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Mastering Bologna

A report on the readiness of UK Chemistry Departments to succeed in the European Higher Education Area

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Introduction

The Mastering Bologna project was a 24 month project designed to gather data and opinion on the readiness of the UK chemistry Higher Education (HE) sector to succeed after the introduction of the European Higher Education Area (EHEA). Data was collected on the structures of UK chemistry degree programmes at the Bachelors and Masters Levels. Further to this, a representative group of Departments was selected to be visited for more in-depth assessment via an externally facilitated SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis. The results of these are reported. The concentration on a single subject has allowed a truly national survey to be completed without sacrificing detail. Although some aspects might be considered to be specific to chemistry, the majority of the challenges faced are common to a broad range of STEM (Science, Technology, Engineering and Mathematics) subjects as well as other disciplines developing Masters provision.

Chemistry is both an academic and a vocational discipline. A successful chemistry HE sector is essential to maintain the UK as a leading knowledge-based economy. It is also a subject in which a relatively high proportion of first degree graduates go on to further study, which reflects the importance of cutting edge chemistry research to the economy. In addition to entering careers as chemistry professionals, chemistry graduates are seen as highly attractive within the broader economy where their practical, analytical, mathematical and problem-solving skills are highly prized.

Chemistry is a globalized subject. Although there is a significant contribution to the domestic economy from local SME's, whose needs must be addressed by the UK chemistry HE sector, the industrial sector is dominated by large multinational companies who recruit internationally, particularly for research positions. UK Higher Education Institutions (HEIs) have a reputation for producing excellent chemistry graduates who can compete successfully in international job markets. UK HEIs are also to be found performing well in international university league tables and the UK has a long history of being a popular destination for international scholars, at both undergraduate and postgraduate levels. Indeed, the UK is second only to the USA as a destination for overseas students to study chemistry.

The structures, curricula and entrance requirements of UK degree programmes are determined by the HEIs themselves, which are independent of direct government control. Government funding of the UK HE sector is via the various Higher Education Funding agencies (mainly for teaching but with significant general research funding) and Research Councils (primarily funding research projects and individuals or groups). The Quality Assurance Agency is empowered by the government with monitoring quality assurance in the higher education sector. This is done through inspections of the institutions' own quality assurance procedures, rather than direct assessment of degree structures and curricula. It does, however, provide Subject Benchmark Statements against which HEIs can compare their degree programmes (Appendix I). UK chemistry first degrees are 'Recognised' at the Bachelors level and 'Accredited' at the Masters level by the Royal Society of Chemistry (RSC), which is the professional body for chemistry in the UK. The RSC does assess curricula and student workloads in its recognition/accreditation processes. Professional acknowledgement of combined courses is dependent on the level of chemistry content. Possession of an accredited Masters degree satisfies the academic requirements for admission to membership of the RSC and the designation 'Chartered Chemist'. The 'Chartered Chemist' status is not a prerequisite to practise as a Chemist, but rather a badge of professional acknowledgement.

This report focuses on the readiness of the UK chemistry HE sector to maintain its place at the forefront of international chemical education after the introduction of the EHEA. This is interpreted as the following:

- To provide the high quality graduates necessary to underpin the knowledge-based economy, both as chemistry professionals and in the wider economy;
- To provide graduates with the skills, knowledge and experience necessary to compete successfully in both global and domestic employment markets;
- To prepare graduates for advanced study;
- To provide students with a fulfilling educational experience;
- To attract the highest quality students, both nationally and internationally, to study chemistry in the UK.

We hold it to be self-evident that the UK chemistry HE sector will only be considered successful if it equips its graduates to succeed in their future lives and careers in the modern global economy. Recognition that UK chemistry degrees have met a series of quality thresholds is not in itself sufficient to maintain the UK's position at the forefront of international chemical education. For the UK chemistry HE sector to be successful in the EHEA, UK chemistry degrees must be widely acknowledged to be qualifications of the highest quality.

Summary of Recommendations

- We recommend that two academic years (120 European Credit Transfer and Accumulation System, ECTS) of Masters level education be made widely available in the UK. We make no recommendation on how the extra year is incorporated into the range of courses provided by individual HEIs, i.e. postgraduate one or two year courses, five year integrated Masters or all of these. However, we do recommend that that the current four academic year integrated Masters degrees remain for the foreseeable future.

- We strongly recommend that the nomenclature of UK Science degree programmes be rationalized as a matter of urgency.

- We recommend that HEIs strengthen their links with industry in the direct provision of student learning opportunities.

- We recommend that HEFCE and the Research Councils agree on financial responsibilities for Masters degrees and make sustainable new provision for Masters level education. This provision should be flexible, with policies that are enabling, rather than prescriptive.

- We recommend that new funding for scholarships for UK students undertaking Masters study is provided by HEFCE and the Research Councils.

Chapter 1

The European Higher Education Area

The 1999 'Bologna Declaration' initiated a ten year programme to introduce the European Higher Education Area (EHEA). Its primary purpose is to allow greater international mobility between member states for study and/or employment through the mutual recognition of higher education qualifications. For this to be achieved a common nomenclature and agreement on standards needs to be implemented; however it does not require the introduction of a single homogenous higher education system. The EHEA is often discussed in the context of 'compliance' implying the existence of a set of rules to be obeyed; this is **not** the case and is a misconception which could prove a hindrance in developing strategies in response to its introduction. However, it should be noted that the Bologna process does make recommendations about structures and credit systems based upon both inputs and outputs, with an emphasis on **compatibility** and **comparability**. This Chapter aims to provide clarity on the Bologna process, using extensive quotation from its various Declarations.

The Bologna Process

It should be noted that what has become known as the Bologna Process is just that – a process. Since the initiation of the process there has been a great deal of subsequent activity at all levels – institutional, regional, national and international. Further intergovernmental meetings have been held in Prague (2001), Berlin (2003), Bergen (2005) and London (2007). The next Ministerial Conference is due to be held in 2009 at the universities of Leuven and Louvain-la-Neuve. It is likely that these meetings will continue well into the future.

Extract from the Bologna Declaration (1999)

"we engage in co-ordinating our policies to reach in the short term, and in any case within the first decade of the third millennium, the following objectives, which we consider to be of primary relevance in order to establish the European area of higher education and to promote the European system of higher education world-wide:

- Adoption of a system of easily readable and comparable degrees, also through the implementation of the Diploma Supplement, in order to promote European citizens employability and the international competitiveness of the European higher education system.

- Adoption of a system essentially based on two main cycles, undergraduate and graduate. Access to the second cycle shall require successful completion of first cycle studies, lasting a minimum of three years. The degree awarded after the first cycle shall also be relevant to the European labour market as an appropriate level of qualification. The second cycle should lead to the master and/or doctorate degree as in many European countries.

- Establishment of a system of credits - such as in the ECTS system – as a proper means of promoting the most widespread student mobility. Credits could also be acquired in non-higher education contexts, including lifelong learning, provided they are recognized by receiving Universities concerned.

- Promotion of mobility by overcoming obstacles to the effective exercise of free movement with particular attention to:

  - for students, access to study and training opportunities and to related services

  - for teachers, researchers and administrative staff, recognition and valorisation of periods spent in a European context researching, teaching and training, without prejudicing their statutory rights.

- Promotion of European co-operation in quality assurance with a view to developing comparable criteria and methodologies.

- Promotion of the necessary European dimensions in higher education, particularly with regards to curricular development, inter-institutional co-operation, mobility schemes and integrated programmes of study, training and research.

We hereby undertake to attain these objectives - within the framework of our institutional competences and taking full respect of the diversity of cultures, languages, national education systems and of University autonomy – to consolidate the European area of higher education. To that end, we will pursue the ways of intergovernmental co-operation, together with those of nongovernmental European organisations with competence on higher education. We expect Universities again to respond promptly and positively and to contribute actively to the success of our endeavour."

There are action lines for which the UK higher education systems are seen as advanced, e.g. quality assurance. Other action lines are in the process of being initiated, although at different rates in different institutions, e.g. the Diploma Supplement. However, the statement that **"Access to the second cycle shall require successful completion of first cycle studies…"** can be construed to be a threat to the UK's integrated Masters Qualifications (e.g. MSci, MEng, MChem etc). It is also notable that in 1999 the European Credit Transfer and Accumulation System (ECTS) was merely an example of a credit transfer system.

The Prague Communiqué (2001) reaffirmed the commitment to the Bologna Declaration and added:

- Lifelong learning will be an essential element of the European Higher Education Area.

- Students should participate in and influence the organisation and content of education at universities and other higher education institutions.

- Promotion of the attractiveness of the European Higher Education Area.

While in many countries these concepts are relatively new, commitments to lifelong learning and student involvement in university decision making are well established in UK HEIs. It is not envisaged that any of these present challenges to UK Chemistry Departments.

The Berlin Communiqué (2003) largely reiterated the above, monitored progress and established action plans. It also included a distinct third cycle doctoral level. An important development was the adoption of The Lisbon Convention on the Recognition of Higher Education in the European Area (see below). However, commitment to ECTS as the preferred system of credit began to appear:

"Ministers stress the important role played by the European Credit Transfer System (ECTS) in facilitating student mobility and international curriculum development. They note that ECTS is increasingly becoming a generalised basis for the national credit systems. They encourage further progress with the goal that the ECTS becomes not only a transfer but also an accumulation system, to be applied consistently as it develops within the emerging European Higher Education Area."

The principal announcement of the Bergen Communiqué (2005) was the adoption of an overarching framework for qualifications in the EHEA:

"We adopt the overarching framework for qualifications in the EHEA, comprising three cycles (including, within national contexts, the possibility of intermediate qualifications), generic descriptors for each cycle based on learning outcomes and competences, and credit ranges in the first and second cycles. We commit ourselves to elaborating national frameworks for qualifications compatible with the overarching framework for qualifications in the EHEA by 2010, and to having started work on this by 2007. We ask the Follow-up Group to report on the implementation and further development of the overarching framework."

It could be argued that adoption of the EHEA Qualifications Framework confirms the ECTS system as the accepted credit transfer system. Any other locally adopted system must be clearly comparable to ECTS. The London Communiqué (2007) further strengthened the statement to:

"Efforts should concentrate in future on removing barriers to access and progression between cycles and on proper implementation of ECTS based on learning outcomes and student workload."

Some common misconceptions corrected

- The EHEA is not a single homogenous higher education system.
- The Bologna Process is not a European Union initiative. It is an intergovernmental agreement, between both EU and non-EU countries.
- The Bologna Process does not have the status of EU legislation and there are no legal obligations for the signatory states.
- There are few rules to be complied with.
- There are no sanctions.
- There are no policemen, inspectors nor bodies to appeal to.

Other Important Agreements

The EHEA Qualifications Framework*

In 2005, the overarching framework for qualifications in the EHEA was adopted by the Bergen Ministerial Meeting. The basic framework adopted is one of **three cycles** of higher education qualification. The Qualifications Framework contains statements referring to both outcomes and typical ranges for ECTS credits for both First and Second Cycle qualifications:

- "1st cycle: Typically include 180-240 ECTS credits.
- 2nd cycle: Normally include 90-120 ECTS credits, with a minimum of 60 credits at the level of the 2nd cycle.
- 3rd cycle: No ECTS range given."

The European Credit Transfer and Accumulation System (ECTS) is a tool of the European Commission[1] that has been adopted as the primary credit system of the Bologna Process and hence the EHEA. It is:

- "A student-centred system based on the student workload required to achieve the objectives of a programme, objectives preferably specified in terms of the learning outcomes and competences to be acquired.
- Based on the principle that 60 credits measure the workload of a full-time student during one academic year. The student workload of a full-time study programme in Europe amounts in most cases to around 1500-1800 hours per year and in those cases one credit stands for around 25 to 30 working hours.
- Credits in ECTS can only be obtained after successful completion of the work required and appropriate assessment of the learning outcomes achieved. Learning outcomes are sets of competences, expressing what the student will know, understand or be able to do after completion of a process of learning, long or short.
- Student workload in ECTS consists of the time required to complete all planned learning activities such as attending lectures, seminars, independent and private study, preparation of projects and examinations.
- Credits are allocated to all educational components of a study programme (such as modules, courses, placements, dissertation work, etc.) and reflect the quantity of work each component requires to achieve its specific objectives or learning outcomes in relation to the total quantity of work necessary to complete a full year of study successfully."

*see http://www.bologna-bergen2005.no/

[1] http://ec.europa.eu/education/programmes/socrates/ects/index_en.html#3

It is also held that no more than 75 ECTS can be accumulated in any 12-month period. It should be noted that an academic year of 1500-1800 hours of nominal study, commonly encountered elsewhere in Europe, is longer than the norm within the UK, where a 1200 hour academic year is more typical.

The Lisbon Convention

The Lisbon Convention on the Recognition of Higher Education in the European Area was adopted in 2003 by the Berlin Ministerial Meeting. It sets the basis upon which mutual recognition of degrees should occur. There are three key points for our purposes:

- The responsibility to demonstrate that a higher degree application does not fulfil the relevant requirements lies with the body undertaking the assessment.

- Each country shall recognize qualifications – whether for access to higher education, for periods of study or for higher education degrees – as similar to the corresponding qualifications in its own system unless it can show that there are substantial differences between its own qualifications and the qualifications for which recognition is sought.

- All countries shall appoint a national information centre, one important task of which is to offer advice on the recognition of foreign qualifications to students, graduates, employers, higher education institutions and other interested parties or persons. These have emerged as the National Recognition Information Centres or NARIC's.

"Mastering Diversity" – UK HE Europe Unit Report

In the summer of 2008, the UK HE Europe Unit published a report comparing current arrangements for Masters provision in France, The Netherlands, Germany and Bulgaria. The full Executive summary is reproduced in Appendix II. Some key points are listed here:

- There is considerable diversity in the available provision, both within and between countries.

- By far the most common length of consecutive Bachelors plus Masters programmes is 5 years, although a great deal of diversity exists in how this packaged (e.g. 4+1, 3+2, or 3.5+1.5 years).

- In practice, 1-year (2-semester), 1.5-year (3-semester) and 2-year (4-semester) second-cycle programmes can be found in all of the countries considered, but there is an overwhelming preponderance of 2-year programmes, particularly for scientific, technical and engineering training.

- Bachelors and Masters are usually 180-240 and 60-120 ECTS credits, respectively.

- Different types of Masters can also be found, e.g. in France the full Masters qualification is usually acquired through a two-year full time equivalent (FTE) programme (120 ECTS), acquired in two separate stages, M1 and M2, with the entry to the M2 being selective and the M1 operating as an exit point; in The Netherlands, a distinction is drawn between 'Standard' and 'Research' Masters.

Chapter 2

Surveys of UK Chemistry Departments

UK HEIs are leading in many of the action lines of the Bologna Process, such as the promotion of lifelong learning, student involvement in university governance, and both institutional and national quality assurance. However, concern has been expressed about the 'fit' of some current UK degree programmes to the requirements of the EHEA.

Currently there are a range of qualifications offered in Chemistry by UK HEIs. These are:

- Bachelors of Science, BSc;
- integrated Masters of Chemistry or Science, MChem or MSci, respectively;
- postgraduate free-standing Masters of Science, MSc (which usually features a relatively high taught component) or Masters of Research, MRes (which is more research focussed);
- PhD.

This flexibility of degree provision in the UK is widely regarded to be one of its strengths. In this chapter we survey the perceptions of heads of UK chemistry departments, analyse the structure and contents of UK chemistry degrees and use SWOT analysis meetings to conduct a detailed assessment of the preparedness of a cross-section of UK chemistry departments. Departments were encouraged to include student representatives in these meetings, and additional student opinion was sought from the National Union of Students (see **Appendix III**).

UK chemistry departments also offer PhD programmes of study. PhD study is more common in chemistry than in many other subjects, reflecting the importance of highly qualified chemistry researchers to the economy. There is a great deal of variety in the length of any individual student's programme of study. Funding for PhD study was traditionally for three calendar years but despite this most candidates take longer to complete the programme. In response to this, and to negative comments in international subject reviews, it has recently become common for funding agencies to provide funding to cover longer periods of study, generally up to four years.

Departmental Perceptions

In the summer of 2007, heads of all UK chemistry departments (41 in total) were asked to complete a questionnaire regarding their department's readiness for the introduction of the EHEA; 22 responses were received. The questions were posed with a numerical answer 1 (low/unimportant) - 10 (high/important). Table 1 contains both the average and most frequently reported values for the responses provided as well as the number of departments providing the most frequent response (in parentheses). In reviewing the results of the survey, of greatest concern are the low values for the answers to the question: "how prepared is the department for the introduction of the Bologna process". It is clear that at this point Heads of UK Chemistry Departments believed that their department was poorly prepared for the introduction of the EHEA.

Table 1. Perceived readiness of UK Chemistry Departments for the introduction of the EHEA.

	Average reply	Most frequent reply (No. of
How closely does your current Bachelors degree in Chemistry fit the Bologna process?	7	9 (4)
Do you think that it is important for your department to provide a Bachelors degree in Chemistry that fits the Bologna process?	8	10 (8)
Do you think that it is important for all of the Bachelor's degrees in your department fit to the Bologna process?	6	10 (4)
How closely does your current Masters degree in Chemistry fit the Bologna process?	2	1 (11)
Do you think that it is important for your department to provide a Masters degree in Chemistry that fits the Bologna process?	6	10 (4)
Do you think that it is important for all of the Masters degrees in your department fit to the Bologna process?	5	1 (5)
Do you feel adequately informed about the Bologna process?	5	3 (3) 8 (3)
How prepared is your department for the introduction of the Bologna process?	4	1 (5)

Further analysis of the responses reveals that in many cases it was believed that currently offered Bachelor's degrees do provide a reasonable fit with the requirements of the EHEA. However, it was generally held that current UK Masters qualifications gave a poor fit to the requirements of the EHEA, with half of all responses giving the minimum available score to this question. There was greater variety in the responses to questions referring to the importance of this result, which may reflect how important the international scene is to the respondents.

Student Workloads and Learning Outcomes

Learning outcomes describe what a learner is expected to know, understand or be able to do after successful completion of a process of learning. Notional student workload indicates the time an average student at a given level needs to complete all learning activities (such as lectures, seminars, projects, practical work, exams, self study, etc.) to achieve the expected learning outcomes. Student workloads were analysed by a survey of all UK Chemistry departments, and an attempt was made to conduct a similar survey of learning outcomes by analysis of Programme

Specifications. However, it transpired that there is such variability in both the structure and content of Programme Specification documents from different HEIs that this was not feasible. The only common statement was that they had been written with reference to the QAA Chemistry Subject Benchmark Statements (**Appendix I**). The Subject Benchmark Statements represent the attributes and capabilities expected of those who complete a course of study and are published to give guidance to HEIs in developing the learning outcomes for their courses. They provide:

- The major aims and purposes that may be associated with degree programmes in Chemistry.
- An outline of subject-matter that may be expected to be covered in study programmes leading to such degree qualifications.
- The abilities, competencies and skills to be developed in students through the study of Chemistry.

Benchmarking statements do not, however, dictate detailed curricula. They are used in this study to give information relating to sector-wide threshold learning outcomes. More detailed analysis of Learning Outcomes can only be achieved on an institution by institution basis.

Bachelor of Science, BSc

The Bachelor of Science (BSc) degree is a long-established qualification in the UK, and in this study 23 departments provided data on their BSc courses. It remains the most widely awarded qualification in Chemistry, accounting for ca. 60% of UK graduates in 2007. Quality assurance is achieved via institutional and Quality Assurance Agency processes, and professional 'Recognition' is by the Royal Society of Chemistry.

The BSc is unambiguously a first cycle undergraduate qualification. Whilst some courses of longer duration are available, the typical full-time BSc is three academic years long (or four academic years in Scotland). As such, when a Diploma Supplement is provided it meets the definitions contained in the series of communiqués composing the Bologna Process for the introduction of a system of easily readable and comparable degrees.

BSc programmes of three academic years' duration are allocated 180 ECTS, which is within the typical credit ranges noted in the EHEA Qualifications Framework. Longer courses can be allocated more credits; part-time courses can be awarded credits on a pro-rata basis. The QAA Subject Benchmark Statements provide Learning Outcomes for BSc programmes that are fully consistent with a first-cycle qualification (**Appendix I**).

Four Year Integrated Masters, MChem and MSci

Integrated Masters qualifications have been available in the UK for over a decade, and accounted for ca. 40% of UK Chemistry graduates in 2007. In this study, 21 departments provided data on their four year integrated Masters degrees. These degrees are 'accredited' by the RSC at Chartered Chemist (CChem) level, and in general students graduate with the Masters qualification without first obtaining a Bachelors degree. The statement from the initial Bologna Declaration that **"Access to the second cycle shall require successful completion of first cycle studies…"** is currently a potential block to the recognition of the UK's integrated Masters degrees as true second cycle qualifications.

ECTS credits

If a way can be found to overcome the above access requirement, the MSci and MChem degrees of four academic years duration could be considered to be the equivalent of a three academic year BSc with an additional 'Masters' year. Using accepted norms this is allocated 240 ECTS (180B + 60M), which is below the typical ranges given in the EHEA Qualifications Framework for a combined first and second cycle qualification:

- "1st cycle: typically include 180-240 ECTS credits; plus
- 2nd cycle: normally include 90-120 ECTS credits, with a minimum of 60 credits at the level of the 2nd cycle".

It is possible that four year integrated Masters degrees are sufficiently intensive that a greater number of ECTS credits could be attributed to these than the standard 60 ECTS for an undergraduate academic year. Hence we analysed the workloads associated with these degree programmes; the averages and standard deviations of which are presented in **Table 2**.[2]

Table 2. Chemistry four year integrated Masters degrees, total workloads; standard deviations in parentheses

	Contact Hours	Total Hours	ECTS (25hr/ ECTS)
Years 1-3	1235 (142)	3949 (794)	158 (32)
Year 4	520 (156)	1302 (266)	52 (11)
Year 1-4 (Std Deviation)	1755 (243)	5251(1025)	210 (41)*

*Only one department reported a course with a workload of greater than 6750 hours (i.e. 270 ECTS @ 25hr/ECTS).

It is clear that there is a great deal of variability in the workloads associated with degree programmes across the departments that responded to the survey, with large standard deviations for all values. Only one department claims the 270

[2] There is a great deal of variety in the degree programmes offered, including opportunities for periods of study in partner universities, industrial placements and a number of Chemistry with/and another subject degrees. This analysis was carried out for four academic year single honours Chemistry courses without external placements. No significant difference was seen between those programmes designated as MChem and MSci. Hence these are combined into a single analysis. 20 courses were included. All degrees have an extended research project as a component of the final year. In-lab hours associated with these have been designated as contact hours, where no distinction was made in the return between in-lab and private study hours for these projects the overall workload allocated was divided equally between the two.

or greater ECTS credits necessary for its integrated Masters degree to be recognised as a combined first cycle and full second cycle qualification. Particularly of note is that the Masters level content, which is concentrated in year four of the degree programmes, is far lower than the 90 ECTS required for recognition as equivalent to a full second cycle qualification. Therefore, based on workload arguments, there is no general case to be made for additional credits to be assigned to , the four year, integrated Masters degrees. Consequently, there is a risk that such degrees will not be recognised within the EHEA as being equivalent to a combined first cycle and full (i.e. >90 ECTS) second cycle Masters programme.

Learning Outcomes

Learning outcomes describe what a learner is expected to know, understand or be able to do after successful completion of a process of learning. For all UK four year MSci and MChem Chemistry degrees to be recognised as equivalent to combined first and full second cycle Masters qualifications the QAA Subject Benchmark Statements must be widely acknowledged as providing sufficient learning outcomes.

The following statements are used in the subject benchmark statements to describe generally the threshold level of competence for holders of a Masters degree in chemistry:

- Knowledge base extends to a systematic understanding and critical awareness of topics which are informed by the forefront of the discipline.
- Problems of an unfamiliar nature are tackled with appropriate methodology and taking into account the possible absence of complete data.
- Experimental work is carried out independently and with some originality.
- Substantial research project at the forefront of the discipline is completed effectively.
- Generic skills are developed appropriately for professional practice.

The learning outcomes as expressed in the Chemistry Subject Benchmark Statements are clearly necessary for four year MSci and MChem Degrees to be recognised to be equivalent to combined first and full second cycle Masters qualifications. However, there is a risk that they may not be considered to be sufficient for this purpose without greater detail. Particularly, there is no reference to how extensive the knowledge and skills acquired at the Masters level should be.

Many UK Chemistry departments offer students the opportunity to undertake study with an industrial partner. These student placements can be in addition to the standard study programme (see below) or can take the place of other elements of the degree (usually the final research project). During these latter placements, theory courses are also taken, often through distance learning. A good industrial placement can provide the graduate with wider experience and enhanced skills in comparison to their colleagues, who spend their entire degree in the academic institution.

Five Year Integrated Masters, MChem and MSci

In Scotland it is common for integrated Masters degrees of five academic years duration to be offered. Using currently accepted norms these can be allocated 300 ECTS credits, 240 at Bachelors level [1st cycle] and 60 at Masters level [2nd cycle]. These degrees are 'Accredited' by the RSC at CChem level, and learning outcomes for these courses are generally equivalent to those claimed for four year Masters degrees offered elsewhere in the UK. Significantly, suitably qualified applicants can be accepted directly into the second year of the programme and undertake a further four years of study.

Two departments in England, Imperial College and Loughborough University, offer a five academic year MSci degree in Chemistry with a Year in Industry. This contrasts with most courses that provide industrial placements as an alternative to some element of in-house study rather than in addition to all elements of in-house study. These courses can be allocated 300 ECTS credits, composed of 180 at Bachelors level and 120 at Masters level[†]. These courses also offer the additional learning outcomes associated with research in an industrial environment.

Postgraduate Masters, MSc and MRes

A number of HEIs offer MSc or MRes courses in Chemistry or closely related subjects. The availability of post-graduate Masters in the core discipline of Chemistry has been in decline for a number of years, which is linked to the lack of funding for home students at this level. Although there is a long history of the provision of MSc Chemistry degrees in the UK, these have never been highly regarded. For many home students an MSc has been seen as a means to 'top up' a first degree that was passed at a level that was not sufficient to qualify the student for direct access to PhD funding. MRes degrees are a more recent innovation and are often associated with preparation for PhD study at subject interfaces, particularly with the biological sciences.

Entry to MSc and MRes courses requires at least a Bachelors qualification, and therefore are unequivocally second cycle qualifications. These courses are of one calendar year duration and under current rules are hence normally allocated 75 ECTS. This is less than required to be designated as a full second cycle qualification, according to the EHEA Qualifications Framework. In order to establish whether these courses could be allocated a greater number of ECTS credits, we analysed the workloads of one year MSc and MRes courses (**Table 3**).[3] Only one Department claimed workloads in excess of 90 ECTS credit. However, it should be noted that this is greater than the generally accepted maximum attainable in one calendar year (75 ECTS). All other Departments claimed workloads equivalent

[†] Note: 60 ECTS credits of this course are composed of the industrial placement, which can be credited at the Masters level, although currently Loughborough does not give credit for the industrial year.

[3] Replies were received from eight HEIs. Where a single Department offers more than one course, a single course was selected to represent that department.

to approximately 75 ECTS and there is no evidence from these responses for the allocation of sufficient ECTS for these one year post-graduate Masters courses to be considered to be full second cycle qualifications of the EHEA.

Table 3. Chemistry Postgraduate Masters, total work-loads; standard deviation in parenthesis.

	Contact Hours	Total Hours	ECTS (25hr/ ECTS)
Minimum	182	1006	40
Maximum	1050	2688	108*
Average	631 (352)	1761 (434)	70 (17)

*Only one department reported a course with a workload of greater than 2250 hours (i.e. 90 ECTS @ 25hr/ECTS).

Two Year Postgraduate Masters, MSc

We were informed of only one two year postgraduate Masters in Chemical Sciences (20 months full time), at the University of Aberdeen. This course was developed to provide a postgraduate Masters degree that was designed to meet the requirements of the EHEA. It is unequivocally a second cycle qualification that is allocated 120 ECTS credits at the level of the 2nd cycle.

SWOT Analysis

As part of the Mastering Bologna project, 11 chemistry departments were invited to take part in a SWOT analysis and an evaluation of their readiness to engage with the Bologna process. The meetings were facilitated and a report presented by an external consultant, Mike Rawlins assisted by John Murrell (**Appendix IV**).

The purpose of the SWOT analysis meetings was not to create a consensus around issues but rather to gather the range of opinions that exist. However, the following key findings have emerged:

Funding was raised as a major issue by all Departments and appears to impact directly on their ability to align with the Bologna Process. Concerns are focused in three main areas:

- The perceived gap in funding provision at the Masters level and hence the need to provide and resource an additional year of study.
- The burden on students in terms of their financing of an additional year of study.
- The inconsistency of funding models and approach used by HEFCE and the Research Councils.

Recruitment - There are wide ranging views on the level of risk facing the recruitment of students into Chemistry as a result of the Bologna process. It is clear that the possible changes to degree frameworks will create uncertainty and will have the potential to undermine recruitment efforts. Therefore, consistent approaches to the EHEA need to be developed to ensure confidence and stability. On the positive side Departments see opportunities arising to improve the quality of qualified students and also to attract more EU and overseas students.

Employment - Linked to recruitment is the challenge for the UK Chemistry HE sector to ensure that graduates have the ability to successfully compete in employment markets. It appears essential that any changes proposed to the degree framework are communicated exceptionally well to all stakeholders, particularly employers, and put into the European context. The UK Chemistry HE sector needs to establish clarity to ensure that qualifying students are valued and able to compete at the highest levels.

Other Resources - Most departments believe in the EHEA they would need to increase or modify their capacity in order to cope with another year's cohort at Masters equivalent level. The impact of any changes will need to be fully assessed in terms of departmental logistics and resources implications [human, physical and financial]. This is particularly important in subjects such as Chemistry where a large part of Masters level programmes require expensive laboratory facilities. The community believes that a poorly resourced transition would create unnecessary stress and undermine the current situation.

Learning from past experience - The development of the integrated Masters was not a happy experience for the UK Chemistry HE sector, and there is a strong desire to learn from the past in order to ensure that any transitions relating to the Bologna Process are well co-ordinated. Many Departments emphasised that the RSC has an important role to play in providing direction and enabling the UK Chemistry HE sector to align around preferred solutions in the EHEA. A critical aspect of this role is to ensure that all solutions are properly recognised and accredited. It is also recognised that the UK Chemistry HE sector cannot move alone and needs to be strongly linked to the other subjects and professional bodies when making final recommendations to HEFCE and the Government. The RSC can have a pivotal role in achieving this.

The EHEA provides a real challenge and opportunity for the various stakeholders to work together to create a teaching and research environment that ensures the UK Chemistry HE sector emerges from any Bologna Process transition in a stronger and more competitive position. At the close of the SWOT meeting the individual participants were asked the following question:

"Taking into account everything that you have heard about the Bologna Process and making the assumption that proper funding will be available, which model do you favour?"

Out of 44 responses:

- 25 Participants (57%) favoured moving to a system with a total of 5 years to the completion of a Masters;
  - 16 (36%) advocated the 3 years Bachelors + 2 years Masters model;
  - 9 (21%) participants advocated a (integrated 3B + 1M) + 1M model.
- One participant (2%) favoured moving to the (integrated 3B + calendar year M) model.

- Six participants (14%) favoured moving to the 3 +1.5 + 3 model.

- 12 Participants (27%) favoured maintaining the status quo (3B + 1M) model.

Although a majority of those who took part in the SWOT meetings favoured moving to a system with a total of five years to the completion of a Masters degree, no consensus was found For either model discussed. It can be seen that there was no great support for the models with extended years, either with a final calendar year or with an extra half year.

Chapter 3

Our Conclusions and the Ways Forward

It may at first sight appear that the UK chemistry HE sector is already fully prepared for the introduction of the EHEA. A diverse range of degree structures, with different exit and entrance points for Bachelors, Masters and PhD are available throughout the UK and no degree structure available in the UK is in any way excluded from the EHEA. Yet the majority of respondents to our surveys believe that their departments are inadequately prepared for the EHEA and that their Masters degrees are a poor fit to the requirements of the EHEA. Our analysis of UK chemistry degree programmes support these concerns.

In this Chapter we review the various types of chemistry degree programmes available in the UK. In our analysis we focus on how each element of the UK provision will contribute to the ability of UK Chemistry higher education to succeed within the EHEA. This success is interpreted as the following:

- To provide the high quality graduates necessary to underpin the knowledge-based economy, both as chemistry professionals and in the wider economy;
- To provide graduates with the skills, knowledge and experience necessary to compete successfully in both global and domestic employment markets;
- To prepare graduates for advanced study;
- To provide students with a fulfilling educational experience;
- To attract the highest quality students, both nationally and internationally, to study chemistry in the UK.

In order to achieve these aims it is necessary that UK chemistry degrees are acknowledged to be of the highest quality. Consequently, when making international comparisons we do so to the very highest standards. Further to this we then proceed to make recommendations of what is necessary to achieve that success.

Bachelor of Science, BSc

UK chemistry BSc degrees do clearly meet all of the criteria necessary to be acknowledged as high quality first cycle degrees throughout the EHEA. They provide students with the skills, knowledge and experience necessary to compete for employment in the general economy as well as a sound preparation for future study. We believe that the introduction of the EHEA is unlikely to have any significant impact upon recruitment, of either Home/EU or overseas students, to these degree programmes. However, the introduction of new Bachelor degrees across the EHEA (some of which taught in English) will increase competition between HEI's and open HE systems to applicants holding scholarships from funders who only support three years of study (e.g. Government of Singapore). The heads of UK chemistry departments have confidence in the future success of their BSc degrees. We fully expect that UK BSc degrees in chemistry will continue to be successful after the introduction of the EHEA.

Four Year Integrated Masters, MChem and MSci

The survey of Heads of UK chemistry departments shows that there is considerable concern for the continued success of UK chemistry integrated Masters programmes. The majority of department heads believed that their Masters qualifications are currently a poor fit to the requirements of the EHEA. It is also clear from the data collected during this project that there is a likelihood that integrated Masters qualifications will not be generally acknowledged internationally to be equivalent to a combined first cycle and full second cycle qualification in the EHEA. Almost half of UK chemistry students graduate with these qualifications and any threat to their continued success could have significant negative consequences for the sustainability of many UK chemistry departments.

For more than a decade MChem and MSci Chemistry degrees have enabled graduates to fill roles as Chemistry professionals, as well as in the wider general economy. We predict that it is likely that MChem and MSci Chemistry degrees will continue to supply graduates who have skills that are attractive to non-chemistry employers (e.g. in the financial services sector). Similarly, it is likely that domestic employers of Chemistry professionals will continue to recruit graduates of MChem and MSci Chemistry degrees, certainly in the early stages of the implementation of the EHEA. However, this is unlikely to be true of international employers of Chemistry professionals at this level, who will be using their own local systems to set recruitment criteria. It is also likely that graduates of two year Masters degrees provided elsewhere in the EHEA will be better prepared to succeed in recruitment processes that include technical interviews/examinations, which are commonplace in the Chemicals industry. This will compromise the ability of UK graduates of these degrees to compete successfully in employment markets.

For the last decade, MChem and MSci Chemistry degrees have also been the preferred entry route for PhD study in the UK. However, there has been concern for some time that they do not provide sufficient preparation for the successful completion of a PhD programme within three years. This has led the Research Councils and some other funders to extend the length of funding for PhD studies to, up to four years. We believe that graduates of MChem and MSci Chemistry degrees who have no additional Masters level experience and only have three years of funding for their PhD studies will be at a severe disadvantage in completing their studies on time if they are expected to reach the current high standards. We also believe that they will be at a disadvantage, in their skills and knowledge as well as in the perception of recruiters, in comparison to Masters graduates with a total of five years university education when attempting to move to non-UK universities within the EHEA for PhD studies.

The SWOT analyses showed that moving to a model with a total of five years to Masters graduation was seen by most departments as providing better prepared graduates and postgraduates as more time would be available for teaching, research and developing skills. Furthermore, analysis indicated that such graduates would be better prepared to compete in employment markets and for future study opportunities.

However, it was widely reported that implementation of this model would require substantial new funding, both of the students and institutions.

As part of the SWOT meetings the possibility of extending these degree programmes by the inclusion of full calendar years or by adding up to half a year was proposed (i.e., 3 + 1* or 3 + 1.5, see appendix IV, point 2.1). These proposals had little support as it was believed that they would not remove any perceived inadequacies of these four year degrees, but would place additional resource burdens on both departments and most importantly students.

MChem and MSci Chemistry degrees have proven to be attractive courses of study to overseas students. The 'fast-track' that these offer to Masters Qualification could continue to attract students. However, if these courses come to be seen to be content-light and an insufficient qualification for entry into international employment as a Chemistry professional, or for further study across the EHEA, then they are likely to be less attractive to students from within the EHEA. Outside the EHEA the situation is likely to be more complex. Overseas students are often funded by their home governments or local educational charities. The attractiveness of degree programmes depend on how well they fit with the local rules. Some funders will only fund studies of a fixed length; others will fund a first degree programme regardless of length or the level of the final qualification. The opportunity to attain a Masters qualification as part of a first degree is likely to remain attractive to those students who are in possession of a scholarship that will allow them to take these degrees. However, should MChem and MSci degrees lose their reputation for providing graduates with good employment prospects their popularity with overseas students will decline. Any loss in overseas students will have negative consequences for the sustainability of a number of UK Chemistry departments.

Our workload data, and the opinions gathered from a number of Chemistry departments, support the proposal that adding an extra year of Masters level training to the integrated Masters qualification is required to equip graduates for specialist employment and PhD study. However, all the departments consulted noted that this will not be possible without new additional funding.

Five Year Integrated Masters

Scottish five year integrated Masters programmes provide graduates with similar skills, knowledge and experience as four year programmes in the rest of the UK. The Scottish model is one of four academic years (240 ECTS) of Bachelors level study followed by one academic year (60 ECTS) of Masters level study. We are concerned that, while these degree programmes fit to widely accepted credit norms within the EHEA, their graduates may not be as well prepared for employment markets and further study as graduates of programmes composed of two academic years (i.e. 120 ECTS) of Masters level study. This will only be fully resolved as the EHEA develops, but the success of these graduates in employment markets and further study is expected to be similar to those described above for other UK integrated Masters degrees, for which the stated Learning Outcomes are very similar. However, Scottish departments could consider increasing the proportion of Masters level components of their courses without significant resource implications.

The five year integrated Masters degrees with an intercalated Year in Industry such as those degrees offered by Imperial College, Strathclyde and Loughborough Universities do provide their graduates with additional advantages over their colleagues who graduate after four years. Graduates of these degree programmes have both a full year's experience in an industrial laboratory and experience of a substantial academic research project. The former is expected to make these graduates very attractive to industrial employers, whilst the combination of industrial experience and a major academic research project will prepare them well for PhD study. On graduation they have familiarity with a wider range of modern research techniques, and to a greater depth, than those who have only had either industrial experience alone or an academic project alone. Students are funded by the industrial partner while they are on the industrial placement and do not have any additional financial burden. Also, industrial partners from both within and outside the UK are used, providing an additional international dimension to the degree programmes. Such degrees programmes have been successful for several years and are expected to continue to be so after the introduction of the EHEA. It is likely that they will become more attractive to students who wish to have a degree that has five years of study to the Masters qualification.

There is some concern that should this five year degree structure become commonplace there may be a problem with the availability of suitable industrial placements. A sizeable increase in the number of industrial placements will require even greater Chemical Industry engagement in HE than currently in place. It is also imperative that the sustainability of the supply of industrial placements is ensured. To achieve this objective, action is required by the RSC and other industry bodies (e.g. the Society of Chemical Industries), the Regional Development Agencies, and the Department for Innovation, Universities & Skills.

Postgraduate Masters, MSc and MRes

The numbers of students taking postgraduate Masters Chemistry degrees in the UK has been historically relatively small, when compared to those taking integrated Masters degrees. Much of the reason for this is that integrated Masters graduates, and in some HEIs Bachelors graduates, are qualified for direct entry to PhD study and postgraduate Masters have been seen as giving little additional advantage in employment markets, unless providing specialist skills and knowledge. It is also clear that there is a danger that UK one year postgraduate Masters qualifications will not be generally acknowledged to be full (i.e. 90 ECTS) second cycle qualifications in the EHEA. Currently accepted norms preclude any student from attaining greater than 75 ECTS credits in any one calendar year. Our workload analysis suggests that this is approximately what is achieved in the majority of Departments that responded.

It is reasonable to assume that UK students seeking careers as Chemistry professionals will continue to favour integrated Masters degrees for some time into the future. On this basis, the pool of candidates for taught postgraduate Masters, MSc, will be dominated by non-UK students, both from within and outside the EHEA, with a small number of UK students seeking to upgrade their qualification. Our analysis suggests

that these degrees are unlikely to be acknowledged to be equivalent to two year Masters degrees offered elsewhere in the EHEA, and are more likely to be viewed as intermediate qualifications, similar to, for example, the French M1 degrees. MRes degrees are more research orientated than taught MSc degrees and are considered to be primarily focused on preparation for PhD studies. Indeed, they sometimes form the first year of a four year PhD programme (i.e. an 'integrated PhD'). The future of these degrees is largely dependent upon how UK integrated Masters degrees are viewed within the EHEA. If graduates of UK integrated Masters degrees are widely accepted as being equivalent to graduates from other Masters degrees from within the EHEA, then MRes degrees will most probably continue in their current niche roles at subject interfaces. However, we note that if graduates of integrated Masters degrees are not perceived to be sufficiently well prepared to complete a PhD within three years nor to compete successfully in the international employment market, then MRes degrees will become an increasingly important qualification. MRes degrees also have the potential to provide the second year of two-years of Masters level training. This could be as a stand-alone qualification, or as part of a two-year Masters degree, or as a part of a four year integrated PhD programme.

Two Year Postgraduate Masters

Although only one of these degrees is currently offered in the UK, at the University of Aberdeen, this degree structure could become an important constituent of the range of degrees offered by UK Chemistry departments after the introduction of the EHEA. It is unequivocally a second cycle qualification and has a great deal of Masters level study. This course has been running for two years and applications for the programme have been high, but these have not converted well to students actually registering for the course. This has been attributed by the department to the lack of student funding for this degree.

Recommendations

The UK HE sector is one of the strongest in the world. UK HEIs have a reputation for producing excellent Chemistry graduates who can compete successfully in international job markets. UK HEIs are also to be found performing well in international university league tables, and the UK has a long history of being a popular destination for international scholars, at both undergraduate and postgraduate levels. The recommendations that follow are for actions that are required to maintain and further strengthen these positions.

It is not the purpose of this report to dictate a single solution to the challenges faced by HEIs with the introduction of the EHEA. Indeed, there is no mechanism by which this could be done. HEIs will make their own preparations for the EHEA in the light of their own aims and objectives. It is this independence of action that has led to the diversity of UK Higher Education that is so highly prized. However, our investigations lead us to the recommendations that follow. We strongly believe that The UK HE Chemistry sector cannot respond to the introduction of the EHEA in isolation. We concur with recent recommendations from the Royal Society that eight years of study to graduation with a PhD should be the norm for all STEM subjects.

UK Bachelor degrees are high quality first-cycle qualification. Indeed their structures have been reproduced across the world, not only in the EHEA. Individual HEIs will continue to review the contents of these programmes in the light of changing external circumstances, but the EHEA does not require any changes in the structures of these degrees.

Every potential version of Masters study that could be applied in the EHEA already exists somewhere in the UK. However, for the UK Chemistry HE sector to succeed in the EHEA the availability of a number of these models needs to spread more widely. Our surveys of UK Chemistry degrees and the majority opinion of the participants of the SWOT meetings both highlight the need for the availability of an additional year of Masters level education for the UK Chemistry HE sector to succeed in the EHEA. However, it is vital to retain flexibility in how this is structured, so as to meet the needs of all stakeholders, including those students not intending to proceed to PhD study or employment as Chemistry professionals. We do not see it as necessary that all degrees that are offered should fit any single perceived model. Flexibility in provision and the choice for students that it provides should be an aspiration for the whole EHEA.

Recommendation 1: We recommend that two academic years (120 ECTS) of Masters level education be made widely available in the UK. We make no recommendation on how the extra year is incorporated into the range of courses provided by individual HEIs, i.e. postgraduate one or two year courses, five year integrated Masters or all of these. However, we do recommend that that the current four academic year integrated Masters degrees remain for the foreseeable future.

Although diversity is a positive quality of the UK HE sector, it can only thrive if the system is clearly defined so that all stake-holders can understand the variety of provision. The pattern of development of UK degrees has led to a number of designations for UK degrees. MSci and MChem are both used as labels for integrated Masters degrees that are essentially the same. MSc and MRes are both used for postgraduate Masters, again with much similarity. MPhil is also used for research Masters, often given to candidates who have failed to meet all of the requirements of a PhD programme. It is highly likely that this will lead to confusion outside the UK.

Recommendation 2: We strongly recommend that the nomenclature of UK Science degree programmes be rationalized as a matter of urgency.

It is clear that one of the primary drivers for advanced study in Chemistry is the role that it plays in the knowledge-based economy. There is a long established tradition of collaboration in learning between HEIs, the Royal Society of Chemistry and the Chemicals Industry.

Recommendation 3: We recommend that HEIs strengthen their links with industry in the direct provision of student learning opportunities.

The SWOT meetings reported here show that the primary obstacle to the development of the diverse range of degree

programmes necessary for the UK Chemistry HE sector to succeed at all levels in the EHEA is that of funding, both for institutions and students. The implementation of proposals for increased postgraduate Masters provision require secure and sustained funding for HEIs. We firmly believe that with stable funding Chemistry departments across the UK will design new high quality advanced Masters degrees that will succeed in the long term.

Recommendation 4: We recommend that HEFCE and the Research Councils agree on financial responsibilities for Masters degrees and make sustainable new provision for Masters level education. This provision should be flexible, with policies that are enabling, rather than prescriptive.

It is difficult to predict how great the demand for these new courses will be and how that demand will change with time. Historically, demand from domestic students has been closely related to the availability of student funding. To avoid serious shortages in vital skills sets, we believe that positive action is needed to encourage the study of Chemistry at all levels by addressing student funding. This could be via the introduction of student scholarships, remission of fees for earlier study when advanced study is taken etc.

Recommendation 5: We recommend that new funding for scholarships for UK students undertaking Masters study is provided by HEFCE and the Research Councils.

Appendix I

Subject Benchmark Statement
Chemistry
QAA 186 09/07

Contents

Preface

Subject benchmark statements provide a means for the academic community to 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.

This subject benchmark statement, together with others published concurrently, refers to the **bachelor's degree with honours** [1]. In addition, some subject benchmark statements provide guidance on integrated master's awards.

Subject benchmark statements are used for a variety of purposes. Primarily, they are an important external source of reference for higher education institutions (HEIs) when new programmes are being designed and developed in a subject area. They provide general guidance for articulating the learning outcomes associated with the programme but are not a specification of a detailed curriculum in the subject.

Subject benchmark statements also provide support to HEIs in pursuit of internal quality assurance. They enable the learning outcomes specified for a particular programme to be reviewed and evaluated against agreed general expectations about standards. Subject benchmark statements allow for flexibility and innovation in programme design and can stimulate academic discussion and debate upon the content of new and existing programmes within an agreed overall framework. Their use in supporting programme design, delivery and review within HEIs is supportive of moves towards an emphasis on institutional responsibility for standards and quality.

Subject benchmark statements may also be of interest to prospective students and employers, seeking information about the nature and standards of awards in a given subject or subject area.

The relationship between the standards set out in this document and those produced by professional, statutory or regulatory bodies for individual disciplines will be a matter for individual HEIs to consider in detail.

This subject benchmark statement represents a revised version of the original published in 2000. The review process was overseen by the Quality Assurance Agency for Higher Education (QAA) as part of a periodic review of all subject benchmark statements published in this year. The review and subsequent revision of the subject benchmark statement was undertaken by a group of subject specialists drawn from and acting on behalf of the subject community. The revised subject benchmark statement went through a full consultation with the wider academic community and stakeholder groups.

QAA publishes and distributes this subject benchmark statement and other subject benchmark statements developed by similar subject-specific groups.

The Disability Equality Duty (DED) came into force on 4 December 2006 [2]. The DED requires public authorities, including HEIs, to act proactively on disability equality issues. The Duty complements the individual rights focus of the **Disability Discrimination Act** (DDA) and is aimed at improving public services and outcomes for disabled people as a whole. Responsibility for making sure that such duty is met lies with HEIs.

The Disability Rights Commission (DRC) has published guidance[3]s to help HEIs prepare for the implementation of the Duty and provided illustrative examples on how to take the duty forward. HEIs are encouraged to read this guidance when considering their approach to engaging with components of the Academic Infrastructure[4], of which subject benchmark statements are a part.

Additional information that may assist HEIs when engaging with subject benchmark statements can be found in the DRC revised **Code of Practice: Post-16 Education**[5], and also through the Equality Challenge Unit[6] which is established to promote equality and diversity in higher education.

Foreword

This document is a revision of the subject benchmark statement for chemistry first published by QAA in 2000.

In 2005, QAA asked the Royal Society of Chemistry (RSC) to consider whether the benchmark statement for chemistry should be revised, and if so to what extent. It also asked the RSC to consider incorporating integrated master's degrees in accordance with United Kingdom (UK) qualifications frameworks and to take into account other relevant developments within higher education (HE) and the chemical science profession.

The review group for the subject benchmark statement for chemistry acknowledges the contribution of the original benchmarking group (2000) in preparing its original statement and recognises the valuable contribution of the statement to chemistry HE in the UK (and beyond) during the past six years.

In revising the statement, the review group seeks to maintain the original intentions and purposes while giving consideration to recent developments in the discipline, HE and the chemical science profession. Studies at master's level have been incorporated to provide one comprehensive benchmark statement for chemistry, covering not only bachelor's degrees with honours but also all master's degrees in chemistry, ie integrated master's degrees, typically titled MChem or MSci, and standalone master's degrees, typically titled MSc or MRes, but not studies leading to the award of MPhil.

The review group adopted this approach since it considered the statement should more clearly illustrate not only the commonalities of degrees in chemistry but, more importantly, the distinct differences at the two levels. It also provides evident articulation to existing UK qualification frameworks and the Framework of qualifications for the European Higher Education Area, which was agreed by Ministers as part of the Bologna Process and which draws on the Dublin descriptors.

Revisions to the original bachelor's degree with honours sections of the statement are minor in most respects. Possibly the most significant amendments are the redrafting of the essential subject matter components and the changes to the subject knowledge section to make it less specific. These were made to address the continually increasing breadth of the discipline and diversity of contemporary chemistry qualifications.

June 2007

1 Introduction

1.1 This statement sets out the benchmark threshold standards in chemistry.

It focuses on four major aspects concerning programmes leading to bachelor's degree with honours and master's degree qualifications:

- the major aims and purposes that may be associated with degree programmes in chemistry
- an outline of subject-matter that may be expected to be covered in study programmes leading to such degree qualifications
- the abilities, competencies and skills to be developed in students through the study of chemistry
- recommendations concerning procedures appropriate for the teaching, learning and assessment of the knowledge, abilities and skills set out above.

1.2 This statement is intended to provide a broad framework within which HE providers can develop purposeful and challenging chemistry programmes that respond to the needs of their students, as well as to the evolving nature of the chemistry discipline. Its purpose is not to impose on HE providers a set of rigid conditions that would stifle innovation in programme development and in the design of learning experiences. It is hoped the statement will continue to make a valuable contribution to chemistry HE and assist in the maintenance of the standard of chemistry degrees and the graduates they supply to the job market.

1.3 Details of the aims, objectives and content of individual programmes will be found in the programme specifications and/or other documentation issued by HE providers.

2 Nature and Extent of Chemistry

2.1 Chemistry can be defined as the science that studies systematically the composition, properties, and reactivity of matter at the atomic and molecular level.

Since matter is everything that can be touched, seen, smelt or felt, it follows that the scope of the chemistry discipline is essentially limitless.

2.2 The subject of chemistry has been divided traditionally into three main branches: organic chemistry - the chemistry of (most) substances containing the element carbon; inorganic chemistry - the chemistry of all other substances; and physical chemistry - the application of concepts and laws to chemical phenomena. Analytical chemistry, which is concerned with the identification of materials and the determination of composition, has become accepted generally as a fourth branch. The nature of chemistry is such that there are no distinct boundaries between the branches of the discipline or indeed with other disciplines.

2.3 Historically, bachelor's degrees with honours in chemistry were developed to encompass all the main branches with a consequent emphasis on breadth of study as well as depth. While a breadth of understanding remains relevant, modern chemistry

is less likely to be categorised strictly in branches and, in reflecting this, degree programmes are designed increasingly on a thematic basis so encompassing topics that overlap traditional branches and address the interfaces of chemistry with other disciplines, such as chemical biology and chemical physics, and with applied fields,

such as environmental chemistry and materials chemistry.

2.4 Broadly-based degrees, commonly titled 'chemistry', remain relevant to the contemporary employment needs of the chemical science profession. Many HE providers now also award chemistry degrees with titles denoting a specialism, eg medicinal chemistry, analytical chemistry, environmental chemistry. These courses tend to attract students with more definite career aspirations. It is accepted that the extent of breadth of study and the depth to which individual topics are treated will vary with the nature

of specific chemistry programmes. It is however critical for employers of chemists that specialist learning objectives in terms of chemistry reflect the degree title.

2.5 In reflecting the vocational nature of chemistry, many HE providers offer degree courses that incorporate a period of study in industry. Such placements are designed on the basis of an agreed programme of work acceptable to both the HE provider and industrial partner and usually involve both a major work-related chemistry project and some guided study.

3 Aims of Degree Programmes in Chemistry

3.1 The general aims of degree programmes in chemistry should include:

- to instil in students an enthusiasm for chemistry, an appreciation of its application in different contexts and to involve them in an intellectually stimulating and satisfying experience of learning and studying
- to establish in students an appreciation of the importance and sustainability of the chemical sciences in an industrial, academic, economic, environmental and social context
- to develop in students, through an education in chemistry, a range of appropriate generic skills, of value in chemical and non-chemical employment.

3.2 The main aims of bachelor's degree with honours programmes in chemistry should include:

- to provide students with a broad and balanced appreciation of key chemical concepts
- to develop in students a range of practical skills so that they can understand and assess risks and work safely in the laboratory

- to develop in students the ability to apply standard methodology to the solution of problems in chemistry

- to provide students with a knowledge and skills base from which they can proceed to graduate employment or to further studies in chemistry or multi-disciplinary areas involving chemistry.

3.3 The main aims of master's degree programmes in chemistry should include:

- to extend students' comprehension of key chemical concepts and so provide them with an in-depth understanding of specialised areas of chemistry

- to provide students with the ability to plan and carry out experiments independently and assess the significance of outcomes

- to develop in students the ability to adapt and apply methodology to the solution of unfamiliar types of problems

- to instil a critical awareness of advances at the forefront of the chemical science discipline

- to prepare students effectively for professional employment or doctoral studies in the chemical sciences.

3.4 Integrated master's degree programmes (eg MChem, MSci) should encompass both honours and master's level aims. Master's degree programmes (eg MSc, MRes) should ensure, through admissions processes or additional study, that the honours level aims have been covered.

4 Subject Knowledge and Understanding

4.1 Each HE provider awarding qualifications in chemistry is free to decide on the content, nature and organisation of its courses or modules and thus chemistry programmes offered by individual HE providers will have their own particular characteristics. Articulation of learning outcomes in chemistry to relevant sections of QAA's qualifications frameworks is considered key.

4.2 Bachelor's degrees with honours programmes ensure that students:

- are fully conversant with major aspects of chemical terminology

- demonstrate a systematic understanding of fundamental physicochemical principles with the ability to apply that knowledge to the solution of theoretical and practical problems

- gain knowledge of a range of inorganic and organic materials

- can evidence their understanding of general synthetic pathways, including related isolation, purification and characterisation techniques

- develop an awareness of issues within chemistry that overlap with other related disciplines.

4.3 A systematic and broad understanding of key chemical concepts will be assumed prior to undertaking master's level study. Master's students will develop an in-depth knowledge and critical awareness of a substantial area of chemistry, and be suitably prepared for contemporary professional practice in the chemical sciences or for studying further at doctoral level.

4.4 While recognising that master's degrees can cover a very wide range of chemistry areas, the desirable characteristics of a degree programme in terms of activities to be undertaken by the student are given below.

Research Training

- Project-specific experimental skills.

- Accessing literature.

- Planning, including evaluation of hazards and environmental effects.

- Making oral presentations, writing reports, including critical evaluation.

- Participating in colloquia.

Research Project

- Implementation of planned experiments.

- Recording of data and their critical analysis.

- Dissertation.

- Outcome potentially publishable.

Advanced Studies

- In area of specialism to support research topic.

- Complementary studies outside, but cognate to, area of specialism.

Problem-Solving

- Development of general strategies including the identification of additional information required and problems where there is not a unique solution.

- Application of advanced studies to the solution of problems.

Professional Studies

- Ethics and societal responsibilities.

- Environmental impact.

- Sustainability.

4.5 The proportion of each activity will vary depending upon the programme's learning objectives. However, research studies (training and project) are likely to form at least one-half of the master's level studies.

5 Abilities and Skills

5.1 Students studying chemistry degree programmes are expected to develop a wide range of different abilities and skills. These may be divided into three broad categories:

- chemistry-related cognitive abilities and skills, ie abilities and skills relating to intellectual tasks, including problem-solving
- chemistry-related practical skills, eg skills relating to the conduct of laboratory work
- generic skills that may be developed in the context of chemistry and are of a general nature and applicable in many other contexts.

5.2 The main abilities and skills that students are expected to have developed by the end of their programme in chemistry are as follows.

Chemistry-related Cognitive Abilities and Skills

5.3 In bachelor's degree with honours programmes:

- the ability to demonstrate knowledge and understanding of essential facts, concepts, principles and theories relating to the subject areas identified above
- the ability to apply such knowledge and understanding to the solution of qualitative and quantitative problems mostly of a familiar nature
- the ability to recognise and analyse problems and plan strategies for their solution
- skills in the evaluation, interpretation and synthesis of chemical information and data
- skills in the practical application of theory using computer software and models
- skills in communicating scientific material and arguments
- information technology (IT) and data-processing skills, relating to chemical information and data.

5.4 Additionally in master's degree programmes:

- the ability to adapt and apply methodology to the solution of unfamiliar problems
- the ability to assimilate, evaluate and present research results objectively
- skills required to undertake a research project the outcome of which is of a quality that is potentially publishable.

Chemistry-related practical skills

5.5 In bachelor's degree with honours programmes:

- skills in the safe-handling of chemical materials, taking into account their physical and chemical properties including any specific hazards associated with their use and the ability to conduct risk assessments
- skills required for the conduct of documented laboratory procedures involved in synthetic and analytical work, in relation to both inorganic and organic systems
- skills in the monitoring, by observation and measurement, of chemical properties, events or changes, and the systematic and reliable recording and documentation thereof
- skills in the operation of standard chemical instrumentation
- the ability to interpret and explain the limits of accuracy of their own experimental data in terms of significance and underlying theory.

5.6 Additionally in master's degree programmes:

- the ability to select appropriate techniques and procedures
- competence in the planning, design and execution of experiments
- skills required to work independently and be self-critical in the evaluation of risks, experimental procedures and outcomes
- the ability to use an understanding of the limits of accuracy of experimental data to inform the planning of future work.

Generic Skills

5.7 In bachelor's degree with honours programmes:

- communication skills, covering both written and oral communication
- problem-solving skills, relating to qualitative and quantitative information
- numeracy and mathematical skills, including such aspects as error analysis order-of-magnitude estimations, correct use of units and modes of data presentation
- information retrieval skills, in relation to primary and secondary information sources, including information retrieval through online computer searches
- IT skills
- interpersonal skills, relating to the ability to interact with other people and to engage in teamworking
- time management and organisational skills, as evidenced by the ability to plan and implement efficient and effective modes of working

- skills needed to undertake appropriate further training of a professional nature.

5.8 Additionally in master's degree programmes:

- problem-solving skills including the demonstration of self-direction and originality
- the ability to communicate and interact with professionals from other disciplines
- the ability to exercise initiative and personal responsibility
- the ability to make decisions in complex and unpredictable situations
- independent learning ability required for continuing professional development.

6 Teaching, Learning and Assessment

6.1 Teaching and learning strategies should be designed fundamentally to provide students with the necessary subject knowledge, understanding, abilities and skills for the chemical science profession.

6.2 HE providers should use a variety of teaching methods to ensure that students remain engaged, motivated and challenged to learn. Chemistry as a subject for learning is amenable to the full range of teaching methodologies, whether well established or innovative. Additionally, the chemical science profession requires graduates who are safe and competent practical workers and so it is crucial that there is a substantial laboratory-based practical component. Teaching methods must ultimately be valid, effective and meet the stated learning objectives.

6.3 It is essential that the procedures used for the assessment of students' achievement in chemistry correspond to the knowledge, abilities and skills that are to be developed through their degree programme.

6.4 Evidence on which the assessment of student achievement is based should include:

- formal examinations, including a significant proportion of 'unseen' examinations
- laboratory reports and skills
- problem-solving exercises
- oral presentations
- planning, conduct and reporting of project work.

6.5 Additional evidence of use for the assessment of student achievement may include:

- essay assignments
- portfolios on chemical activities undertaken
- literature surveys and evaluations
- collaborative project work
- preparation and displays of 'posters' reporting project work
- reports on external placements (where appropriate).

6.6 At the master's level, there will be a strong emphasis on requiring students to apply their knowledge of chemistry to the solution of unfamiliar problems. Assessment of the research project, based upon much of the evidence listed above, will be crucial in determining whether master's level learning outcomes have been achieved.

7 Benchmark Standards

7.1 All students graduating with a degree in chemistry are expected to demonstrate that they have acquired the knowledge, abilities and skills in the areas identified in the foregoing sections.

7.2 The following statements describe generally the threshold level of competence for holders of a bachelor's degree with honours in chemistry:

- a basic knowledge and understanding of the content covered in the course is evident
- problems of a routine nature are generally adequately solved
- standard laboratory experiments can be carried out safely and with reasonable success though the significance and limitations of experimental data and/or observations may not be fully recognised
- generic skills have been developed to a basic level.

7.3 The following statements describe the typical level of competence for holders of a bachelor's degree with honours in chemistry:

- knowledge base covers essential aspects of subject matter dealt with in the programme and shows some evidence of enquiry beyond this. Conceptual understanding is good
- problems of a familiar nature are solved in a logical manner, and solutions are generally correct or acceptable
- experimental work is carried out in a reliable and efficient manner
- performance in generic skills is sound and shows no significant deficiencies.

7.4 The typical level should apply to the majority of graduates who consequently will possess the potential to progress to a master's degree programme in chemistry.

7.5 The following statements describe generally the threshold level of competence for holders of a master's degree in chemistry:

- knowledge base extends to a systematic understanding and critical awareness of topics which are informed by the forefront of the discipline
- problems of an unfamiliar nature are tackled with appropriate methodology and taking into account the possible absence of complete data
- experimental work is carried out independently and with some originality
- substantial research project at the forefront of the discipline is completed effectively
- generic skills are developed appropriately for professional practice.

Appendix A - Membership of the review group for the Subject Benchmark Statement for Chemistry

Professor D Phillips (Chair) - Imperial College London

Dr A D Ashmore - Royal Society of Chemistry

Dr D W Barr (Secretary) - Royal Society of Chemistry

Dr P R Davies - Cardiff University

Professor R F W Jackson - University of Sheffield

Professor J Leonard - AstraZeneca plc

Professor D Littlejohn - University of Strathclyde

Dr G Nicholson - AWE plc

Professor F L Pearce - University College London

Professor C C Perry - Nottingham Trent University

Dr G J Price - University of Bath

Professor N V Richardson - University of St Andrews

Appendix B - Membership of the Original Benchmarking Group for Chemistry

Details below appear as published in the original subject benchmark statement for chemistry (2000).

Professor E W Abel (Chair) - University of Exeter

Professor P W Atkins - University of Oxford

Dr S J Gruber (Secretary) - Royal Society of Chemistry

Professor L I B Haines - University of North London

Professor R C F Jones - Open University

Professor R F Kempa - University of Keele

Professor M I Page - University of Huddersfield

Professor B J Parsons - North East Wales Institute

Professor D Phillips - Imperial College London

Professor D A Rice - University of Reading

Professor K Smith - University of Wales, Swansea

Professor A Townshend - University of Hull

Professor P Tasker

Professor J M Winfield - University of Glasgow

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[1] This is equivalent to the honours degree in the Scottish Credit and Qualifications Framework (level 10) and in the Credit and Qualifications Framework for Wales (level 6). (back to text)

[2] In England, Scotland and Wales (back to text)

[3] Copies of the guidance Further and higher education institutions and the Disability Equality Duty, guidance for principals, vice-chancellors, governing boards and senior managers working in further education colleges and HEIs in England, Scotland and Wales, may be obtained from the DRC at www.drc-gb.org/library/publications/disabilty_equality_duty/further_and_higher_education.aspx (back to text)

[4] An explanation of the Academic Infrastructure, and the roles of subject benchmark statements within it, is available at www.qaa.ac.uk/academicinfrastructure (back to text)

[5] Copies of the DRB revised Code of Practice: Post-16 Education may be obtained from the DRC at www.drc-gb.org/employers_and_service_provider/education/higher_education.aspx (back to text)

[6] Equality Challenge Unit, www.ecu.ac.uk (back to text)

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Appendix II
EXECUTIVE SUMMARY OF 'MASTERING DIVERSITY'

A REPORT PREPARED FOR THE UK HE EUROPE UNIT ON CURRENT ARRANGEMENTS FOR MASTERS PROGRAMMES IN FRANCE, THE NETHERLANDS, GERMANY AND BULGARIA

(1) This study was designed as a desk-based survey of current arrangements for delivery of Masters programmes in four 'Bologna Process' countries, with a particular focus on duration, credit-rating and admission. The results therefore depend on the availability of online data, which are in some cases very detailed, as well as systematically organized, and in other cases patchy; helpful comments have also been provided by Dutch, French and German national agencies;[3] and there are some helpful national websites.[4]

(2) There have been some very rapid changes in higher education (HE) during the past five years, but higher education systems are still developing and there are more changes in sight. Continuing change should therefore be expected for the foreseeable future.

(3) The Higher Education systems of these four countries are of very different size. The French system includes 94 universities, 30 university institutes, 153 engineering schools (and many other institutions) and has two and a quarter million students. The German system has 116 universities, 166 **Fachhochschulen** (universities of applied sciences), 57 colleges of art and music, with about two million students. In the Dutch system there are 14 universities and 40 **hogescholen** (universities of applied science) and just over half a million students. The Bulgarian system has 37 state-owned Higher Education Institutions (HEIs: universities, specialized higher schools and colleges) and about 200,000 students in public HEIs.

(4) It is essential to bear in mind that HE systems in all four cases are governed by national legislation – to a degree that is unfamiliar in the UK. In all of the countries the length of first- and second-cycle (Bachelors and Masters) programmes is defined by law. In full-time equivalent (FTE) terms this breaks down as follows: in Germany the length of consecutive Bachelors + Masters programmes is 5 years (although this might consist of 4+1, 3+2, or 3.5+1.5 years); in the Netherlands, the FTE period can be 4 or 5, or in special cases 6, years: 4+1 in hogescholen, but each of the combinations of 3+1, 3+2 and 4+2 in universities (4+2 for medicine, art and teaching); in France, it takes 3+2 years to reach the Masters qualification, but there are several different qualifications available at second cycle level; in Bulgaria 4 years are required for a Bachelors qualification and a total of 5 years to reach the Masters. In practice 1-year (2-semester), 1.5-year (3-semester) and 2-year (4-semester) FTE second-cycle programmes can be found in all of the countries considered, but there is an overwhelming preponderance of 2-year programmes, particularly for scientific, technical and engineering training.[6]

(5) ECTS is also a matter for legislation: in France, Germany and Bulgaria a full-time semester's work merits 30 credits and there are two semesters per year (in Germany formal semester length is 6 months, although the teaching period per semester is 14-16 weeks), hence 60 ECTS p.a. In the Netherlands a year's work is also worth 60 ECTS credits and the year length is 42 weeks long (in effect 2 x 21 weeks). In practice, in all places, ECTS credits are nearly always allocated on the basis of 30 per semester, and hence 60 per fulltime year, whatever the length of the year.[7]

(6) Bachelors and Masters are legally 180-240 and 60-120 ECTS respectively in Germany; 180 and 120 in France; 240 and 60 where Masters follows the same programme as Bachelors, or total 300 for Masters qualification, in Bulgaria (but in practice in some Bulgarian universities 90 ECTS is standard for a Masters following a Bachelors programme).

(7) Annual expected workload is defined by law in Germany as 1800 hours per year (30 hours per ECTS credit) and in the Netherlands as 1680 hours p.a. (28 hours per ECTS credit). This is not defined by law in France, although there is 'broad agreement' that 1600 hours p.a. is an appropriate workload. In practice individual programmes in those countries, and the components of individual programmes, appear consistent with national requirements. It is more difficult to assess expected total workload in Bulgaria but some universities

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[3] Very grateful thanks are due to Bruno Curvale of the French AERES (Agency for the Evaluation of Research and Higher Education), Patrick Neuhaus of the German Rectors' Conference (HRK), Mark Frederiks of the Dutch NVAO (Netherlands-Flemish Accreditation Organization), and French and Dutch Bologna Experts Patricia Pol and Leonard van der Hout; I am also extremely grateful to colleagues Bill McCann and Dr Iliya Nedin for assistance with data collection.

[4] Especially: http://www.hrk.de, http://www.hochschulkompass.de/ and http://www.daad.de/ for Germany; http://www.nvao.net/ and http://www.nuffic.nl/ for the Netherlands; http://www.cpu.fr, http://www.education.gouv.fr/pid316/reperes-et-references-statistiques.html and in due course http://www.aeres-evaluation.fr/ for France; and for Bulgaria see http://www.neaa.government.bg/ (largely in Bulgarian), and also in Bulgarian http://bologna.hrdc.bg/ and http://www.minedu.government.bg/.

[5] Figures in this paragraph, except for Germany data (which come from the German Rectors' Conference), are taken from 2007 (and occasionally 2005) Stocktaking reports prepared for Bologna Process ministerial meetings.

[6] Some subject areas lie outside the new higher education systems: law, medicine and theology in Germany (although in practice plenty of Masters programmes in law are offered); and medicine in France.

[7] There are variations from this, most strikingly in Bulgaria but very occasionally in the other countries in respect of management degrees or degrees with unusual special requirements.

publish a clear understanding that 1 ECTS credit is associated with a load of 25-30 hours.

(8) To suppose that the beginning and ends of semesters define the student's total study period would be a mistake. Work on dissertations and projects characteristically continues after class tuition ends, just as it does in the UK; so, frequently, does work experience, particularly in those countries where work experience is a significant element in the overall assessment; and examinations often fall outside the teaching semester.

(9) There is no single model for the delivery of Masters programmes in continental Europe. There are clear variations in duration and workload, but there are also variations in types of Masters degree and in the mechanisms for handling Masters training. While all adhere to Bologna objectives, there is nothing like standardization here: different countries implement Bologna principles in different ways and there is a strong stamp of national character about each. UK institutions should beware of supposing that there is a single continental model.

(10) The range of models available for delivery of Masters programmes is particularly interesting and UK HEIs might benefit from considering them: the part played by required and assessed work experience, in addition to dissertations and projects, is of interest; the clear difference in types of Masters available in the Netherlands, for example, is another point of interest, particularly the distinction between a 'standard' Masters and a Research Masters; the staged approach to acquiring the Masters qualification in France is another.

(11) In France the Masters qualification is usually acquired through a two-year FTE programme (120 ECTS), acquired in two separate stages, M1 and M2, which follow the three-year FTE Licence qualification (180 ECTS). Candidates with Licence in the same subject area as that of a desired M1 have a right of access to the M1 programme; hence, admission is essentially automatic on production of the relevant documentation. By contrast, access to M2 is virtually always by selection, and sometimes by open competition, on production of certificates, a dossier of work, and often a research proposal. Candidates usually need M1 in a specified, closely related, field to proceed to M2; and numbers are often limited. There is therefore no automatic right to continue to the second stage of the Masters programme. In effect, completion of the first stage, M1, is a viable stopping point, given the more limited access to M2; indeed, some universities advertise this stage as an 'Intermediate Diploma [i.e. degree]' at second-cycle level.[8]

(12) In all the countries considered here, admission to a Masters programme is normally permitted on the basis of a first-cycle qualification in a relevant or specified subject area; this is often a matter of right for the student, particularly where the Masters is sought in the university where the first-cycle degree was taken.[9] In practice, in Germany and the Netherlands, and sometimes in Bulgaria, additional tests of competence are increasingly required by admitting universities. In France, by contrast, as indicated above, while the right to begin the Masters programme is clear, progression to the second (M2) stage is by selection.

Wendy Davies
18.xi.2007

[8] Terminology: diploma/Diplom/diplôme is the usual word for English 'degree' in most continental countries; it does not designate some sub-degree qualification.

[9] Procedures exist for considering alternative first-cycle qualifications and prior experience as appropriate qualifications for entry.

Appendix III
Submission from the National Union of Students

Introduction
The National Union of Students (NUS) is a voluntary membership organisation comprising a confederation of local student representative organisations in colleges and universities throughout the United Kingdom which have chosen to affiliate and which pay a membership fee. We have nearly 750 constituent members (CMs) - virtually every college and university in the country.

NUS is one of the largest student organisations in the world and represents the interests of around seven million students in further and higher education throughout the United Kingdom. NUS provides research, representation, training and expert advice for individual students and students' unions. We deal with over 15,000 welfare enquiries each year and train over 3,000 students' union officers.

Governments from 46 European countries, including the UK, have decided to create a European Higher Education Area. As a result there are major reforms taking place in many of these countries. These developments are known as the "Bologna Process" and affect all areas of higher education.

Student Mobility
Academic mobility of students and staff is one of the core issues and key principles in building the European Higher Education Area. At the Ministerial Summit in Prague (2001) the mobility goal was reaffirmed by focusing on the removal of obstacles to the free movement of students, teachers, researchers and administrative staff. The social dimension of mobility was also introduced, ensuring that all students and staff, no matter their socio-economic or cultural background, should be able to be mobile.

However there is still a long way to go to achieve these aims. The number of UK students going abroad as part of the Erasmus scheme was only 7,131 in 2005/6 compared to 16,321 European students coming to the UK. Statistical analysis also shows that UK mobile students are more likely to be white, from a high-income family with previous experience of travelling or living abroad, and generally more self-assured and academically capable than their peers.[10]

Studying abroad can be an excellent experience and result in significant personal development as well as making the student more employable. There are many barriers to students studying abroad or that impact on the experience of those that do study abroad. The key question is whether the time spent studying abroad will be recognised as an integral part of their qualification and credits given on an equivalent basis to the institution that they study in the UK.

There are often concerns about the financial impact of studying abroad. Erasmus students receive an additional grant of, on average, 440 euros per month, however the average costs can be higher in countries where living costs are more expensive. UK students studying on Erasmus are able to apply for most of the same financial support than if they studied in the UK, and pay a portion of their UK tuition fees in their home institution as opposed to paying them in the host country. A common fear amongst students is that they may lose their part-time jobs that they have back in UK.

It is important that students are given the opportunity to study abroad and made aware of the opportunities available. We must also ensure that no student doesn't choose to study abroad simply for financial reasons.

Recognition
The Bologna Process aims to ensure that periods of study abroad should also be recognised. Study abroad should be given equivalent credit to if the student had been studying in the UK and that this is incorporated into their final qualification. Study abroad should be seen as an integral part of study rather than as added bonus.

The aim of encouraging mobility is not just for students and lecturers but also for graduates. The recognition of UK qualifications within the European HE Area is still an area of concern for students.

There have also been questions surrounding the one-year Masters degree that is usually awarded in much of the UK. It is interesting to note that the majority of UK Masters students take taught qualifications rather than the two-year research Masters that is common in many other European countries. Whilst our one-year Masters meets the Bologna framework of 90-120 credits, they still come under a great deal of scrutiny. NUS would want to ensure that one-year Masters are supported as useful entry points to further study and future employment and would emphasise that diversity is one of the cornerstones of the European Higher Education Area and that there is still a place for the one-year Masters.

It is also worth noting from a student perspective that whilst in the UK a Bachelors or Honours degree is the usual qualification for graduates to enter employment in much of the rest of Europe the usual requirement is a Masters and if we are to ensure a truly mobile graduate workforce we will need to ensure that UK students with a Bachelors are given opportunity for employment overseas.

Learning Outcomes and Quality assurance
When assessing the quality of higher education, NUS believes that in a mature HE system the emphasis should be on improving quality rather than just approving it. NUS welcomes moves by the QAA to incorporate enhancement within its Institutional Audit process and recognise the developments in Scotland. It is also important that the quality of education should not simply be measured by the inputs, such as the number of contact hours that students receive, but rather we should be measuring the learning outcomes. This is already broadly the case in the UK and the Bologna Process aims to integrate learning outcomes in the European Credit Transfer System to translate the learner's experience more accurately.

[10] UK HE Europe Unit, "The Future of Student Mobility", Feb 2008

We would also emphasise the importance of students being involved in shaping their learning experience at all levels and that students also have a valuable contribution to make to enhancing quality through both internal audit and external audit mechanisms. This is already the norm in many European countries and the European Standards and Guidelines within the Bologna Process are useful in supporting this development in the UK.

Diploma Supplement

Students value the Diploma Supplement, consisting of a transcript, programme/ course information, and the description of the national framework as a useful tool to enable recognition and believe that it should be used more and more broadly. There is still much evidence[11] that the Diploma Supplement is still not issued "automatically and free of charge to students graduating from 2005".

Conclusion

Whilst the Bologna Process has not required the dramatic reforms of many other European countries, it has still resulted in some improvements and even promotion of good practice for the UK higher education system, as well as the UK HE sector sharing best practice with other countries, and benefits for students. There is, however, still some way to go – especially to ensure the aim of genuine mobility of students and graduates.

[11] UK HE Europe Unit Survey of UK HEI engagement in European HE developments

Appendix IV
SWOT Analysis

1) Background

As part of the ongoing Mastering Bologna project, Mike Rawlins and John Murrell visited 11 Chemistry Departments across the UK to carry out a SWOT analysis and evaluate their readiness to engage with the Bologna process. The Departments, shown below, had been selected by the Steering Committee and were chosen to best represent the diversity of the UK Chemistry HE sector.

University of Bangor	Manchester Metropolitan University
University of Bristol	Open University
Imperial College	Queen's University, Belfast
University of Edinburgh	University of Sheffield
University of Leicester	University of Sussex
University of Manchester	

Mike Rawlins also met with members of the Chemistry Department at the University of Southampton to learn from their work on the Bologna Process. Professor John Dyke had previously given a presentation to the RSC on Southampton's views and the need for action.

The project team were warmly welcomed at all Institutions and the host participants gave generously of their time, opinions, insights and concerns. It is clear that there is a tremendous passion and pride in what 'Chemistry UK' has achieved over the past few years, in what has been a difficult environment. Each department has its own unique approach and character, providing a strong reminder of the great diversity that exists across the UK in terms of the course models and learning experience for students.

This diversity naturally provides a broad spectrum of views and a fertile ground for dialogue. The conversations identified a number of strong unifying views and underlying uncertainties which underpin a keen desire to work together to find a way of both maintaining what is good about Chemistry UK, whilst also acknowledging the possible opportunities provided by Bologna longer term to build an even stronger Chemistry position.

A detailed list of staff involved in each meeting is given at the end of the report but in general terms participants were key members of staff involved in undergraduate recruitment and teaching; postgraduate school recruitment; and research and departmental management. Student representatives were present at four meetings.

The purpose of the SWOT analysis meetings was not to create a consensus around issues but rather represent the range of opinions that exist. In doing so, the meetings appear to have raised awareness of the main issues relating to the Bologna process and stimulated further conversations within Departments.

2) Meeting's Agenda and Process

The meetings generally lasted for about 2½ hours and consisted of three parts:

2.1 General review of the Bologna Process (1 hour)

This session was designed to prompt questions and catalyse conversations around key issues. It also ensured that there was a common understanding of the Bologna Process amongst those attending.

During the session the principles, facts and current views on benefits and issues relating to the Bologna Process were shared with participants. It also introduced the four potential models under consideration, see below.

- 3 + 1 + 3 or (3 + 1) + 3…existing system including the integrated Masters
- 3 + 1* + 3…existing system with extra material over the summer of year 4
- 3 + 1.5 + 3…existing system with an extra half year in 2nd cycle
- 3 + 2 + 3…existing system with an extra year in the 2nd cycle

The numbers relate to the years of study required in each cycle of Bachelors, Masters and Doctorate. There are natural graduation points after each cycle and the existing system also represents the possibility of an integrated Masters with graduation after 4 years of study. For the purposes of this report it is assumed that each model includes the possibility of an integrated Masters.

Once a common understanding was achieved, the group took part in a SWOT analysis.

2.2 SWOT analysis – process followed at each meeting (1 hour)

Here participants were asked to take part in an analysis to highlight the Strengths, Weaknesses, Opportunities and Threats (SWOT) facing their departments

Under each category, participants were asked to identify the topic, that they thought were the most relevant and most important to their Department on the day of the analysis. There were no predetermined lists of topics.

To use time effectively, participants worked in two sub-groups and wrote their views and comments onto pre-prepared wall charts, an example of which is shown in Figure 1.

First of all, the subgroups worked in parallel with one group focused on the Strengths whilst the other focused on Weaknesses of their Department. Each group wrote down the significant topics under their respective headings of Strengths and Weaknesses. Then they discussed and added appropriate comments under each of the possible models. After a period of about 15 minutes the sub-groups swapped around and added any additional comments.

The parallel sub-groups then focused on Opportunities and Threats. Once again, they wrote their own comments onto the posters.

Figure 1
Example of a poster used during the SWOT analysis

Strengths topics	(3 + 1) + 3 (status quo) comments	3 + 1* + 3 (calendar yr) comments	3 + 1.5 + 3 comments	3 + 2 + 3 comments

At the end of the SWOT analysis the whole group reviewed the overall output and had an opportunity to clarify and discuss any interesting emerging topics.

Individual participants were then asked the following question:

"Taking into account everything that you have heard about the Bologna Process and making the assumption that proper funding will be available, which model do you favour?" Their responses are recorded in Section 4.5.1.

2.3 Evaluating Readiness (30 minutes)

Working as a group participants were then asked to review the following criteria and estimate the amount of effort required to deliver their most favoured model.

- Staff Availability
  - Academic
  - Support
- Staff Engagement
- Recruitment Processes
- Course Design / Development
- Office and Write-up space
- Laboratory Space
- Laboratory Equipment
- Computing Facilities
- Student Accommodation

3) Topics Most Frequently Raised During the SWOT Analysis – a tabular summary

As indicated in the previous section, each Department was asked to take part in a SWOT analysis to highlight the Strengths, Weaknesses, Opportunities and Threats facing their departments when considering four potential models for the BSc, Masters & Doctorate degree cycles.

The following tables provide an overview of the topics which were most frequently raised by the groups of participants during their analyses. Some summary notes are also included which compare comments on the four models. Section 4 provides a more detailed description of the key findings emerging from the overall conversations.

3.1 Most Frequently Mentioned Strengths

Topic	Number of Departments raising each topic
Strong Recruitment UG / PG	9
Quality of students	9
Employment / Placement	8
Familiarity with Course Structure	7
Cost to students relative to Europe	6
Reputation of Department	5
Staff Expertise	5

The strengths noted most frequently by Departments are based on their current activities and relate directly to the (3+1)+3 model.

Strong Recruitment
If Chemistry UK continues with the current 3+1+3 model then Departments would expect recruitment to continue in the same way. However, moving to the 3+1*+3 or the 3+1.5+3 model might cause confusion amongst both students and employers, and would also create timing issues during PhD recruitment. Moving to the 3+2+3 model is seen as conditional on funding but may be more attractive to overseas students and the best UK students. However, it was felt that overall numbers may be reduced.

Quality of Students
Moving to the 3+2+3 model was seen as providing better prepared graduates and postgraduates as more time would be available for teaching, research and developing skills. The downside being that more staff time would be taken up by teaching rather than pursuing their research. Adopting the 3+1*+3 or the 3+1.5+3 model would have a similar but smaller impact.

Employment Placement
The current degree system is understood by employers in terms of value and skills capability when considering students for placement or full time employment. Moving to the 3+2+3 model is likely to provide higher quality, better prepared and more mature candidates. Employers would get better students

at no extra cost. In addition students' degrees would be more compatible within the EU. Moving to the 3+1*+3 and 3+1.5+3, however could cause confusion within the employer and student community with a possible lack of compatibility with the Bologna Process.

Familiarity with Course Structure
As indicated above, the current course structures BSc, MChem etc are understood by all involved. Moving to a new approach such as the 3+1*+3 or 3+1.5+3 model may undermine this understanding by causing confusion about course structure and content. Moving to the 3+2+3 model may still cause initial confusion but will provide opportunities to improve the student quality.

Cost to Students
Any move away from the current model will involve some form of additional cost to students, whether it is increased living expenses or the possibility of additional tuition fees. There is already a cost burden on students and some Departments believed any additional cost will act as an obstacle for recruitment. In addition the 3+1*+3 and 3+1.5+3 models will remove the possibility of students earning money by working through the summer. Clearly the 3+2+3 model whilst providing more freedom during the second cycle, will involve one year of extra fees and expenses.

Staff Expertise & Reputation
For the most part, Departments believe they have about the right number of high quality staff to support their activities. Therefore, extending the teaching requirement by moving to any of the alternative models will put additional teaching and supervisory workload on staff. This in turn will take a number staff away from their core research activities.

Reputation
Moving to either of the 3+1*+3 or 3+1.5+3 models may cause confusion with all stakeholders and undermine the reputation of Departments. A move to the 3+2+3 model provides an opportunity to raise the quality of research students and therefore enhance reputation, provided that the transition is managed properly.

3.2 Most Frequently Mentioned Weaknesses

Topic	Number of Departments raising each topic
Cost of study to students – e.g. current and potentially increasing fees	7
Funding – e.g. general constraints; limiting EU recruitment; Masters level	6
Retention and Recruitment	4
Industrial engagement / placement	4
Workload – current demands on teaching and admin staff	4

Cost of study to students
The 3+1*+3 model will increase overall costs to the students to fund the extra few months but on top of this they would lose the opportunity for summer working. A significant increase in the length of study time in the 3+1.5+3 and 3+2+3 models will clearly require students to increase their loans or find alternative source of funding. Increasing costs will also have impact on part time students who may be faced with up to another two years of study.

Funding
A similar story relates to the funding requirements for Departments. There are no clear mechanisms for funding an additional year of study and therefore moving towards a 3+1.5+3 or 3+2+3 model would not be possible without this issue being addressed. The funding solution should also take into account the constraints on recruiting EU students into Masters level as they may be put off by the higher UK fees.

Retention and Recruitment
The current UK model, 3+1+3 is viewed as a weakness by some Departments as it is seen as having a declining prestige in the overseas market. However the longer 3+2+3 will provide increased challenges to recruitment in the UK and can also be seen as a weakness for recruitment. Even if the funding issues are resolved there is a general belief that there would be a decline in numbers applying for the two years Masters cycle.

Industrial engagement / placement
Comments generally relate to the 3+2+3 model. There is concern that it may be more difficult to find additional industrial placement opportunities. In addition, although there may be fewer students qualifying with a two years Masters or PhD, there was a concern that employers might see the two year Masters cycle as being over qualified. The 3+1*+3 and the 3+2+3 models were not favoured and were seen as having the potential to cause confusion, in terms of qualification and also the timing of recruitment.

Workload
Each of the extended models raises logistical questions in terms of teaching and supervising the additional time: the 3+1*+3 removes a summer of research activity; the 3+1.5+3 increases the workload further and the 3+2+3 signals a significant increase and a probable negative impact on research activities. More staff would be required to properly resource the extra demands and maintain standards.

3.3 Most Frequently Mentioned Opportunities (in order of frequency of reporting)

Topic	Number of Departments raising each topic
Attracting EU students	8
Increased mobility within the EU for study and employment	7
Increase research capability	6
Interaction with Industry and increasing employment prospects	5
Maintain and increase student numbers (MChem)	4
Widen the curriculum and increase teaching capability	4

Attracting EU students

Departments believe that aligning with the 3+2+3 model will help improve marketability and provide a good opportunity for the UK to attract more EU and overseas students. The 3+1.5+3 model was seen as a half way house, which, if compatible with Bologna would have some attraction but may cause confusion.

Increased mobility within the EU for study and employment

Following the above comments, once the UK is aligned with Bologna it should make it easier for students to move between institutions. Currently the UK is a net importer of students but longer term Bologna may stimulate more UK students to take opportunities elsewhere.

Increase research capability

These comments relate to the increased time that students would spend studying and researching if the UK adopted the 3+1.5+3 or 3+2+3 models. There is a belief that Departments can increase the amount of research done, whilst producing better qualified students at Masters and PhD level. Some saw more opportunities for research collaborations.

Interaction with Industry and increasing employment prospects

There is a view that the additional year of study within the 3+2+3 will ensure that UK trained students will be better able to compete in the jobs market. Employers will see 'a level playing field' and this should create more demand for UK students and also stimulate employers to offer more placements.

Maintain and increase student numbers (MChem)

Assuming that the funding issues are resolved, some Departments see alignment with the Bologna process as an opportunity to maintain and increase MChem numbers, as the programme would be seen as high quality training essential for professional qualification.

Widen the curriculum and increase teaching capability

The 3+2+3 model provides an additional year for Departments to take the opportunity to 're-design' their course structures either to widen the curriculum and / or provide more depth in terms of experience.

3.4 Most Frequently Mentioned Threats (in order of frequency of reporting)

Topic	Number of Departments raising each topic
Recruitment	10
Non compliance with Bologna	6
Employment becomes more difficult	5
Reduced funding – change not properly funded	5
No consistency of fees across Europe	2
Demands on Infrastructure	2

Recruitment

The threat to recruitment is seen in a number of ways. The current 3+1+3 model is seen as losing prestige, particularly in Europe and Asia and of potentially being incompatible in a post Bologna environment. However, the 3+2+3 model is also seen by some as a less attractive option because of the combination of increased costs and the extended period of study. It is believed that this factor would make recruitment an increasingly difficult challenge in a post Bologna era. In terms of the MChem, it is thought that an increasing number of students may stop taking the Masters component because of the likely changes.

Non-compliance with Bologna

A number of Departments believe that a significant threat will exist for the future of Chemistry if the existing UK 3+1+3 model is seen as non-compliant with the Bologna process by students, EU institutions and employers.

Employment becomes more difficult

This threat results from the comments above. If the existing system is maintained then some Departments believe that the job market may become more difficult for UK trained students.

Reduced funding – change not properly funded

A continuing theme is that Departments are concerned that any proposed changes will not be adequately funded, which will put additional pressures onto Chemistry UK.

Demands on Infrastructure

As discussed in earlier sections the changes required to move to an additional year of study will put substantial demands on the current infrastructure, staff and facilities.

No consistency of fees across Europe

Linked to funding some saw the inconsistency of fees across European institutions as a real threat to the development of a coherent future funding strategy.

4) Detailed Description of Key Findings and Issues arising from the Conversations and SWOT analyses

Within this section the reader will see a number of comments which have been highlighted in blue. They are not exact quotes but closely represent comments made during the various meetings held with Departments and their purpose is to illustrate the broader discussion.

4.1 Funding

4.1.1 General Comments

Funding was raised as a major issue by all Departments and appears to impact directly on their readiness and ability to align with the Bologna Process. Concerns were focused in three main areas

- the perceived gap in funding provision at the Masters level and hence the need to provide and resource an additional year of study to become Bologna aligned around the 3 + 2 + 3 model.
- the burden on students in terms of financing another year of study
- the inconsistency of funding models and approach used by HEFCE and the Research Councils

There were also a range of views which promoted the potential competitive advantage of the shorter, less costly (3+1) integrated Masters offered by Chemistry UK.

"The current funding structure of the Doctoral Training awards is incompatible with the Bologna process. This major problem needs to be addressed."

4.1.2 Impact on Departments

Five Departments emphasised that funding is in place for the existing Bachelors and Integrated Masters degrees. They see this as a strength from the perspective of Chemistry UK and believe it to be very important for this support to continue in a post Bologna era.

In contrast there was genuine concern that second cycle Masters degrees do not have guaranteed funding and it is not clear what funding mechanism might be used in a future framework aligned around the Bologna Process.

"We recommend that the current way Research Councils award funding and studentships should be re-thought, as the current system is not compatible with the Bologna process."

This lack of clarity on funding is seen as a weakness and significant threat in the current system by four Departments, in terms of the ability of Chemistry UK to compete in the future. Furthermore, the uncertainty around funding is acting as a significant barrier for future planning according to four of the Departments visited.

4.1.3 Impact on Students

The burden of funding on students is a primary concern and was raised by at least six Departments. Any significant alignment toward the Bologna process will involve the need to resource an additional year of study. Notwithstanding, the potential cultural barriers towards working for another year, the sheer challenge of finding the funding may well be beyond the reach of a significant proportion of students.

"From a student perspective it was felt that current timescales of a UK MSc or an MRes are an advantage. Some students would prefer a one-year MSc/MRes over a similar two-year course."

Student representatives were present at four meetings. In general the prospect of another year of studies was seen as a significant barrier for them. They felt that the UK offered a very competitive model, compared to the rest of Europe both in terms of time and cost to achieve a valued degree award. This opinion was shared by many of their academic colleagues and a general view emerged from conversations that extending studies for another year was a real threat and longer term would probably reduce the numbers of students attracted to Chemistry in the UK.

4.1.4 Coherent Funding Model

"We feel very strongly that any decisions made by the Government or HEFCE to adopt the Bologna process must be backed up by appropriate funding for Departments and Students."

Eight Departments referred to the important role of the funding bodies in providing more clarity and direction around future funding. Currently, Departments believe that there is a disconnect in the funding models at HEFCE and Research Council level. Currently HEFCE funds 1st degree (1st cycle) activities and the Research Councils fund 3rd cycle Research activities. Therefore there is a real risk that the middle cycle will be left out of funding considerations – as is currently the case. There were clear requests for HEFCE and the Research Councils to take the opportunity of the Bologna process to develop a more coherent and co-ordinated approach.

Four Departments believe that adequate funding for all three cycles would provide a necessary incentive for Chemistry UK to make a co-ordinated transition to align with the Bologna Process. In addition, the Bologna Process was seen as a real opportunity for the Government and Funding organisations to create a fairer and more co-ordinated funding regime across all cycles.

Although this report focuses on Chemistry it is clear that a consistent approach is required across the science and engineering sectors. Six Departments made specific mention of the inability of Chemistry UK to move alone. It is seen as

critically important for all disciplines to adopt the Bologna principles in a coherent way. Some highlighted the point that they see the RSC as having a critical role in making this happen.

4.1.5 Concluding Remark

Bologna provides a real challenge and opportunity for the various stakeholders to work together and create a funding environment that ensures Chemistry UK is able to be a competitive and leading contributor globally.

4.2 Recruitment & Quality of Students

4.2.1 Discussion

Nine Departments cited recruitment as one of their main strengths. After some difficult years, it was reported that student numbers are still increasing with a strong intake of good students coming through the system. At least five departments are at full capacity with a significant number of students electing to take the integrated MChem / MSci award.

For some departments the level of recruitment from the EU and overseas was lower than they would like and therefore they cited recruitment as a weakness. Overall, the continuing success of a majority of Departments is dependent on their ability to recruit locally and nationally. Therefore, activities likely to cause uncertainty in the student population such as a transition to Bologna aligned awards are seen as a potential threat to the current recruitment efforts.

"EU students have a great attitude towards self learning, they are at a very good standard, they work hard and pull up the performance of UK students."

The prospect of moving to a Bologna aligned degree structure and hence the 3 + 2 + 3 model, raised a number of issues that people saw as potential threats. The requirement for an extra year of study at the Masters level coupled to additional student funding requirements are seen as having the potential to dissuade UK, EU and Overseas students from choosing to take up Chemistry courses in the UK. One Department believes that the USA may become a destination of choice in this situation.

To balance the above concerns, a majority of Departments recognise that there are significant opportunities to enhance their recruitment in a post Bologna era. Assuming that they were aligned around the 3 + 2 + 3 model, at least eight Departments believe they could recruit more undergraduate students from the EU.

"We feel that the introduction of a two-year Masters would exclude a social group of students who couldn't afford to fund the second year themselves."

Two Departments highlighted the importance of their one year stand-alone taught Masters programmes, which often provides access to Chemistry for students from other scientific backgrounds and an important source of funds. These programmes often attract significant numbers of EU and overseas students. There is concern that aligning with Bologna would threaten these courses and may also result in the social exclusion of some students.

The opportunity to recruit more EU students is seen as a bonus, because of the general view that EU students when compared to their UK counterparts tend to be better skilled, more mature, have a greater work ethic and a superior self learning ability.

"Students from Europe tend to be more experienced than those students within the UK. They are better prepared for research."

A strength of the 3 + 2 + 3 model identified by some Departments is that it will produce graduates with a greater breadth of Chemistry experience. In addition, students will be more mature especially at the end of a doctorate. Seven Departments highlighted that there is a real opportunity to raise the quality of students graduating from the UK compared to those coming from the EU. This would have related benefits for Departments in terms of the quality of research and also for the students who would be able to compete more successfully in the European market place. However, as noted previously, the higher quality might be gained at the expense of student numbers, as some students may find the extra year a significant barrier to entry. Once again the importance of achieving the correct level of funding needs to be emphasised.

In terms of future threats, four Departments believe that the competitive position of Chemistry UK would be further eroded if it maintains the existing 3 + 1 + 3 model. It would be out of alignment with the rest of Europe and therefore UK graduates would struggle to compete with their EU counterparts in the jobs market.

4.2.2 Concluding Remarks

There are wide ranging views on the level of risk facing the recruitment of students into Chemistry. It is highly likely that the resulting changes will create uncertainty and have the potential to undermine recruitment efforts. A consistent approach needs to be developed. Departments also see the Bologna process providing opportunities to improve the quality of qualified students and also to attract more EU and overseas students.

4.3 Employability

4.3.1 Discussion

Six of the Departments rated the employability of their students as a major strength and they reported that their students had built a good reputation in the jobs market.

Another strength noted by some Departments was that in general, employers understand and trust the UK Bachelors and Integrated Masters awards. They are naturally very

involved in providing placements and therefore get to know the students well. These employers are also able to build good relationships with the Departments thus maintaining important links into the Chemistry community. There was concern at the prospect of the Bologna process creating uncertainty and undermining this strength.

"There are signs that UK industry is now starting to look overseas for good PhD students. Most mainland EU students are amongst the top students that are undertaking a PhD here."

Although there is a wide range of views around the current recruiting needs of employers there is a significant weight of opinion, backed up by personal examples that the trend for large employers is to favour the recruitment of European graduates. There were also a number of comments indicating that Departments themselves tend to favour EU students at doctoral level because of their broader experiences and increased maturity.

Again there is a wide range of views around the topic of mobility and related barriers for UK students moving in and around Europe. Five Departments saw alignment with the Bologna process as being very beneficial in producing students who would be more marketable and better able to compete in a pan European job market. There is also a belief that aligning with the Bologna process is essential to avoid the real threat of the UK being isolated from the employment market.

However, it is worth noting at this point that Departments report only a low level of demand from UK students for degree courses linked to European language modules.

"It was felt that the UK HE system does have a 'branding issue' with various courses at MChem, MSCi, MSc and MRes level. In private business these titles are not fully understood and many employers simply only understand 'PhD and BSc'."

Whatever the outcome of the Bologna Process for Chemistry UK, some Departments emphasised that it is vital for the Chemistry community, preferably led by the RSC to spend time and resources ensuring that all stakeholders understand the nature of any transition, the range of awards and the value that they bring to the UK and EU.

4.3.2 Concluding remarks

It appears essential that any changes proposed to the degree framework are communicated exceptionally well to all stakeholders, particularly employers and put into the European context. The Chemistry UK community needs to establish clarity for all stakeholders to ensure that qualifying students are valued and able to compete at the highest levels.

4.4 Resources & Facilities

Nine Departments noted major strengths in two key areas, namely the quality of their academic staff for teaching and research activities and the quality of their facilities. Five departments also thought that they had potential weaknesses that might be realised if there was a significant increase in workload or an additional requirement for extra space.

In a post-Bologna environment, most Departments believe they would need to increase or modify their capacity in order to cope with another year's cohort at Masters equivalent level. For the larger Departments this could amount to a significant number of additional students remaining in study and requiring laboratory space, writing up space, lectures rooms etc. As a number of Departments are already at capacity, with tight budgets, the importance of creating a properly funded solution was again emphasised. Some believed they would only be able to cope by reducing the numbers of students in each year.

Consequently Departments believe they would need to spend significant time developing the logistics, course content and staff availability to accommodate this extra cohort of students.

4.4.1 Concluding remarks

The impact of any changes will need to be fully assessed in terms of Departmental logistics and the overall cost of resourcing. A poorly resourced transition would create unnecessary stress on the community.

4.5 Accreditation

"The RSC should provide an important lead particularly around accreditation."

Academics are generally agreed that the current UK BSc awards would be aligned and compatible with the 1st cycle of the Bologna process. However, when looking at the integrated Masters they recognise that the lack of a compatible, accredited 2nd cycle award was a significant threat. Some Departments argue that maintaining the difference in time scale of the masters – UK (one year) versus European (two years), when viewed from outside the UK is clearly not sustainable in the longer term, especially when there is growing evidence of more countries outside the Bologna signatories seeking to align their systems around the Bologna process.

As noted in an earlier paragraph there is a lot of pride within the UK Chemistry community based on the reputation of the range of programmes available to undergraduate students. Of particular note is the integrated Masters and the essential role that RSC accreditation plays in providing an assurance around standards. Indeed, the current four year integrated Masters was seen by some as having a potential competitive advantage in a post Bologna era. Two Departments specifically noted the importance of their accredited integrated Masters degrees and rated them a strength.

In contrast, seven Departments raised concerns around the current UK approach and the possibility of the integrated Masters losing its accreditation when considering the future post Bologna era. This scenario was seen as both a weakness and a threat.

This was also seen as a threat in Scotland where their current set up follows the 3 + 2 + 3 model, but here there are compatibility

issues with the rest of the UK in terms of entry requirements. A move in terms of accreditation to change the overall workload or define entry standards would have a negative impact and require changes to the recruitment approach.

A number of questions were received relating to the flexibility of the Bologna Process and the 3 + 2 + 3 model. Some academics are very keen to understand how the eight year period might be divided. At least three Departments talked about having a "3 + 1 + 1 + 3" model, which allows the integrated Masters to be maintained but also allows for an additional year to be added. The current trend for longer periods of Doctorate funding might indicate a way to support this approach. Comments were also made about ensuring there was flexibility in terms of exit points.

The nature of activities during the additional year is yet to be defined but suggestions ranged from additional taught modules through to industrial placement or research work focused on preparing students for entry to their Doctoral studies. One suggestion raised the possibility of running a two year DPhil award.

4.5.1 Preferred Models

At the end of the SWOT analysis each group reviewed their overall output and had an opportunity to clarify and discuss any interesting emerging topics.

Individual participants were then asked the following question.

> "Taking into account everything that you have heard about the Bologna Process and making the assumption that proper funding will be available, which model do you favour?"

Out of 44 responses:

- 25 Participants (57%) favoured moving to the 3 + 2 + 3 model of which nine participants advocated a (3 + 1) + 1 + 3 model to provide more flexibility in the use of study time.
- One participant (2%) favoured moving to the 3 +1*+3 model.
- Six participants (14%) favoured moving to the 3 +1.5 + 3 model.
- 12 Participants (27%) favoured maintaining the status quo (3 + 1) + 3 model.

4.6 Leadership and the need to take a co-ordinated approach

> "Chemistry UK has a fantastic opportunity to lead on this issue and needs to grasp it. A fragmented approach would be a disaster, and we need to learn from the development of the MChem award."

The lead taken by the RSC in managing the Mastering Bologna project is very welcomed and applauded by the Departments visited. A number felt that it was important for the RSC to lead the debate and catalyse similar actions across the scientific and engineering sectors in order to take full advantage of the emerging situation and address the Bologna needs.

> "We strongly feel that a consensus needs to be reached amongst the RSC and the UK HE institutions, particularly in the disciplines of Chemistry and Physics."

Supporting the above view, some Departments expressed frustration at the lack of coherent leadership being displayed by Government and the supporting funding agencies.

4.6.1 Alignment or Fragmentation

> "Fragmentation should be avoided as this would have a negative effect on recruitment and university reputation."

Overall, there is a strong demand for clarity of direction, clear decisions on key aspects of policy and a connected Chemistry community. In most of our discussions, people expressed keen interest in what other professional disciplines were doing.

There is a clear consensus from Departments that it is essential for Chemistry UK to act as a unified body, gain agreement on the way forward and make change as and when necessary in a concerted and planned transition. It is also recognised that there is a real danger of fragmentation. Departments are looking for co-ordinated leadership but a number of the larger departments, particularly those with research led activities, felt they would react to events in order to maintain their competitive position and reputation and / or follow others as required. It was emphasised by some that any change needs to be well planned and co-ordinated to avoid past mistakes.

4.6.2 Learning from past performance

On the basis of various comments, the development of the integrated Masters was clearly not a happy experience for the UK Chemistry community. A number of Departments made the point that the Chemistry community must learn from those past experiences and work in a connected way to manage the potential changes implicit in the Bologna process.

Some saw an inertia at their Universities to fully engage in the Bologna process and its implications. In a number of cases there appears to be a low level of engagement and understanding at the most senior strategic decision making levels. This has made it very difficult for individual departments to engage in meaningful conversations with senior leaders and other Discipline peer groups within their Institution. However, there was at least one example of where a University had made clear commitments at the most senior level to become Bologna aligned by 2010. In this situation the Chemistry Department was able to become much more proactive in planning and influencing the way forward.

5 Evaluating readiness

This exercise was carried out after the SWOT analysis. Its purpose was to get a feel for the amount of effort that Departments would need to make to achieve the Bologna

aligned model 3 + 2 + 3 and/or whatever other model they preferred. They were asked to consider a set of criteria and estimate the effort required in each area.

A score of 10 indicated a maximum effort required whereas a score of 0 indicated no effort needed.
It is difficult to pick out any clear trends with Departments having their own particular challenges. In the top set of people related criteria, the totals appear to indicate that Staff Engagement will require the most effort with Course Design and Development a close second.

In terms of facilities, creating sufficient Laboratory and Office space is clearly a major issue.

	Effort required 10 = maximum effort & 0 = no effort									total
Department / Criteria	A	B	C	D	E	F	G	H	J	
Academic Staff Availability	0	10	4	3	3	7	5	0	4	36
Support Staff Availability	3	0	0	9	3	7	5	8	4	39
Staff Engagement	7	10	2	2	5	10	5	7	8	56
Recruitment processes	3	10	0	2	6	2	7	6	5	41
Course design and development.	5	6	2	8	4	10	3	7	6	51
Office and Write-up space	10	10	5	10	0	2	6	8	9	60
Laboratory space	10	10	9	10	3	10	4	4	9	69
Laboratory equipment	3	10	5	5	3	5	6	7	9	53
Computing facilities	3	10	5	3	3	5	3	2	9	43
Student accommodation	8	4	0	0	10	10	3	0	0	35
total	52	80	32	52	40	68	47	49	63	

Other criteria mentioned by individual Departments were:

Criteria	Effort
Course Delivery	5
Lecture theatres	5
Gaining Senate approval	10
Outreach and cultural issues shift	6
Supervision of students	2
Assessment & Feedback	5

5.1 Funding

When Departments were asked about the level of financial support required to ensure a competitive capability in a post Bologna environment they identified four main areas needing additional funding. These are:

- the annual costs to students for their living expenses including rent, travel, etc
- the annual costs of supporting each student in terms of course requirements
- the annual costs covering academic and administrative salaries
- the capital costs covering facilities refurbishment and equipment

Capital costs were dependent on the current status of buildings and laboratory space. In some cases the extra intake could trigger the need for a new building to provide enough space.

6 Some Observations and Comments

6.1 Which students are most affected by the Bologna process?

> "It was felt that the standard of science teaching in Schools had diminished in recent years which had lead to a lower standard of PhD students."

During the conversations, there were frequent references to the quality and ability of the best students. On the basis of comments received, an assertion of this report is that the highest quality students, the first tier, will always be in demand and will normally be able to make clear choices about their courses. They will probably think more deeply about their longer term futures than others and then be able to make transition between institutions and degree cycles more easily. It seems reasonable to assume that UK courses will need to have the correct accreditation and marketability in order to continue to attract these students.

The second tier of students will contain the good, solid workers who are likely to seek professional employment in Chemistry related areas, either inside academia or elsewhere. This group may be more vulnerable to changes in degree structure. They might end up with a non-Bologna aligned degree, which will create barriers to their ongoing career. There appears to be a significant challenge for Chemistry UK to ensure these students remain motivated to become professional Chemists.

A potentially even bigger challenge for Chemistry UK is to ensure the interest and engagement of the remaining third tier, probably containing the majority of students who want to study Chemistry. Chemistry UK needs to maintain the output of significant numbers of qualified students in the discipline so that they can fill the demand for Chemistry related roles. As previously described there are real concerns that a potential lack of clarity in the range of future Chemistry UK awards will be a significant 'turn-off' and threaten the recruitment of this group – students may just choose to study something else.

"It is felt that the time taken to complete some degrees, if the Bologna process was adopted, would put students off taking Chemistry and they would perhaps follow a different discipline."

6.2 Awareness and Bias for Action

At all departments there was at least one champion who was charged with monitoring the Bologna Process, however, the general level of understanding about the longer term implications of the process were not deeply understood. In some institutions the working assumption was that ongoing programmes around the integrated Masters would be acceptable within the Bologna Process – it is not clear that this is actually true. One request was made to better understand what is actually happening in and around Europe in terms of Masters awards.

As mentioned earlier, there was a range of attitudes towards the Bologna Process. Some Departments believed there was little to do until the issues of funding and direction of the UK were resolved, whilst other Departments were much more proactive and sought to engage the community and develop a position of influence. To some extent the approach appears to be influenced by size. Larger Departments have more resources available and can be more flexible, therefore having a capacity to respond to whatever change comes along. Medium to small Departments are prepared to follow but may be put under more strain to compete at all levels.

6.3 Continued Communication and Connection

There appears to be a strong need to ensure that the Chemistry community remains closely connected to Bologna related issues and events. Leadership from the RSC in creating a clear and consistent way forward will also encourage the Community to work together and be successful in making whatever transitions are necessary.

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25th June 2008

Appendix V
List of documents consulted

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Appendix VI
The 'Mastering Bologna' Steering Group

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Appendix VII
Acknowledgements

The Mastering Bologna steering group wish to thank the following people for their assistance in compiling this report:

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