation', 'Analytical techniques' and some of the other chemical knowledge/skills score higher in response to this question and 'Independent learning ability', 'Time management and organisational skills' and 'Safe handling of chemical materials' score lower.

*Some of the other generic skills scored highly for those graduates with little or no chemical involvement in their activities*

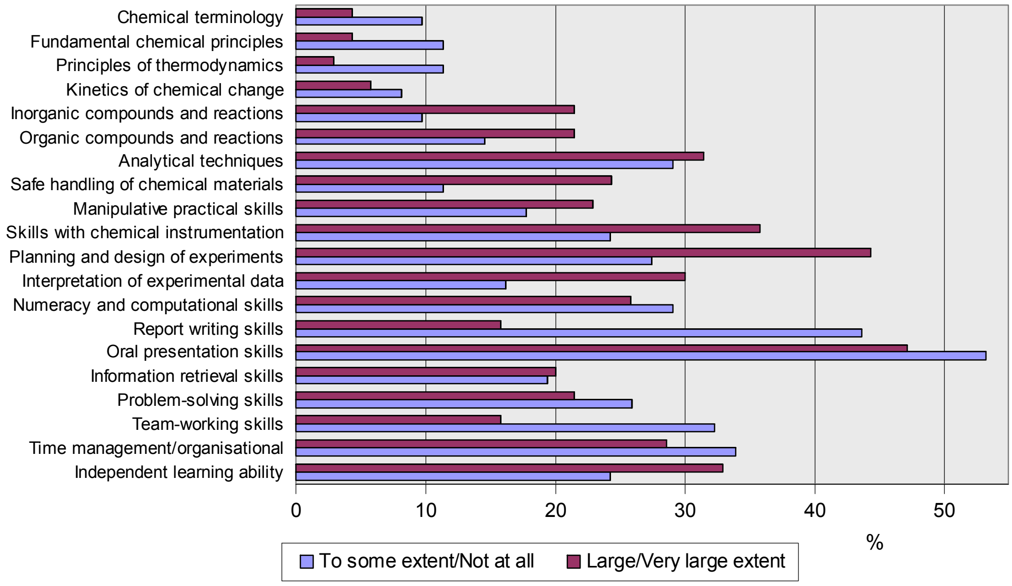


**Figure 15: Percentage of employed graduates indicating they would have liked more opportunity to develop the areas of knowledge/skills in their degree, with respect to chemistry in their activities**

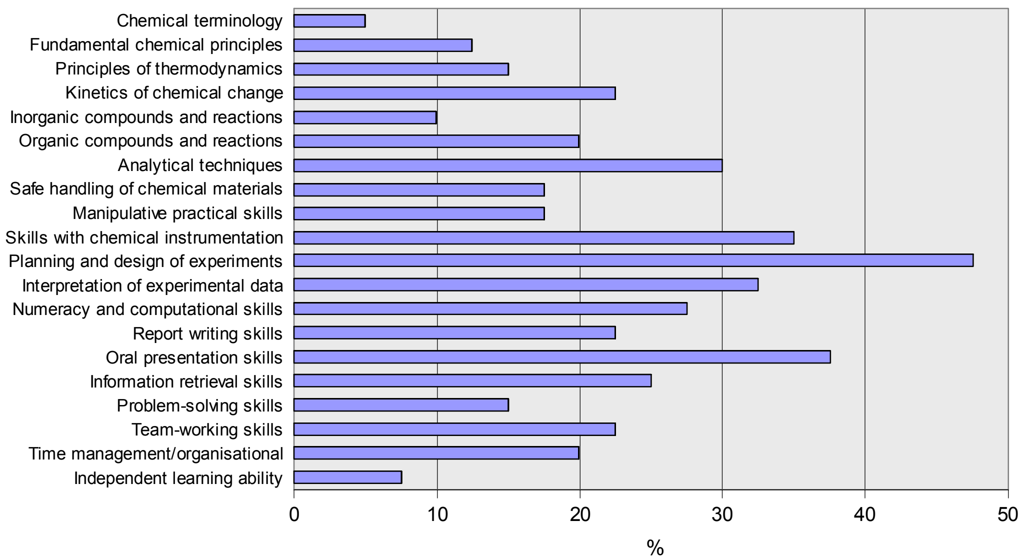


**Figure 16: Percentage of graduates undertaking PhDs indicating they would have liked more opportunity to develop the areas of knowledge/skills in their degree**

## 5.6 Answers to open form questions

The survey included three open form questions.

***Please indicate any areas of knowledge or skills, other than the 20 given above, which you have had to acquire in your career since completing your undergraduate degree and which were not covered, or were not covered sufficiently, in your degree.***

This produced 85 responses. The most frequently mentioned areas of knowledge/skills were: commercial awareness/industry related skills; environmental impact/green chemistry; MS Office and MatLab programmes; job application and interview skills; project management. Others frequently mentioned related to the graduates' current employment, eg teaching skills and legislation.

***Please indicate any areas of knowledge or skills, other than the 20 given above, which were part of your undergraduate degree, but have been of little or no use in your career.***

This produced 50 responses. The low response rate is probably indicative of a general satisfaction with the content of the degree programmes. Some answers were specific to the particular university programme taken and, although these comments may be of value to those universities, they are of limited general interest.

Individual answers included:

- *All skills and knowledge areas have been of use in my PhD.*
- *I use it all! It's a pretty thorough list you have!*
- *Unfortunately, I felt most of the material covered during my degree was tailored more towards continued study or a research role within an academic establishment rather than to a practical role in the wider job market*
- *Examination/revision skills......not something that I find to be very 'real world'. In the work place I don't need to memorise everything, only understand it as I can look things up in books, on the internet etc. I think more assignments and reports would be useful as this is a way of using your knowledge in the same way as you do in the work place.*

*I think more assignments and reports would be useful as this is a way of using your knowledge in the same way as you do in the work place*

***Please provide any comments which you think may be useful in developing the curriculum of undergraduate chemistry degrees. Additionally, if you wish, please explain or expand on any of the answers you have given above.***

This produced 104 responses. Many graduates expressed satisfaction with the programme they had undertaken, irrespective of whether their activities since graduation were chemistry -related.

Topics mentioned most frequently related to gaining more experience of oral presentations and team-working. Several graduates would have liked more assistance with regard to getting placements and jobs. Some graduates would have liked more industry-related degree content, and, in the absence of a one year placement, short placements in industry.

Individual answers included:

- *As an accountant I don't need detailed chemistry knowledge, however I believe that the hard work required for completion of my degree set me in good stead to work and study at the same time. I believe the transferable skills course we had has been invaluable to me.*
- *Communication skills are important to all science graduates who continue to work in a chemical science-related environment, whether that's academia, industry, or another sector.*
- *The course needs to focus on skills an employer will want, including teamwork and problem solving particularly.*
- *More team-working skills but less assessed team-work.*
- *More report writing (for some labs this could be a PowerPoint presentation), not lab reports but more in style of journal publications.*
- *Labs shouldn't be prescriptive, should be able to plan own experiments.*

*Many graduates expressed satisfaction with the programme they had undertaken*

# 6. Discussion

For new chemistry graduates it is clear from this study that generic skills are very important, irrespective of whether the graduates are employed in chemistry or non-chemistry related jobs. This is very much in line with reports, mentioned above in the Background, that list the graduate skills required by employers. This evidence should be valuable to academic staff when advising undergraduates on the importance of generic skills development during their undergraduate programme. It has been observed by the authors that the views of recent alumni are often more convincing to undergraduates than the views of employers.

Graduates studying for PhDs also consider generic skills to be very important, although chemical knowledge/skills are considered equally highly. This evidence may be useful to academics in convincing research-focused colleagues of the importance of skills development activities in the chemistry curriculum.

This study shows an imbalance between the use of skills after graduation and their development within degree programmes. This is demonstrated both by 'Development deficit' data and by answers to the question about which skills the graduates would have liked the opportunity to develop more within their degrees. The highest scores for these parameters are given in Table 2 for all graduates and for graduates studying for PhDs, along with some results from the pilot survey of 2006 graduates.

The results provide evidence for greater inclusion of generic skills such as oral presentation in chemistry degree programmes. There is also evidence for inclusion of more experimental and analytical techniques, and, partly based on the open form answers, inclusion of more opportunity to design experiments rather than have prescriptive recipe-style practical activities. Such evidence can be very useful to academics involved in programme design, in particular to those wishing to take initiatives which incorporate generic skills development within a laboratory setting.

Results from a focus group of chemistry graduates undertaken during the pilot survey of 2006 graduates provided some useful information. The graduates were not surprised that the use of generic skills came out strongly relative to the chemical skills. When it was put to them that might indicate decreasing the chemical skills content in the degree programmes relative to the generic skills, the general consensus appeared to be that they didn't wish this to happen. Rather, they would like the methods of teaching to be such that more training in generic skills could be included whilst maintaining the chemical content. This is therefore an issue of pedagogical innovation rather than curriculum content.

**Table 2: Results given in rank order for the ten highest scores for all graduates and graduates taking PhDs, taken from the current survey (2007 graduates) and from the pilot survey (2006 graduates)**
*(Note: Areas of knowledge/skills in merged cells have equal scores)*

<table>
<tr><th rowspan="2"></th><th colspan="3">All graduates</th><th colspan="3">Graduates taking PhDs</th></tr>
<tr><th>‘Development deficit’ 2007</th><th>Like more developed 2007</th><th>‘Development deficit’ pilot survey 2006</th><th>‘Development deficit’ 2007</th><th>Like more developed 2007</th><th>‘Development deficit’ pilot survey 2006</th></tr>
<tr><td>1</td><td>Time management</td><td>Oral presentation</td><td>Time management</td><td>Planning and design of experiments</td><td>Planning and design of experiments</td><td>Planning and design of experiments</td></tr>
<tr><td>2</td><td>Oral presentation</td><td>Planning and design of experiments</td><td>Team-working</td><td>Time management</td><td>Oral presentation</td><td>Oral presentation</td></tr>
<tr><td>3</td><td>Team-working</td><td>Chemical in-strumentation</td><td>Problem-solving</td><td rowspan="2">Chemical in-strumentation<br>Numeracy and computational</td><td>Chemical in-strumentation</td><td>Chemical in-strumentation</td></tr>
<tr><td>4</td><td>Information retrieval</td><td>Analytical techniques</td><td>Oral presentation</td><td>Interpretation experimental data</td><td>Numeracy and computational</td></tr>
<tr><td>5</td><td>Numeracy and computational</td><td>Time management</td><td>Numeracy and computational</td><td>Team-working</td><td>Analytical techniques</td><td>Information retrieval</td></tr>
<tr><td>6</td><td>Independent learning ability</td><td>Report writing</td><td>Independent learning ability</td><td rowspan="2">Safe handling of chemicals<br>Report writing</td><td>Numeracy and computational</td><td>Time management</td></tr>
<tr><td>7</td><td>Problem-solving</td><td>Numeracy and computational</td><td>Information retrieval</td><td>Information retrieval</td><td>Report writing</td></tr>
<tr><td>8</td><td>Planning and design of experiments</td><td>Interpretation experimental data</td><td>Planning and design of experiments</td><td rowspan="3">Interpretation experimental data<br>Oral presentation<br>Independent learning ability</td><td rowspan="3">Kinetics of chemical change<br>Report writing<br>Team-working</td><td>Team-working</td></tr>
<tr><td>9</td><td>Report writing</td><td>Independent learning ability</td><td>Report writing</td><td>Independent learning ability</td></tr>
<tr><td>10</td><td>Safe handling of chemicals</td><td>Team-working</td><td>Interpretation experimental data</td><td>Interpretation experimental data</td></tr>
</table>

# 7. Conclusions

7.1 Completed survey forms were received from a total of 196 graduates from nine universities, an overall response rate of 36%.

7.2 A total of 133 graduates (68%) gave employment as their current main activity and 40 graduates (20%) were undertaking PhDs. Only 16% of the graduates indicated no involvement of chemistry in their activities since graduation.

7.3 The generic skills were scored at a higher level of usefulness than the chemical knowledge/skills. With the chemical knowledge/skills, apart from basic chemical terminology and principles, analytical chemistry was considered to be of most use. A similar pattern was found for all nine universities.

7.4 For all of the areas of knowledge/skills, more than 50% of graduates considered they had developed them 'Well/Very well' within their degree programmes and this rose to more than 70% for the chemical knowledge/skills.

7.5 Significant differences were found between universities in how well the different areas of knowledge/skills were developed.

7.6 For degrees without industrial placements, development scores for the MChem/MSci degrees were significantly higher than for BSc degrees for both the chemical knowledge/skills and the generic skills.

7.7 Development scores for MChem/MSci degrees with an industrial placement were significantly higher than for BSc degrees for generic skills, but not significantly different for chemical knowledge/skills.

7.8 Development scores for MChem/MSci degrees without industrial placements were significantly higher than for degrees with industrial placements for chemical knowledge/skills, but not significantly different for generic skills.

*With the chemical knowledge/skills, apart from basic chemical terminology and principles, analytical chemistry was considered to be of most use*

7.9 Relative to usage, the generic skills were less well developed than the chemical knowledge/skills within degree programmes. This is highlighted in terms of 'Development deficits', which were highest for 'Time management and organisational skills', followed by 'Oral presentation skills' and 'Team-working skills'.

7.10 Graduates would have liked more opportunity in their undergraduates degrees to develop 'Oral presentation skills' in particular. This is followed by 'Planning and design of experiments', 'Skills with chemical instrumentation', 'Analytical techniques', 'Time management and organisational skills', 'Report writing skills', 'Numeracy and computational skills' and 'Interpretation of experimental data'.

7.11 Graduates who were studying for PhDs would have liked more opportunity in their undergraduate degrees to develop 'Planning and design of experiments', followed by 'Oral presentation skills', 'Skills with chemical instrumentation', 'Interpretation of experimental data', 'Analytical techniques', 'Numeracy and computational skills', 'Information retrieval skills' and' Independent learning ability'.

7.12 The open form answers provide a useful source of information for degree programme development.

*... graduates who were studying for PhDs would have liked more opportunity in their undergraduate degrees to develop 'Planning and design of experiments'*

# 8. Recommendations

It is recommended that when undergraduate chemistry degree programmes are being revised, additional opportunities should be provided for developing generic skills, in particular oral presentation skills. Additional opportunities should also be provided for planning and design of experiments, skills with chemical instrumentation and analytical techniques.

Undergraduates should be advised about the range of skills new graduates require. Presentations by recent alumni may be one of the best ways to put over this message.

# 9. Acknowledgements

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