Review of Chemistry Programmes

- In Denmark and in the United Kingdom

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Preface

This report is the result of a joint project between the Danish Evaluation Institute (EVA) and the Quality Assurance Agency for Higher Education (QAA). The aim was to provide a vehicle for an initial testing of the applicability of the recently developed European Standards and Guidelines for Quality Assurance (ESG). The two agencies have a history of cooperation on joint projects, including the Transnational European Evaluation Project (TEEP) in 2003.

The report is based on a review of five Danish chemistry programmes at the universities of: Aalborg, Aarhus, Roskilde, Copenhagen and Southern Denmark and of four UK Chemistry Programmes at, respectively, University of: Aberdeen, Bath, Bristol and Nottingham Trent University. The universities participated on a voluntary basis.

The report consists of two parts: a comparative part and a part with individual feedback to the Danish institutions. The comparative part of the report provides an analysis of the teaching and learning experience in the chemistry programmes in Denmark and the UK. The report also contains an assessment of the implementation and the differences between the first and second cycles (bachelor and masters degrees). Finally, the report examines quality assurance mechanisms applied to, and within, the programmes. The second part of the report summarises the current strengths and developmental opportunities of each chemistry department in Denmark. Although this report contains the individual feedback only to the Danish institutions, the UK institutions also received individual feedback in the same format as the Danish ones (i.e. concerning good practice and developmental opportunities) but have together elected not to publish it.

The review was based on transparent criteria for student learning experience and quality assurance in alignment with the ESG. Before being used, the criteria were circulated and discussed among the participating departments.

The expert panel, QAA and EVA hope that the report will encourage further development in the departments that were reviewed, and anticipate that the report will be a useful tool in ensuring that they continue to provide chemistry programmes of high international standard in the future.

The review has been conducted between January 2005 and October 2006 by the Danish Evaluation Institute (EVA) and Quality Assurance Agency for Higher Education (QAA) in cooperation with an international expert panel. Both agencies wish to thank the panel and the participating departments for their help and co-operation in ensuring the success of the project.

John Winfield	Peter Williams	Christian Thune
Chairman of the panel	Chief Executive, QAA	Executive Director, EVA

1 Summary

This report focuses on the teaching and learning experience of the chemistry programmes in Denmark and UK and on the quality assurance mechanisms applied to, and within, the programmes. The report assesses the implementation and the differences between the first and second cycles and seeks to identify those elements and expectations that distinguish the bachelor degree from the master degree in Denmark and UK.

Good student experience in chemistry programmes
The review shows that chemistry programme in Denmark and UK are characterised by high motivation from both teachers and students and that the latter in general find that the chemistry programmes provide them with a good student learning experience. Learning and teaching methods support the achievement of the outcomes and the departments use a variety of teaching and assessment methods to support and assess student learning.

Difference in implementation of the 3+2 cycle between Denmark and UK
The main difference between the Danish and UK systems is that, while Denmark has implemented the Bologna 3+2 bachelor/master cycles for all degrees, in the UK, an integrated programme leads directly to a master degree; a process which is not aligned with the Bologna proposals. In Denmark, the two cycle system has become part of the national regulation of higher education, and this is probably the main reason why the Danish universities have implemented the first and second cycle degree structure; in the UK, universities are self-governing and are not required to design programmes to national requirements, although the government has signed the Bologna declaration.

More clarity on difference between bachelor and master level
Some departments need to be more specific in describing and communicating the difference(s) between the bachelor and master levels with regard to aims and competences. This is especially important when bachelor students and master students follow the same selected courses. It should be clear to both students and staff what is expected of a bachelor and master student's work, and what is the difference.

Structural barrier for mobility
It is apparent that both the Danish and UK departments have different ways of structuring their programmes. The panel finds the variety of structures an important strength and believes it to be essential that this plurality is safeguarded. However, in Denmark the very different ways of structuring the degree programmes at the departments may create a barrier for student mobility between bachelor programmes at different universities, and between different universities at the bachelor-master transition, as the students might be required to take additional study packages to qualify for entry into another university's master programme.

Danish laboratories do not live up to international standards
There is considerable difference between the quality of laboratories and the management of safety in the laboratories in the Danish and UK departments respectively. The panel is strongly concerned that the majority of the Danish labs do not fully live up to international standards due to lack of external/internal funding. It is therefore recommended very strongly that a serious effort is made to address this issue, as it has a profound effect on the quality of chemistry education.

Need for more holistic and formalised approach to quality assurance
The majority of the Danish and the UK departments have a comprehensive and coherent student course evaluation system where feedback from students is taken seriously and acted upon. However, the panel recommends the Danish departments to consider a more holistic approach to quality assurance and not to rely too much on student course evaluation in their procedures. In a future quality assurance system, an annual gathering of data from different sources concerning the programme, and with the study board reporting to the faculty, including descriptions of good practices, would contribute to an enhancement of teaching and learning.

The report contains more conclusions and recommendations than stated in this summary. These are provided continuously through the report and in connection with the analysis in the different chapters.

2 Introduction

2.1 Background

The proposal for a joint review of chemistry education in Danish and some UK universities developed from initial discussions between the Danish Evaluation Institute (EVA) and the Quality Assurance Agency for Higher Education (QAA). At a later stage, the Royal Society of Chemistry (RSC) in the UK also became involved. QAA and EVA have collaborated on joint projects on a number of previous occasions, gaining experience together through several international projects, including TEEP 1.[1] This project was also considered to be a good vehicle for an initial testing of the applicability of the recently developed European Standards and Guidelines for Quality Assurance (ESG).[2]

2.2 Purpose

The main purposes of the review are, firstly, to identify and assist in the dissemination of good practice within the area of chemistry teaching in Danish and UK universities, and, secondly, to develop and apply a method for peer review of the student learning experience and the supporting quality assurance mechanisms at programme level. The review is to be based on experience

[1] The Transnational European Evaluation Project (TEEP) was a pilot project conducted by the European Association for Quality Assurance in Higher Education (ENQA) and its member agencies between June 2002 and October 2003. It explored the operational implications of a European transnational quality evaluation of study programmes in three subject areas: History, Physics and Veterinary Science.

[2] http://www.enqa.eu/documents.lasso. The Bologna Declaration encourages, among other things, European co-operation in quality assurance of higher education with a view to developing comparable criteria and methodologies. At the Bergen meeting of May 2005 the European Ministers of Education adopted the "Standards and Guidelines for Quality Assurance in the European Higher Education Area" drafted by ENQA. The Ministers committed themselves to introducing the proposed model for peer review of quality assurance agencies on a national basis.

gained in selected chemistry (bachelor and master) programmes, as provided by Danish and UK universities.

The objectives of the review include describing and evaluating the following:

The educational context for the programmes, to provide:
- a factual basis to support an understanding of the programmes offered, and their self-evaluation within the departments involved.

The student learning experience, to provide:
- an assessment of the programmes in terms of content, intended learning outcomes, learning and teaching methods to support the achievement of the outcomes, and assessment methods used to demonstrate student achievement;
- an assessment of the level of implementation of the first and second cycle degree structure, and whether the programmes have formulated goals for bachelor and master degrees that match national and/or other descriptors, including the "Dublin descriptors";
- an assessment of the critical differences between the first and second cycles, and particularly identification of those elements and expectations that distinguish the bachelor degree (and its graduates) from the master degree.

Quality assurance, to:
- develop a better understanding of the quality assurance mechanisms used within chemistry programmes in the UK and Denmark, including the role(s) of external examiners;
- examine quality assurance mechanisms applied to, and within, the programmes;
- Encourage those responsible for the programmes to reflect on the effectiveness of their existing quality assurance mechanisms and consider what influence the recently published ESG might have on their processes and activities.

2.3 Scope

This report covers chemistry programmes in Denmark and the UK. A research chemist is a specialist, working within a limited area of chemistry, often on the border to other subjects like physics, biology and geology. Thus, the other subjects are no longer separate, but overlap, and these hybrids are given new names such as material science, nanotechnology, medicinal chemistry and life science. In order to achieve a common scope and make the review comparable, it has been decided to review only the programmes defined as "chemistry".

In the Danish case, this extends to programmes that lead to the title of:
- Bachelor of Science in Chemistry, or

- Master of Science in Chemistry (cand.scient i kemi).

However, it also means that programmes that are closely connected to chemistry and may lead to the same labour market segment were not reviewed. This includes programmes such as Bachelor of Engineering ("diplomingeniør"), Bachelor/Master of Science in Engineering (M.Sc.Eng. = "civilingeniør"), Bachelor/Master in Biochemistry, in Pharmaceutical Science, in Environmental Chemistry[3], in Nanotechnology and in Molecular, Biomedicine[4]. The Bachelor of Engineering is to be accredited by EVA in 2006.

In the case of the UK, the programmes included in this review are the bachelor programmes that lead to a degree in chemistry and master degrees that are accredited by RSC:
- Bachelor of Science (Hons)
- MChem/MSc degree programmes.

The review covers the bachelor and master programmes in chemistry at the following five Danish, and four UK universities:
- University of Aalborg
- University of Aarhus
- University of Aberdeen
- University of Bath
- University of Bristol
- University of Copenhagen
- Nottingham Trent University
- University of Roskilde
- University of Southern Denmark.

A further presentation of the different universities is provided in appendix D.

[3] The bachelor degree in Environmental Chemistry at Copenhagen University is included in the review, as it is part of a joint structure with Chemistry. However, the panel only reviewed the Chemistry part of the programme and not the degree itself.

[4] Chemistry related programmes in Pharmaceutical Science and Master of Engineering are offered by The Danish Pharmaceutical University and The Danish Technical University. Furthermore, a Bachelor of Science in Engineering in Chemistry is offered at University Colleges.

2.4 Organisation of the review

An international panel and a joint project group from EVA and QAA carried out the review. The international expert panel was responsible for the academic quality of the review. The members of the international expert panel that undertook the reviews were:

- Professor John Winfield (chair), University of Glasgow
- Professor Bjørn Pedersen, University of Oslo
- Dr. Michael Brorson, Principal Research Chemist, Haldor Topsøe A/S, Denmark
- A representative from the project group below covered the quality assurance aspects at each of the site visits.

A further presentation of the panel is provided in appendix C.

The joint project group consisted of the following people from the Quality Assurance Agency for Higher Education (QAA):

- Director Nick Harris,
- Assistant Director Fiona Crozier;

and, from the Danish Evaluation Institute (EVA):

- Chief Advisor Tine Holm,
- Evaluation Officer Claus Beck Hansen,
- Evaluation Assistant Mette Juul Jensen.

EVA and QAA have been jointly responsible for the methodological and organisational aspects of the review. EVA has been responsible for writing the draft report and the institutional feedback to the Danish institutions, based on the contributions, recommendations and conclusions of the panel. QAA was responsible for drafting the feedback letters to the UK institutions. The RSC has contributed to the section on chemistry education in the UK.

Nick Harris, Fiona Crozier and Tine Holm have previous experience of international QA-projects, including, for example, the Transnational European Evaluation Project (TEEP).

2.5 Methodology

The five chemistry programmes in Denmark participated in the review as part of the national cyclic review on the basis of EVA's initiative, whereas the four UK chemistry programmes volunteered to participate.

As this review took the place of a Danish national review of chemistry education, it was important to organise the review so that it met the national requirements regarding methodology.

The review, therefore, had to be criteria-based and consist of three methodological elements: self-evaluation, site visits, and a labour market survey. In the following paragraphs, each element will be described in more detail.

2.5.1 The use of criteria

To ensure transparency, comparability and adherence to the ESG, the review was based on published criteria. In formulating the criteria, the following aspects were considered:

- in accordance with the ESG, the standards for internal quality assurance within higher education institutions that have been adopted by the education ministers of the Bologna Process signatory states;
- the criteria used in TEEP I and II;[5]
- the generic reference points for bachelor and master degrees as suggested by the Framework for Higher Education Qualifications for the European Higher Education Area, and as adopted by the respective ministers (including the so-called Dublin descriptors);[6]
- guidelines, criteria and regulations that exist within national contexts.

All departments had the opportunity to comment on the selected criteria prior to commencing the exercise.

The criteria are presented in appendix E.

2.5.2 Self-evaluation

Each chemistry department produced a self-evaluation report, describing and analysing the extent to which they addressed and met the agreed criteria that were the basis of this review. In addition to this, the departments also assessed the perceived strengths and developmental opportunities of the bachelor and master programmes they provide. The self-evaluation process was designed to fulfil two distinct aims:

[5] *For the definition of TEEP 1 see page 9. The Transnational European Evaluation Project II (TEEP II) was a detailed follow-up to the first transnational European pilot project (TEEP I) coordinated by ENQA in 2002-2003. TEEP II was a European-wide transnational quality evaluation scheme, which aspired to identify means and common elements for quality education in the Joint Masters Programmes in three subject areas: water management; cultural and communication studies; and law and economics.*

[6] *See A Framework for Qualifications of the European Higher Education Area, dated 18 February 2005 at http://www.bologna-bergen2005.no/*

- to provide necessary documentation for the work of the expert panel in connection with the site visits and for this report;
- to motivate discussions and reflections on internal strengths and developmental opportunities and, thereby, stimulate further improvement of the quality of the education programmes provided.

The self-evaluations were carried out in accordance with a set of guidelines outlined by EVA and QAA. Questions in the guidelines were formulated in such a way that the answers would provide the expert panel with the information necessary to assess the programmes on the basis of the criteria.

The information provided was mainly of a qualitative nature, though some limited quantitative data was also provided. The self-evaluation reports included references to relevant documentation, including curricula details. The documentation was distributed to the expert panel, EVA and QAA.

The self-evaluation reports proved to be a valuable instrument in the assessment of the programmes. Most of the reports were very thorough and comprehensive, indicating a high level of commitment from the departments.

2.5.3 Site visits

The expert panel and the project team carried out a one-day site visit to each of the departments during March and April 2006. The purpose of these site visits was to provide the expert panel and the project team with an opportunity to discuss the self-evaluation reports, both in general terms and regarding some detailed aspects, and also to investigate unclear and less substantiated sections. The site visits also served to validate the information provided in the self-evaluation report. Each visit comprised interviews with the self-evaluation group, departmental and faculty (or their equivalent) management, academic staff and students.

2.5.4 Register based labour market survey

As part of the review of the Danish chemistry programmes, a register based labour market survey was conducted among master graduates of chemistry. The purpose of the survey was to gain some insights into the proportion of graduates in employment, and the types of employment undertaken. The survey was based on data from Statistics Denmark, which each year collects the data from the universities. The newest accessible data was from 2004 and, as we would like to look into the chemistry graduates' labour market affiliation one year after their graduation, the most recent data covered graduates from 2003. As a result, this survey covers graduates having completed their studies during the period 2001-2003. It is also important to stress that the survey

only includes graduates with the title: Master of Science in Chemistry (cand.scient i kemi). The results of the register based survey are presented in chapter 5.

2.5.5 Report

The results of the review are published in this report – which is publicly available. As the four UK chemistry programmes have volunteered to participate, the results for these institutions remain anonymous. Although this report only contains the individual feedback to the Danish institutions, the UK institutions have still received individual feedback in same format as the Danish ones (i.e. concerning good practice and developmental opportunities).

2.6 Content of the report

The report contains a summary, an introduction, 2 main chapters and a number of appendices.

Chapter 1 provides a summary of the main conclusions derived from the comparative considerations. This chapter (2) introduces relevant methodological aspects of the review. Chapter 3 contains the comparative part of the report and focuses on both the Danish and the UK programmes in relation to the focus areas: student learning experience and quality assurance. Furthermore, chapter 3 briefly introduces the organisation of chemistry in DK and the UK respectively, as well as at the individual departments. Chapter 4 provides individual responses to each of the five participating Danish institutions based on the main conclusions regarding the individual programmes. Chapter 4 also contains the results from the register based labour market survey.

3 Comparative perspectives

3.1 Chemistry in Denmark and the UK

The purpose of this chapter is to outline the context of chemistry education in which the chemistry programmes of the Danish and UK departments operate. In the UK, "pure" chemistry students often constitute a large proportion of the total student population of the chemistry departments, whereas in Denmark, students of "pure" chemistry only account for a smaller proportion of the departments' total student population. It seems that the UK universities continue with a more traditional education, while most of the Danish universities are on the move. This might be due to the fact that the UK universities are operating in a much larger market, as the population of UK is much larger than Denmark. The following sections will describe the UK and the Danish chemistry contexts.

3.1.1 Chemistry in the UK[7]

The number of universities in the UK currently offering degree programmes with "chemistry" in the title is 55. This does not necessarily indicate the number of university chemistry departments. For example, a few universities offer just one degree in, say, "biological and medicinal chemistry" which is supported by a bioscience department. The number of universities in the UK offering chemistry degree courses ten years ago was 81, which indicates that there has recently been a significant decline in the number of UK universities offering chemistry.

The number of UK universities offering degrees titled simply "Chemistry", which generally implies wide ranging studies in chemistry, is 43. Of these, 38 offer both BSc (Hons) and MChem/MSc degree programmes, 1 offers just MChem and 4 offer Bachelor of Science (Hons) only.

[7] *The following description and numbers are based on information from the Royal Society of Chemistry, 2006*

The total number of UK chemistry undergraduates in each year of study is around 2,700 – 3,000. For example, in 2004, 3,089 students were admitted to chemistry degree programmes while, in the same year, 2,735 graduated with a chemistry degree.

Extended (or enhanced) undergraduate degrees ("M" degrees) in "chemistry", "chemistry with ----" and "chemistry and ----" programmes are very common in the UK. Originally introduced as a response to a perceived reduction in the extent to which students were prepared for tertiary chemistry study from the secondary public examinations, MChem/MSci programmes (the title used depends on the university concerned) now appear to be regarded as the usual entrance route to becoming a professional chemist.

The investment required to provide up-to-date laboratories for university chemistry teaching is significant; substantial outside support is required. The pressure for improvement is a positive factor; it is a response both to UK Health and Safety legislation and to the close relationship that exists between many university departments and the chemical and pharmaceutical industries. The latter is reflected in the large number of degree programmes in which industrial placements are an integral part of the teaching activities.

In the traditional UK chemistry department, sub-discipline elements, inorganic, organic, physical, and in some cases analytical and theoretical, were strongly represented and had considerable autonomy for action. This pattern is still apparent, although there will be collaboration in most departments of this type to avoid duplication of teaching material. In contrast, an increasing number of departments seek to emphasise in their teaching the links between chemistry and cognate subjects, particularly biology and materials. In some instances, traditional departmental and faculty structures (in which disciplines are emphasised traditionally) have been abandoned in favour of structures that facilitate teaching (and research, which may be the major driver) at discipline interfaces. Both types of "departments" were well represented in the UK-part of this project.

Devolution of political power from Westminster has had a significant effect on higher education, which is now the responsibility of the constituent parts of the UK. Each part has its own funding body and polices for disciplines may not always be identical across the UK.

3.1.2 Chemistry in Denmark

Compared with the UK, the study of pure chemistry in Denmark is limited. Five Universities – Aarhus, Aalborg, Copenhagen, Roskilde and the University of Southern Denmark – offer bachelor and master degrees in chemistry (cand.scient. i kemi).

Historically, chemistry graduates in Denmark went into the public sector - primarily as teachers in upper secondary schools, where teaching of chemistry still requires a M.Sc. with at least a minor in chemistry. Industrial jobs, on the other hand, were traditionally filled with graduates of chemical engineering from the Technical University of Denmark. In the 1970's this began to change, and chemistry was probably one of the first non-technical science subjects where industrial jobs became important. In the course of the following decades the need for upper secondary high school teachers declined, and graduates probably also found these positions unattractive. Now chemistry graduates go primarily into private and public research while only a small fraction choose upper secondary high school teaching. The job markets for chemical engineers and chemistry science graduates have now partially merged. As a reflection of this, the universities outside the capital region have within the last decade started to offer study programs in both chemical engineering and in non-technical chemistry. These programs run in parallel but usually, to a greater or lesser extent, overlap so as to use teaching resources economically.

The main challenge that has confronted the science faculties (technical or not) in recent years has been the declining interest among high school graduates in continuing with a tertiary education in science. With intake quotas unfilled, no minimum grade requirements for admission have been enforced, and this has not increased the prestige of the subjects among prospective students. In an attempt to attract more students, some of the former non-technical universities have, as mentioned above, ventured into the chemical engineering area. Other major initiatives include the introduction of many new (non-engineering) study programmes in which chemistry is a major component in a context that seems to have more immediate appeal to high school graduates than purely "chemistry". Part of the reason for this could be that job opportunities in many cases are more clearly defined upon entry to the program. These new study programmes, to be mentioned below, are, however, outside the scope of this report.

At most universities, the pure chemistry degrees constitute only a minor part of the teaching obligations of the chemistry department. Thus the teaching of students with a non-chemistry focus in their science degree plays an important role. The organisation of chemistry within the different departments for each of the Danish programmes is described below.

At Aarhus University, two chemistry degree programmes are based in the department of chemistry: the chemistry programme and the medicinal chemistry programme. Furthermore, the department of chemistry is involved in the interdisciplinary nanotechnology programme.

An equivalent organisation is found at the faculty of science at the University of Copenhagen, which offers bachelor and master programmes in chemistry and environmental chemistry in addition to a number of other chemistry-related programmes, such as biochemistry, nanotechnology and molecular biomedicine, the latter in cooperation with the faculty of health sciences.

Also at the University of Southern Denmark, the students at the department of chemistry follow a number of different programmes, such as nanoscience, pharmaceutical chemistry, pure chemistry as well as programmes combining chemistry with a minor subject (either within or outside the faculty of science).

At Roskilde, in the department of life sciences and chemistry, three different disciplines are represented under one roof: chemistry; molecular biology; and environmental biology. Programmes in chemistry are offered in combination with environmental biology and molecular biology. Programmes are also offered across departmental borders, i.e. with physics, mathematics, computer science and other subjects.

Finally at Aalborg University, there are strong links to the engineering disciplines, as the school of chemistry, environmental engineering and biotechnology is responsible for bachelor of science/bachelor of engineering and master of science/master of science in engineering programmes.

3.1.3 Student intake and entry requirements

The enrolment systems in Denmark and the UK differ in the level of freedom which the universities have to set their own entry requirements and the number of places they offer.

In Denmark, enrolment is centralised in the sense that each student has to fill out only one application form for entrance to a university study. The student's priorities in terms of subjects and universities are listed on the form. A central system then enrols students according to priorities and available places.

The general entrance level for university is the Upper Secondary School Leaving Examination or The Higher Preparatory Examination which level is equivalent to the UK A-level. In supplement to general degree specific optional subjects or a specific level of attainment is required. the ministerial order defines entry requirements specific to the various bachelor programmes, For instance, entry to the Danish chemistry programmes generally requires, until 2007, advanced level (A-level) in mathematics and intermediate level (B-level) in chemistry and physics. From 2008, the requirements for the chemistry and biochemistry programmes (Aarhus University and University of Copenhagen) have been changed to advanced level in mathematics, and one advanced level and one intermediate level in chemistry and physics, whereas the entry requirements for nanotechnology (all universities) and the natural sciences (Roskilde University, University of Southern Denmark and Aalborg University) remain the same, i.e. ABB.

In addition, the universities have the possibility of requiring the achievement of a certain grade in these high school examinations, or of setting a maximum number of students they can accept for

each individual study. There are no specific grade requirements for enrolment on the chemistry programmes at the Danish departments - only the national pass-level requirement.

In the UK, although a student completes a single form, the universities decide centrally, at departmental or at faculty level, which students they would like to admit. Consideration of applications is made against the background of the stated entry requirements of the school or department. Admission decisions can be based on a range of factors, including academic achievement and potential, relevant skills and aptitudes, evidence of motivation and commitment and, where relevant, work or practical experience. Some departments interview all applicants as part of the process of deciding who may enrol.

In Denmark, the main issue is to attract a sufficient number of students for science and technology programmes. A tendency has, therefore, been to market new programmes with titles and content that appeal more to prospective university students than just "chemistry". This has, in particular, been the case at those universities where the precise direction of study has to be decided upon entry to the university, i.e. without a more general first year. Such undertakings have to be weighed carefully against the risk of attracting students with little real commitment and/or poor qualifications.

The strength of a central system is that all students, based on their academic achievement, have equal rights to admission at a certain university. However, there is also the risk of high drop-out rates as student motivation and capacity are not specifically assessed in the application process. Furthermore, central orders on level requirements may conflict with the development of subject choices among the student population. One of the Danish institutions considers the change in entry requirements for the chemistry and biochemistry programmes effective from 2008 a serious threat to the critical mass of their programme. They are concerned that not enough students from upper-secondary school will meet the high entry requirements and the specific subject combination and, therefore, fewer students will be able to apply.

Interviewing students is an important part of a competitive system, as exists in the UK. In addition to discussions about academic topics, student attitude/motivation can be assessed. Most UK departments feel that it is necessary for them to "sell" their respective advantages; and these will not be solely academic, e.g. factors such as social life and locality may have an influence.

A disadvantage of a distributed system of entry is the need for resources to mount an effective operation. At many of the UK departments visited, involvement in recruitment was a significant part of an academic staff member's administrative workload. A positive feature is that departments have been forced to look critically at the purpose and quality of their promotional material/information packs (both hard copy and web-based).

The intake at the five Danish and four UK institutions is presented in tables 1 and 2. However, it is difficult to compare intakes as the degree structures are very different – see section 4.2.1 for a detailed description.

Table 1
Student intake at the bachelor level 2001-2006*

	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006
University of Copenhagen[1]	46	33	37	32	51
University of Aarhus[2]	9	17	24	25	-
University of Southern Denmark[3]	29	33	34	35	-
University of Aalborg[4]	1	3	3	11	-
University of Roskilde[5]	27	31	19	24	15
University of Aberdeen[6]	23	11	19	10	-
University of Bath[7]	67	69	66	81	110
University of Bristol[8]	28	26	27	27	22
University of Nottingham Trent[9]	46	43	32	48	53

Source: The self evaluation documents

**Please note that the table covers students admitted in total as of October 1st.*

[1] *Until the year 2003, there were three different independent entries to the chemistry-related Bachelor programmes: Chemistry, Environmental Chemistry and Chemistry/Another Subject, where the other subject was typically one from the natural sciences. Effective from 2004 there is only one entry: the chemistry programmes that after one year split into Chemistry or Environmental Chemistry.*

[2] *The numbers cover BSc students in chemistry.*

[3] *It is not possible to give the exact number of first year chemistry students, since the students are matriculated as science students and do not choose programmes until after one year. However the percentage of the students who want to study chemistry is close to 20 percent, which has been used to calculate the numbers above.*

[4] *Covers both intake in the freshman year and those students that later choose chemistry as another subject.*

[5] *The students at RUC also follow a second subject, which is weighted equally to chemistry*

[6] *The figures are based on those students whose registered intention, currently or on leaving the University, is or was chemistry. They do not include those who entered the university with that intention, but transferred to another discipline - e.g. Biochemistry - but DO include students belonging to the relevant cohorts that came from other disciplines.*

[7] *Students admitted to the chemistry department may transfer between the BSc and MChem programmes (if eligible) until the end of Year 2. It is therefore not appropriate to differentiate between these entries; as a consequence the numbers include the intake for both the BSc and the MChem.*

[8] *Covers BSc Honours in chemistry.*

[9] *Numbers are taken from the Student progression and Achievement Statistics and cover the BSc/MChem year one.*

Table 2
Student intake at the master level 2001-2006*

	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006
University of Copenhagen[1]	28	27	39	33	-
University of Aahus[2]	-	-	-	-	-
University of Southern Denmark[3]	29	20	15	12	15
University of Aalborg[4]	-	-	-	-	-
University of Roskilde[5]	16	15	28	23	27
University of Aberdeen[6]	7	10	13	12	-
University of Bath[7]	67	69	66	81	110
University of Bristol[8]	82	106	105	90	148
University of Nottingham Trent[9]	46	43	32	48	53

Source: The self evaluation documents

**Please note that the table covers students admitted in total as of October 1st.*

[1] *Bachelors graduating from the Chemistry/Another Subject programme are admitted into the masters programme in either Chemistry or the other subject. Thus, the table includes only those that chose Chemistry.*

[2] *Up to 2005 students were allowed to follow courses at master level even though they had not obtained a bachelor degree. Due to the registration system at the Study Office such students were registered both as bachelor and master students until they had obtained a bachelor degree. Consequently, there is no valid information on student intake at the master level.*

[3] *The intake covers MSc students in Chemistry.*

[4] *It has not been possible to collect separate data for intake at the master level.*

[5] *The students also follow a second subject.*

[6] *The intake covers students on the integrated master (MChem) The figures are based on those students whose registered intention, currently or on leaving the University, is or was chemistry. They do not include those who entered the University with that intention, but transferred to another discipline - e.g. Biochemistry - but DO include students from the relevant cohorts gained from other disciplines.*

[7] *Students admitted to the chemistry department may transfer between the BSc and MChem programmes (if eligible) until the end of Year 2. It is therefore not appropriate to differentiate between the entries; as a consequence the numbers include the intake at both the BSc and the MChem level.*

[8] *The intake covers students on the integrated master (MSci)*

[9] *Numbers are taken from the Student progression and Achievement Statistics, and cover the BSc/MChem year one.*

3.2 The student learning experience

This section considers the student learning experience. There are four areas of focus: degree programme structure and content; programme aims; descriptors for learning outcomes - including competences; and teaching, learning; and assessment methods. Under each headline, the criteria are discussed from a comparative perspective.

3.2.1 Degree, programme structure and content

There are both similarities and differences between the countries and institutions regarding nominal duration of the bachelor and master programmes, as well as in terms of programme structures. This section of the report will explore these differences.

Degree structure

In Denmark, the structure of all university programmes was changed in 1993 from a five year integrated master degree to a two cycle model: a three year bachelor followed by a two year master programme. This model is aligned with the Bologna cycles, most obviously in terms of timing, and as the bachelor programme now constitutes a complete programme in itself, the structure is intended to increase opportunities for mobility of students between institutions at the bachelor/master interface and allow students to exit university after 3 years with a formal degree in hand.

Students start a BSc degree in natural science at an average age of 23, and it became evident from the site visits that the vast majority of bachelor graduates continue in a master programme at the same university. [8] However, a few students mentioned that they were considering taking their master degrees at another university, indicating that students are gradually becoming aware of the institutional shift possibility. At least one department had experienced that some bachelors from other universities had enrolled in their master programme.

It was the overall impression from talking to both students and staff that few employers hire science bachelor graduates – they prefer candidates with a master degree. One reason may be that there are many well recognised short and medium cycle vocational programmes that employers prefer over the more general university programmes. Furthermore, in Denmark the option of becoming an upper secondary school teacher on the basis of a Bachelor of Science does not exist - as it does in the UK.

There is, however, one exception to the Danish 3+2 structure. Two of the Danish departments has for several years worked with an alternative, where they have created what they call a 4+4 model. For the first three years, the student follows an ordinary bachelor programme. Then the

[8] *Source: UNI-C Statistics and Analysis. The average age is for 2004.*

student can continue on a master programme, which is normally of two years' duration. However, if the student qualifies, he/she can enrol on a PhD programme after only one year of study on the master programme. If the student is admitted into the PhD programme, he/she is awarded a master degree after a total of six years of study, and a PhD degree after eight years. The model is designed to attract more students into a research career and is followed by approximately 80% of the chemistry department's PhD students, even though it is also possible to finish an ordinary two year master degree before applying for a PhD. From discussions with the programme management, it became apparent that the programme is very prestigious, and, at the same time, the students get a lot more financial support than regular master students.

The UK degree structures differ from the pattern found in Denmark. The most common pattern is that found in England, Wales and Northern Ireland (EWNI). The distinct pattern in Scotland, which has evolved separately for historical reasons, is summarised after the EWNI pattern.

The EWNI degree structure differs from the Danish in several respects. Departments typically offer bachelor degrees with honours (an "ordinary" or "pass" bachelor degree is normally only awarded to a student who does not reach the honours standard) and integrated master degrees (MChem/MSci). Students might typically enter a bachelor programme at 18 or 19 years of age, with the bachelor programme being of either three or four years duration. In the latter case the programme might include a year (or equivalent) working in industry, a professional placement, or a study-year abroad.

It was evident from discussions with teaching staff that they encourage students who want to become teachers or find employment in which acquired generic skills are important, to take a bachelor degree. Those students who wish to use chemistry in a career sense, i.e. to practice as a professional chemist, will be encouraged to take an extended master degree. These are usually accredited by RSC as providing the appropriate academic background for a professional career.

The MChem/MSci degree is a four year integrated programme. It has an identical starting point to the corresponding bachelor programme; much of the first two years will be common to both programmes and, normally, year three will have elements that are common to both programmes. A bachelor degree is not awarded "on the way" however. Master degrees are variously enhanced, compared with their bachelor counterparts, by the inclusion of advanced modules at the master level, a more demanding research project and/or a substantial professional placement in industry or at a university outside the UK.

The third element in the EWNI Degree Structure is postgraduate programmes, PhD or master by research (MSc or MRes). Postgraduate master programmes, of one or two years' duration, although less common than formal ones, are still found at some institutions. Their consideration

did not form part of this project but the MSc is relevant, since it is at the same level of attainment as MSci/MChem.

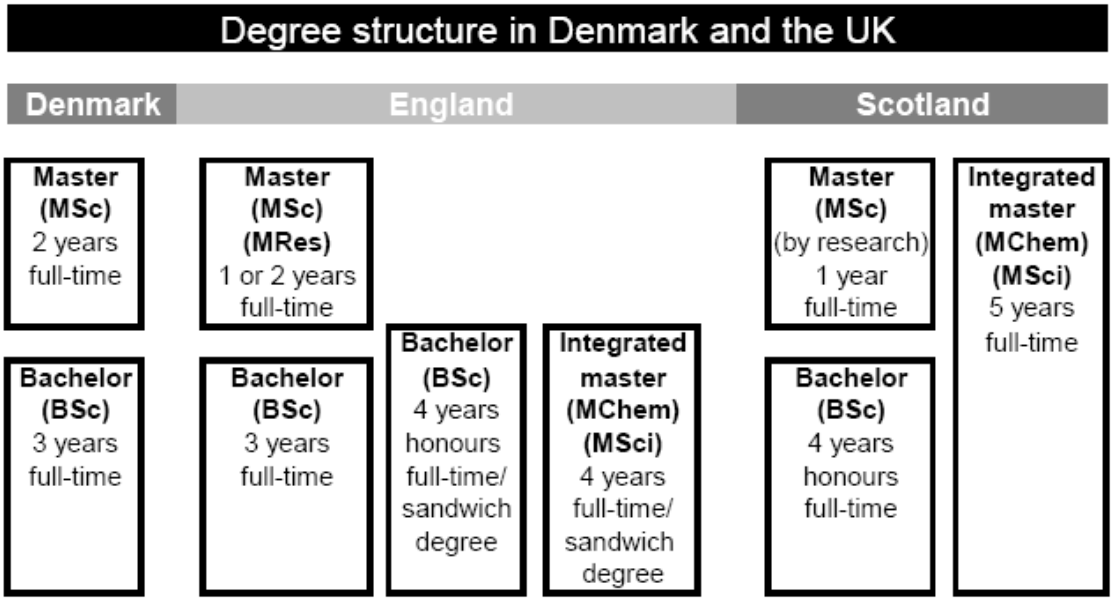
In Scotland, students can finish secondary school aged 17 and start directly at university. However, they can also take an extra year at secondary school before commencing university. If the student takes the extra year, he/she might be able to go straight into the 2nd year at university. On the site visit, however, it became apparent that most students enter at the age of 18 or above, and that the majority go into the 1st year, even though they are not obliged to.

Although many features of the Scottish system, as it affects chemistry, are identical to those described for EWNI above, there is an important difference. In Scotland the traditional bachelor pattern is more generally found than in EWNI. Year 1 comprises three subjects studied with equal weighting; in year 2, two subjects are often studied. It is perfectly possible, therefore, for a student to delay a final decision between a bachelor with honours or a master subject programme until the end of year 2. Depending on the decision taken, this will be followed by full time study of chemistry (or "chemistry with", "chemistry and"), either for years 3 and 4 leading to a BSc with honours, or for years 3 ,4, and 5 leading to MSci/MChem.

The "non-honours" bachelor degree has traditionally been a significant part of the Scottish system. A recent development is a three year BSc designated degree comprising a year (year 3) of full time study in the "designated" subject (chemistry in the present case) following on from years 1 and 2. Technically, it could be argued that this is a first cycle degree to be followed by a two year master programme (second cycle).

On the site visit, it also became apparent that one UK department is currently in the process of developing a two year postgraduate master programme in chemistry. This would allow the department to offer either the integrated 5 year master in chemistry or a 3+2 model along the lines of the Bologna cycles.

The figure on the next page illustrates the general degree structure in Denmark and the UK.



The Panel concludes

The panel finds the main difference between the Danish and UK systems to be that, whilst Denmark has implemented the Bologna 3+2 bachelor/master cycles for all degrees, in the UK, the main award in chemistry comes from an integrated programme that leads directly to a master degree; a process which is not aligned with the Bologna proposals. In Denmark, the two cycle system has become part of the national regulation of higher education, and this is probably the main reason why the Danish universities have implemented the first and second cycle degree structure; in the UK, universities are autonomous and are not required to design programmes to national requirements, although the government has signed the Bologna declaration.

The Danish system is far simpler than those found in the UK. A simpler system is far easier to relate to those of others. A benefit of a more complex system is its flexibility; for example a wide variety of student backgrounds and expectations can be accommodated.

Although there are two exit points in the Danish system, in practice the first exit is not yet used. Hence neither Denmark nor the UK can yet be said to adhere to the Bologna first and second cy-

cle philosophy. There are good reasons for this, probably having their origins in national practices which, of necessity, can change only slowly. It would be disastrous to attempt to designate one of the systems as the"better".

The most obvious point of correspondence between the two systems is at the end of the master degree. The Panel considers that expected outcomes and competences from both to be very similar or identical. The question arises therefore,"What is the added value arising from the additional year required in Denmark compared with the UK?" One answer to this question is that there is more time for the student to undertake the substantive research project, which is required in both countries.

The panel also finds that the development of a two-year postgraduate master programme in chemistry at one UK department, although challenging, is a forward thinking initiative that, with its consideration of relevant European reference points, is excellent and to be encouraged.

Programme structure

The Danish departments participating in this exercise all use the European Credit Transfer and Accumulation system (ECTS) to quantify their programmes. While the UK departments also use credit systems, ECTS is not necessarily the primary system, although they can make "conversions" when needed. However, when it comes to programme structure, differences appear.

In Denmark, the bachelor and master degrees are 3 and 2 year full-time programmes, respectively. During the BSc and MSc, students have the opportunity to spend part of their time in the programme abroad as part of the Socrates/Erasmus programmes, or under other international student exchange agreements.

Students may choose to work with a particular project or attend courses for one or two semesters at a foreign university, the minimum workload must be equivalent to 30 ECTS. Also part of the master thesis may be researched or written abroad. However, the thesis cannot be completely transferred but must be assessed at the Danish university where the student is based.

The UK university departments offer the bachelor degree in chemistry either as a 3 year (four in Scotland) full-time programme or as a four-year sandwich degree, incorporating a 1 year professional placement or a study year abroad. They also offer 4 year (5 years in Scotland) master programmes aimed at graduates intending to enter professional practice or pursue a research career. The master is offered either as a 4 year full-time programme that can lead to a PhD programme, or as a 3 year full-time study programme with a study year abroad or a year of professional

placement in industry; this may also lead to a PhD programme. Some of the departments also offer a foundation degree – a 2 year programme aimed at students with work experience in a relevant area.

From a comparative perspective, the use of placement programmes is interesting; they are not offered in the Danish programmes. At one UK department, students get an early introduction to the placement scheme during their first year through detailed information, and later on by means of attending a conference of those students currently undertaking industrial training and discussing their experiences. This allows them to make a decision based on clear information, and also allows them to consider the role of the placement in relation to the programme in which they are studying. Students are well supported by visits from university representatives during their placement year and are allocated a supervisor at their place of work. All supervisors are briefed so that they understand the expectations and intended outcomes of the placement year. Students are further supported by their personal tutor at the university during their placement year if so desired. Output that is assessed from a placement year may include a research report, thesis, a company profile document, distance learning activities.

At the bachelor level, the Danish universities structure their programmes differently. Three of the universities have a basic study programme that bachelor students within the natural sciences follow. These basic study programmes are interdisciplinary and of either one or two years' duration. One reason for having the basic study programme is to avoid students having to select upon entry to university the particular subject that will be the end target for their study programme. It was evident from the site visits to the universities that department managers, teaching staff and students considered that the basic study programme gave a wide introduction to the natural sciences and, as a consequence, made it easier for the students to make informed choices of subjects for their bachelor degree and, therefore, also helped reduce the number of drop-outs. This is similar to the broadly-based Scottish first year that was described above.

At another department, there is one common entry for both chemistry and environmental chemistry. After the first year, the students choose whether they want to graduate as a bachelor in chemistry or environmental chemistry. Finally, at one department, the students select chemistry from the beginning, but have the opportunity to choose electives within other subject areas during the programme.

Arrangements for studying abroad tend not to be formalised in study plans and are usually arranged by the master project supervisor for students that express a desire to spend some time abroad. At least one science faculty provides grants for studying abroad. However, studies abroad are by no means part of the typical student's programme even though there are many international arrangements that formally provide the opportunity. These arrangements, typically be-

tween individual universities, are based on reciprocity, and Denmark is not able to attract as many students as it would like to. The countries that do attract many students are typically English-speaking; a pleasant climate and exciting surroundings also helps the popularity. To attract foreign exchange students, the Danish universities will have to rely on scientific excellence. Since a world-leading position in the areas of science and technology is the declared aim of the Danish government one could hope that the reciprocity problem will disappear over time.

The UK universities also have different structures. At one university, all students enrolling on a chemistry degree programme can choose another subject besides chemistry in the first year. This other subject is usually selected from within the science faculty but can also include a foreign language. At another university, all chemistry students follow a common programme of study for the first two years. This structure means that students do not have to declare upon entry the programme or degree they wish to study. However, their grades and choices of courses in the first two years may limit their choice of degree. At a third university, all students have to choose a degree when they enrol. However, after two years of study, students can switch from the foundation degree to a bachelor or master, from a master to a bachelor or from a bachelor to a master degree. It is important to emphasise that assessment results and the number of exam attempts may limit the student's options.

At the fourth UK University, all students are admitted to a general degree programme that is unspecified. Particularly during the first two years, the students have a wide range of options in choosing their subjects, and this gives them the opportunity and flexibility to consider the longer term programme they wish to study.

Another interesting aspect regarding the programme structure is how the departments divide the academic year. Some of the Danish chemistry departments use a block structure, while others use a semester structure. One of the departments that use a block structure has chosen to divide the year into four blocks, instead of the usual two. Each block covers nine weeks, including exams, and the students attend a maximum of two courses in each block. Considerable thought is put into this new structure and it is a hope that the new initiative, among other things, can help remedy the problem that all the Danish departments face in relation to high drop-out rates and the very large number of students who do not complete their programme within the set time. In the UK, some of the departments have changed from an arrangement akin to the block system, returning to a semester-based assessment. The reason for this was that they thought the students had a tendency to focus on the content of the different courses, and less on the programme as a whole. In other words, they believed the students had a tendency to focus too much on bite-size learning.

The Panel concludes

It is apparent that both the Danish and UK departments have different ways of structuring their programmes. The panel found the variety of structures to be an important strength and believes it to be essential that this plurality is safeguarded. However, during the site visits in Denmark, the panel noted that the very different ways of structuring the degree programmes at the departments can create a barrier for student mobility between bachelor programmes at different universities, and between different universities at the bachelor-master transition, as the students might be required to take additional study packages to qualify for entry to another university's master programme.

Another main difference between the UK and Danish structure is the use of placement programmes in the UK degree programmes. The panel was impressed with the organisation and management of the placement programmes and the variety of placements offered, especially at some of the UK universities. In particular, placement in industry has the great advantage that it provides the students with valuable insight into the labour market and ties departments and industry together. Furthermore, feedback from industry is an important element in developing, assuring and enhancing the quality of the programmes.

Another interesting contrast is that some of the Danish universities are implementing a block structure, whereas in the UK, two of the participating universities have left the block structure in favour of the semester based model. The UK institutions argue that the block structure resulted in "bite-size" learning, and a lower level of coherence between studying and learning than might be desirable. The panel found it difficult to compare the impacts of programme structures on learning, between Danish and UK institutions, largely because the UK institutions do not have the same problem regarding drop out that the Danish departments face.

Content

It is important that the composition of the courses and curricula is characterised by progression in learning opportunities, and that this is planned so that they support the students' achievement of the programme aims.

It is evident from the self-evaluation reports, and the site visits, that the content and weighting of different study elements differ across departments.

Although there are many differences in approach among the nine institutions that formed the basis of this project, the Panel recognised that within the constraints imposed by available re-

sources, the programmes endeavoured to maintain the traditional breadth of the subject. Recognisable themes, certainly at the basic level, that can be described as inorganic, organic, physical (including theoretical) were present in nearly all cases. All departments subscribed to the view that chemistry is an incremental subject, but the extent to which this "incrementality" was achieved from the initial year of the subject through to the master level depended on the staffing resources available, laboratory facilities and the size of teaching budgets. All departments subscribe to the view that their master degrees are, or at least should be, research based. The strongest departments according to the criteria given above were the most obviously successful in providing good portfolios of research-based topical teaching appropriate to the final (or penultimate) year of a master degree.

It should be born in mind however, that interdisciplinary courses (such as nanotechnology, materials) and chemistry programmes that specialise in some aspect (such as medicinal chemistry) were largely excluded from examination. In some Danish programmes, there is a requirement that a master programme must involve two subjects. This is an additional constraint for a small department in developing a portfolio of research-based teaching; modules produced must in some way be cognate with a student's other master subject.

Specifically for the two Danish programmes in which project based learning plays an important part, the issue of programme content is more difficult to address than for traditional programmes. At one of the departments, the bachelor and master programmes consist of 50% courses and 50% project based learning modules. The chemistry courses reflect the full spectrum of chemical science and they are supplemented by some courses in related sciences. Since less time is spent on teaching core chemistry by means of courses, some of this must be acquired by the students in the project based learning modules where, of course, other competences are acquired as well. The projects are to a large extent defined by the students themselves and there is, therefore, freedom to focus on subjects of interest. The experimental equipment available at the institute will, however, restrict this freedom. At the other department where a project based learning program is offered, non-chemistry subjects take up at least 33% of the combined BSc + MSc degrees after the initial freshman year. Core chemistry competences are acquired partly in so-called project supporting courses and partly in the projects themselves. Since each project is unique it is difficult to generally assess which core competences are acquired and at which level.

The Panel concludes

The Panel has concluded that it is increasingly difficult for a small department to continue to provide a range of bachelor and master programmes (irrespective of the system, Danish or British) that are rigorous and provide a reasonably wide spectrum of topics, which at the master level, are research-based.

3.2.2 Aims

This section of the report focuses on the aims of the programmes. Aims are essential for a number of reasons: firstly, they provide prospective students with information on which to base their choice of study and support transparency for others; and secondly, explicitly formulated aims provide management and teaching staff with terms of reference for designing content and progression within and between courses, as well as aiding selection of the most appropriate teaching methods for (different parts of) the different courses.

In Denmark, the general aims of any bachelor and master programme are outlined in the ministerial order on bachelor and master programmes from 2004. The key elements in the general aims are that both the bachelor and master degrees are supposed to qualify the student for further studies and employment.

It is evident from the self-evaluation reports that some of the Danish departments are still in the process of formulating aims for both their bachelor and master programmes in chemistry with regard to the need to adhere to the ministerial order of 2004. This is partly due to the fact that many of the departments have recently revised their programmes or are in the process of revising them.

It also appears from the self-evaluation reports that the process of formulating aims has been very similar at the different Danish departments. For most of the departments involved, the aims have been determined by the chemistry department and, at the faculty level, by the study board. Some have involved external stakeholders in the formulation process. The departments further state that the aims are publicly available, either on their website or in printed format. Aims are documented particularly well for Danish bachelor programmes; master programmes are at present far less well described, but it appears that this aspect will be developed in the future.

With regard to the UK departments, there are no legislative requirements guiding the departments in relation to the formulation of the aims of their programmes. However, panels of experts

have formulated a subject benchmark statement for the bachelor degree with honours in chemistry at the UK departments. It is generally anticipated that this subject benchmark, which is published by the QAA, has been and will be used as an authoritative reference point when departments are designing and developing new programmes. One university referred to the subject benchmark in its self-evaluation report and stated that they concur with its aims. Other UK departments do not explicitly refer to this or other external reference points in their self-evaluation report, but from the site visit it was evident that all departments consider external reference points when designing and developing new programmes. It also appears from the self-evaluation report and/or the site visits that aims are publicly available either on the departments' websites and/or in printed format.

The Panel concludes

The evidence gathered during the site visits and from the self-evaluation reports indicate to the panel that almost all the departments have formulated clear aims for their programmes. At the same time, it was evident to the panel that the aims were also available to students and other relevant stake holders.

3.2.3 Descriptors for learning outcomes, including competences

This section focuses on the departments' work with learning outcome descriptors and the extent to which they apply external reference points, including the Dublin descriptors, in their work.

Since 2001, there have been frameworks for higher education qualifications in the UK, with one for England, Wales and Northern Ireland (FHEQ), and one for Scotland. The FHEQ for Scottish qualifications is incorporated within the Scottish Credit and Qualifications Framework (SCQF). The main purpose of each framework is to ensure a consistent use of qualification titles, to enable stakeholders to understand the achievements represented by higher education qualifications and to maintain international comparability of standards, especially within Europe. The framework includes a number of generic descriptors that set out the learning outcomes of the major qualifications for each of the levels of the framework.

In 2003, the Danish Bologna follow-up group followed the UK example and produced a similar framework for higher education qualifications in Denmark - the Danish Qualification Framework. Prior to this, the Danish universities primarily used aims to describe their programmes. Today the Danish universities are obligated to work towards describing their programmes using outcome descriptors; however they are not obliged to use the Danish Qualification Framework.

In 2005, the Bologna follow-up group put forward a general Framework for Higher Education Qualifications of the European Higher Education Area. This framework was adopted by the ministers of the Bologna Group in 2005. The document contains the Dublin descriptors which set out, in rather generic terms, the anticipated outcomes and competences associated with the completion of each of the Bologna cycles.

It is evident from the above short introduction that the UK universities have worked with descriptors for learning outcomes for a somewhat longer period than their Danish counterparts. This is also obvious from reading through the self-evaluation reports. The UK university departments all refer to the FHEQ/ SCQF. Several of the departments further state that attention is also paid to the requirements for accreditation by the Royal Society of Chemistry when outcome descriptors are formulated for study programmes. It is interesting that none of the departments refer to the Dublin descriptors in their self-evaluation reports. However, it became apparent during the site visits that many of the departments knew of their existence.

The Danish departments, however, are at different stages with regards to formulating outcome descriptors. Some departments have come far, while others still have a way to go. One university, for instance, has formulated generic and subject specific competences for almost all of their chemistry degrees and courses, while others have only formulated descriptors for the bachelor level, and only the generic ones. Not many of the Danish institutions refer to the Danish Qualification Framework in their self-evaluation report. However, it was evident on the site visits that all departments use this as an external reference point in formulating their outcome descriptors. One of the reasons why they do not follow the qualifications framework explicitly might be that it can be difficult to translate, and make programme specific.

Another interesting aspect with regard to formulating descriptors of learning outcomes is whether the departments have a clear understanding of the critical difference between the bachelor and master levels and, in particular, with regard to the identification of those elements and expectations that distinguish the two degrees from each other.

From the self-evaluation reports and site visits it is evident that some departments have given the matter more thought than others. In general, it is fair to say that the departments which have formulated outcome descriptors for both bachelor and master programmes have the best explanations of the critical differences.

The Panel concludes

The self-evaluation reports and the site visits indicated to the panel that the UK institutions are ahead of their Danish colleagues with regard to formulating outcome descriptors and applying external reference points in that work. However, this is not surprising, as outcome descriptors are quite new to the Danish departments.

Regarding international reference points, neither the Danish or the UK institutions are using the Dublin descriptors as reference points to indicate the difference in outcomes between bachelor and master level.

During the UK site visits, it also became apparent to the panel that it can be difficult for departments to address all of the various and different external reference points when formulating outcome descriptors for their programmes, especially if there are inconsistencies between the available reference points. Clearly, the requirements of particular and important accreditation processes are likely to take precedence over those of a more generic and perhaps wider application. Were there to be inconsistencies between RSC accreditation criteria and, for instance, the Dublin descriptors, departments would give far greater priority to fulfilling the RSC criteria, as these are crucial to the accreditation process. This example shows that there are potential barriers to adopting the European Framework and its descriptors in a "literal" sense, although they were of course never intended to be used in such a way.

The evidence gathered during the site visits indicated to the panel that some departments need to be more specific in describing and communicating the difference(s) between the bachelor and master levels with regard to aims and competences. This is especially important when bachelor students and master students follow the same elective courses. It should be clear to both students and staff what is expected of a bachelor and master student's work, and how it differs.

At present, neither the UK or Danish system has a set of comprehensive criteria to map courses, projects and other teaching activities to the master level. The UK does have a QAA benchmark statement at the bachelor level, which has proved useful in helping to decide whether a topic/activity is appropriate as bachelor or master; this document has been adopted as the source document for Eurobachelor.

3.2.4 Teaching, learning and assessment methods

This section focuses on the different teaching, learning and assessment methods used by the UK and Danish departments.

The programmes incorporate a variety of learning and teaching methods to ensure that students develop a range of different skills. It is evident from the self-evaluation reports that some of the departments have put a lot of thought into which learning and teaching methods are the most appropriate in helping students to achieve the aims and competences of the programme, especially in relation to generic and subject specific competences.

In general, lectures are the primary element of teaching in the majority of all the degree programmes. The departments describe this as an efficient and cost-effective way to convey knowledge to an entire class, but laboratory experiments, exercises, group work and seminars are also teaching methods that all of the departments use. All the departments place a great emphasis on ensuring that different teaching methods are used during a day and/or week to provide a balance.

Two of the Danish universities have committed themselves to problem-based learning as the primary educational paradigm, and, linked to this, all of the students are placed in groups. The group sizes vary between programmes, but there are usually between 4-7 students per group at the bachelor level and 1-4 students per group at the master level. This group work comprises up to 50% of the student workload, with each group writing a report during the semester, often in collaboration with industry. The remaining part of the teaching programme is made up of courses, which normally include lectures, exercises and laboratory work. The students organise the projects themselves under the supervision of a teacher, who meets them on a regular basis. The two universities consider problem-based learning as a great strength of their programmes, as the students, in addition to the strict syllabus-based elements of their qualifications, also develop problem-oriented skills that enable them to acquire the knowledge and approaches needed to solve a wide range of given problems.

While the panel appreciates the strengths of the problem-based learning approach, it is concerned by the situation where declining staff numbers reduce the range of subject expertises taught and available in-house for problem-based projects.

Finally, quite a few Danish departments conduct the teaching of their master programmes in English. On the site visits it became apparent that there were two distinct reasons for this. Firstly, it introduced the students to the English terms relevant to their discipline area, and, secondly, it made it possible for foreign students to follow the same courses. Some universities, however,

were reluctant to conduct bachelor level teaching in English, as they considered it important that the students also gain a thorough knowledge of the Danish chemistry vocabulary.

Research projects are an important teaching method in both countries. In both systems it is recognised that the criteria for a bachelor project should differ clearly from those of a master project. The most commonly found form of differentiation is that a master project should aim solely at results that are publishable. As a result, it is appropriate that master students should be integrated into academic research groups, and that project work should be carried out in research laboratories. In the UK master project, there will normally be associated activities, e.g. training in research methodology, through advanced laboratory work or by other means; communication of results not only through writing a report or thesis, but also by oral and poster presentations. In some departments these activities formed part of the assessment. In Denmark it is customary to undertake project work at both bachelor and master levels; this is not always the case in the UK, as bachelor projects, i.e. forming part of a BSc but not part of a master programme, may not always involve original research, though the subject matter will be "original" to the student. In (Danish) departments where PhD student grants are in short supply, there appears to be an unfortunate, though understandable, tendency for students to extend the project time in order to obtain publishable results that are complete. One reason is that a publication is a way to increase the graduate's chances of receiving one of the extremely few full PhD. scholarships that the universities allocate. These full university scholarships are the only way of financing a PhD. in a research area where the department /prospective supervisor do not currently have an external grant that can be used to finance or co-finance PhD's. (e.g. from the Free Research Council, Industry or the Danish National Research Foundation) The increased level of ambition regarding the scientific results obtained in the master programme does not help completion rate statistics.

With regard to assessment methods, there are also differences between the departments. In those Danish departments that have changed their systems into a block-structure, this has meant a reform of teaching, learning and assessment methods to fit the new structure and to support the changes towards competence based programmes. At one department, new assessment methods have led to fewer written examinations than before. Continuous assessment is now being used on a number of courses in order to stimulate the students' work-performance during the course period, and presentations and oral examinations have been reintroduced to many courses in order to train the students' communication skills. However, the reform has mainly involved the bachelor programme, and most of the institutions are now changing their master programmes as well to suit a more competence based philosophy.

An interesting assessment method is to be found at the Danish universities using problem based learning and project work. Firstly, the group submits their project report. The assessment of the report consists of a joint group presentation of 45 minutes' duration. This is followed by a num-

ber of questions from the teacher and external examiner. These questions refer both to the courses that the students have followed during the semester and to the report content. It is not unusual for this type of examination to take up to 5-6 hours, depending on group-size. The universities argue that this type of assessment evaluates both the students' generic and subject specific competences in a way which complements the principles of problem based learning and the students' project work.

The Panel concludes
It was evident to the panel that all the departments use a variety of teaching and assessment methods to support and assess student learning. The panel found this to be very positive.

The panel also found the problem based learning approach very interesting, and noted that it seemed to be well-suited and motivating for the good students, but at the same time not ideal for other students who might not get the (extensive) support they needed to complete the programme.

3.3 Quality assurance

This section examines quality assurance. There are six focus areas: policies and procedures; approval, monitoring and periodic reviews of programmes and awards; quality assurance of teaching staff; learning support; information systems; and public information. Under each heading, we will discuss the criteria from a comparative perspective.

Concerning quality assurance and enhancement, the Danish and the UK systems rest on the same basic philosophy that the universities are, themselves, responsible for the implementation of proper mechanisms to ensure the quality and standards of their programmes. This is supplemented by external quality reviews at either programme or institutional level[9]. In both countries, audits (institutional reviews) are conducted to review the quality assurance systems of the institutions. In the UK, the term "academic infrastructure" provides a means of describing academic standards in UK higher education. This consists of a code of practice for the assurance of academic quality and standards in higher education, frameworks for higher education qualifications in England, Wales and Northern Ireland, and, in Scotland, subject benchmark statements and programme specifications. Furthermore, the ESG set out standards for good internal and external quality assurance in European Higher Education.

[9] *The Danish QA system in the university sector will in the future consist mainly of programme accreditation.*

3.3.1 Quality assurance policies

The UK institutions visited are characterised by having more established and formal systems of quality assurance, both at university and department level. All institutions have a university strategy and a university Quality Assurance Manual to which the departments refer. The universities apply the academic infrastructure as a set of reference points against which they can assess both their institutional procedures and subject provision. The departments have translated the institutional level policies to departmental level in terms of the department's approach to ensuring an appropriate focus on quality assurance and to ensuring a sense of ownership. Furthermore, all departments have internal processes and procedures in place to ensure the academic standards of the programmes. Finally, the departments also focus on quality enhancement in a continuous process of evaluation, identification, improvement and sharing of good practice.

Until now, quality assurance at the majority of the Danish chemistry departments has been characterised by a strong collegial culture with emphasis on informal procedures and reliance on student evaluation and external examination of students as the main QA mechanisms. There have not been any formal policies or systematic approaches to quality assurance besides student course evaluation through student feedback. However, two universities have recently been involved in an external audit by EVA, which has led to university initiatives to formulate a university strategy on QA and a supporting structure. The chemistry departments at these universities are, therefore, waiting for the university initiative before formulating departmental policies. At another university, the strategy is to establish a framework for accreditation of the main scientific areas of the university and to conduct audits of the five faculties combined with selected evaluation of programmes. However the strategy has yet to be implemented.

One Danish university has a more formalised systematic approach towards QA. Policies and procedures have been outlined in a quality handbook, which governs the framework within which the individual programmes should develop their quality work. The department has implemented these institutional procedures in its own quality manual.

The Panel concludes

The panel considers that the UK institutions have developed systems of quality assurance and development, where institutional level policies and procedures have been translated to departmental level policies and procedures, and implemented. The Danish institutions are still at a developmental stage – apart from one institution where strategies and policies are in the process of being formulated at institutional level. The panel recommends that the Danish institutions in their future work on implementing the institutional level strategy learn from the good practice at the UK institutions.

3.3.2 Approval, monitoring and periodic reviews of programmes and awards

The systems for approval, monitoring and periodic review differ between the Danish and UK departments. One reason is that new Danish programmes must be finally approved by the Ministry of Science, whereas the UK institutions decide themselves concerning the establishment of new programmes. Another reason is that the monitoring and periodic review of programmes are more formalised in the UK departments than the Danish departments.

Approval of new programmes

At present, new university programmes in Danish higher education must be approved by the Ministry of Science, Technology and Innovation. New programmes must fulfil criteria such as labour market relevance, etc. In the initial process, a curriculum is submitted to the relevant study board for initial approval. Once approved by the study board, the programme is forwarded to the faculty for final university approval and then sent to the ministry for approval. In the future, new programmes will be accredited by a national accreditation body.

In the UK the approval of a new course is a process carried out entirely within a university. It will follow a well established set of procedures, for which there will be an auditable trail. It is not uncommon for a departmental industrial liaison committee (or equivalent) and external examiners to be consulted as part of the process. Accreditation plays an important role in the quality assurance of new and existing professional degrees. Accreditation is voluntary and is carried out by the Royal Society of Chemistry (RSC), the professional body for the chemical sciences in the UK, who invites universities to submit their courses for accreditation. This is granted for a five year period; its purpose is to ensure that the academic requirements of the professional designation Chartered Chemist (CChem) are satisfied. The standards required for RSC accreditation are such that it is likely that they can be met only by an enhanced programme of the type offered by MChem/MSci. It is important for graduates to be recognised as holding an accredited degree, as this is a prerequisite for becoming a professional member of the RSC. At many universities, a master degree

is a requirement in order to be considered for a PhD. Therefore, all the chemistry departments in this review had the stated aim of being and remaining accredited. Accreditation of MChem courses is granted on a quinquennial basis following submission to the RSC committee of detailed course descriptions and assessment procedures, including examination papers, model answers, external examiners' reports and examples of student course work.

Monitoring and periodic review of programmes
At the Danish departments the main quality mechanism for monitoring programmes is the curriculum revision/study plan by boards of study, which involves reformulation of the objectives, content, form and structure of the programmes. Furthermore, many of the programmes have recently reformulated their study plans so that the objectives for the programmes and curricula are expressed in the form of expected competences. In most of the departments, the only periodic review is, presently, the external review of programmes conducted by EVA. Two departments are planning to introduce more systematic internal review at programme level as part of the study reform.

The panel considers that accreditation, as it is performed in the UK, only makes sense in relation to well-established job functions for which certain well-defined competences are considered essential. These competences are in the UK defined by the learned or professional societies. In this context, a future central Danish accreditation institute would have to rely heavily on experts within the various fields. Even then, accreditation would be a difficult matter in the cases where programmes are developed to reflect new directions of science (e.g. medicinal chemistry, nanoscience or biophysics). Alternatively, accreditation of programmes could be based on, for example, the Dublin descriptors for characteristics of bachelor and a master degrees. In this case the accreditation process could probably to a large extent be conducted at an administrative level, but it would only be of very formal value if no experts in the field were involved on a regular basis to monitor the quality of the programme graduates.

At the majority of the UK departments, programmes are subject to a more comprehensive and systematic approach to monitoring and periodic review. Monitoring of programmes is an annual process, which involves the gathering of different sources of information with a view to improving programmes. Reviews of programmes initiated by the universities themselves take place in a review cycle (ranging from every 2-6 years) and normally include external participation.

Typically, annual monitoring reports are prepared by the staff or director of studies and take into account broad aspects of each programme, including student and staff feedback, progress statistics and comments from external examiners. At one university, the programme reports are considered by the Faculty Teaching and Quality Committee as part of a process for the dissemination of good practice. At another, the programmes are subject to an Annual Programme Review

(APR). A Faculty Quality Assurance Team (FQAT) visits the department once a year having received the review report. Common to all is that an annual report is produced and submitted to the department head.

Feedback from students – in the form of student course evaluation – is only one of the sources of information that the programme committees of the UK departments use to inform and improve the quality of the programme. Feedback from external examiners (see section 3.3.3), statistical data and reflections by staff as individuals and in teams are also used systematically as evidence of the programme quality, and analysed annually. Information gathering is considered a natural part of their programme improvement work, and information about the student population and their behaviour is used to plan the programme and to correct for inadequacies.

In the Danish chemistry programmes, quality assurance procedures are predominantly based on course evaluation by students. Some of the departments have a well-established student course evaluation system, and follow-up procedures are in place. The teaching staff are primarily responsible for conducting the student course evaluations at the end of each course, and written feedback is then distributed to the study committee, where the students are also represented. Some departments include statistical data in order to monitor programme quality, but this applies to only a minority of the programmes and there is no systematic and strategic approach to gathering evidence other than student course evaluations to monitor quality.

However, although student course evaluation takes place systematically at bachelor level, this is not the case at master level due to the limited number of courses and lower numbers of students. Some master students with whom the panel met called for more formal feedback mechanisms at master level. The panel recognises the critical mass problem in conducting systematic student course evaluation but suggests that this is supplemented with other feedback methods, e.g. focus group interviews or written feedback on thesis supervision.

It is evident that the student role in programme quality procedures is taken seriously by the majority of the Danish and UK programmes. There seems to be a good dialogue between students and staff at all departments, and students are encouraged to raise any concerns they have at the earliest opportunity. Students also play a role in formal decision making processes through committee representation – in Denmark through representation and the vice-chair position on the study board, and in the UK through the staff-student liaison committee. The latter can play a very important role at several levels. In the UK departments, the Panel was particularly impressed by the work of those committees that were chaired by their Head of Department.

The Panel concludes

The panel considers the monitoring used by some of the UK departments, where the programmes are reviewed on an annual basis to be very efficient. The majority of the Danish and the UK departments have a comprehensive and coherent student course evaluation system where feedback from students is taken seriously and acted upon. However, the panel recommends the Danish departments to consider a more holistic approach to quality assurance and not over-rely on student course evaluation in their procedures. In a future quality assurance system, an annual gathering of data from different sources concerning the programme, with the study board reporting to the faculty, including descriptions of good practices, would contribute to a university enhancement strategy.

3.3.3 Quality assurance of assessment procedures

The Danish and the UK systems share the distinctive features of European higher education in that both systems include an extensive external examiner system as part of their system for assuring quality in student assessment. Although the two countries have the same element of assessment and legitimacy inherent in their external elements, the two systems are very different in their organisation and in the degree of quality assurance of the assessment procedures.

In Denmark, the external examiners – chosen from a national pool – are directly involved in the assessment of students as a means of ensuring a national standard of marking, and to ensure fair assessment of students. One third of all assessments of student work – including the bachelor project and the final thesis – must be carried out by external examiners. Furthermore, an external examiner should provide feedback to the programme on the quality of the programme/courses. Legislation provides the framework and guidelines for examinations, e.g. examination types, the roles of the external examiners, and the Danish 13-point scale for marking/grading[10]. The external examiner system has an important role in ensuring that assessment of the individual student is done fairly and impartially. However, it is also a system with very high costs, and there is some evidence that the role of the external examiner in providing feedback on the quality of the programme is not used effectively and consistently across programmes.[11] One of the problems here is that the particular blends of different chemistry competences and focus areas vary substantially between the institutions that offer chemistry programmes. A unique subject blend and structure

[10] The Danish 13-point scale will be replaced on September 1st 2007 by a new scale. Part of the objective is to increase the comparability between Danish and foreign grading scales.

[11] This point was one of the main conclusions of an evaluation of the external examiner system in Higher Education in Denmark by EVA in 2005.

is a way for the institution to market its programme(s). The external examiner thus tends to comment on what is course specific rather than what relates to the programme as a whole. The comments are, therefore, primarily valuable only for the individual course teacher. The external examiner system as described above will be revised in the future. However, it is not yet finally decided how the system will be designed.

In the UK, the role of the external examiner is to moderate internal marking. In the case of undergraduate (first cycle) qualifications, external examiners are often asked to check assessment tasks given to students, especially at the end of year/stage examinations. Academic level is considered, together with content and clarity of interpretation. The external examiners are involved at the progression and/or completion stages of programmes of study. In first cycle qualifications, this normally involves sampling a range of student work. At master level, providing the class size is relatively small, an external examiner is more likely to see all of the students' work. This is helpful, as it is often impossible for internal staff to assess student work completely objectively; the external examiner is more able to take a view across the cohort about consistency, etc. As in Denmark, the UK external examiner system is not a cheap option to support quality assurance. In the absence of any national accreditation of either institutions or programmes, however, it provides an independent means of considering the aims, design and delivery of programmes, and the achievements of its students. External examiners are not drawn from a national pool, but are selected and invited by the "employing" institution. Whilst many institutions have induction sessions for their external examiners, there is no national training system, although there are broad requirements set out in a code of practice, and plans are underway to encourage greater consistency in training across the sector. Summaries of UK external examiners' reports are published, although far greater detail is usually provided to the programmes themselves. Such reports are also routinely scrutinised by a senior member of the institution, and the institution is obliged to respond to any points raised by an external examiner.

Evidence based on the self-evaluation shows that all the UK institutions have quality assurance procedures that involve close contact to external examiners to assure the consistency of marking and the quality of the programme. All departments have a system where each external examiner, at the end of each academic year, submits a formal written report to the institution that is considered at both departmental and senior institutional levels. Such reports may comment on the programme content, structure, conduct of the examinations, and other matters of relevance to undergraduate teaching. The reports are discussed, and responses formulated as part of the review of the teaching year or annual programme review. The final list of marks/awards is not signed until the external examiner(s) is satisfied, and will verify that the conduct of the examinations and the standards set and achieved have been properly assessed.

At the Danish departments, the external examiners provide quality assurance of the individual student performance, but not consistently an assurance of internal assessment methods and level. Based on the site visit documentation, it was evident that there is an implicit understanding between staff and external examiners concerning level, but this is, according to students and staff, not explicitly communicated to students and new members of staff. For example, there is no formal internal mechanism to ensure that levels and expectations as to student performance are applied consistently across courses.

Also, the differences in expectations connected with courses at bachelor level and master level are not made explicit – which is even more important in cases where both bachelor and master students attend the same course. In general, students at the Danish departments would like more information from the departments on what constitutes a good bachelor project or thesis. Students are informed on assessment methods and schedules through the study handbook, and by teachers responsible for the courses. However, based on the information gathered on the site visit, it was not evident how the programmes ensure that students are informed of what is expected of them in order to achieve a certain grade.

Almost all UK institutions have an institutional assessment policy, which is interpreted into a departmental assessment policy and distributed to all staff members. Procedures and details of how grades are allocated for the various degree programmes, together with expected learning outcomes, are provided in the programme specifications and in the student handbooks. In general, students and staff in the UK chemistry departments consider that they are well-informed on assessments.

The Panel concludes

The panel considers that the main difference between the Danish and UK external examiner system is that, in practice, the Danish system has its main focus on the assessment of the individual student, and the assurance of level occurs between the individual teacher and external examiner in the assessment situation. In contrast, the UK system also focuses on the assurance of assessment procedures applied and the consistency of grading across the programme.

The panel recommends that the Danish departments strengthen quality assurance relating to the assessment procedures by making sure that levels of assessment are coordinated across the programme and not left to the individual teacher. A good starting point would be to produce an interpretation of the ministerial order on grading for use at departmental level and make this available to all students, staff and external examiners. This is in order to ensure that all staff and ex-

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ternal examiners have the same interpretation of levels and grading, and that this is made explicit to students and new staff.

3.3.4 Quality assurance of teaching staff

Both in the UK and Denmark, new staff are presented with comprehensive pedagogical development programmes, but the extent to which continuous development of teaching qualifications plays an important role for all staff varies between the two countries.

At the Danish departments, good training opportunities are available to assistant professors. It is compulsory for them to go through the assistant professor training programme, and a range of pedagogical/didactic courses is on offer. Most of the universities have a centre for pedagogy that organises the courses. At two universities, there are special Centres for Science Education in the Natural Science departments that provide the courses. However, those requirements for the pedagogical development of assistant professors are not expected of other teaching staff. For lecturers and professors, pedagogical courses are offered, but it is up to the staff to take up the opportunity. At two other universities, the pedagogical courses are supplemented with peer training for the teams of teachers/supervisors who teach the first two years of the Bachelor of Science programme. At all the departments, course evaluation by the student is an instrument for following up on the teaching quality provided by the staff, and the study director can take action if there are cases of poor teaching.

Teaching skill is becoming an increasingly important aspect in appointment procedures for lecturers and professors, as teaching portfolios are being introduced at some of the chemistry departments. However, teachers' pedagogical qualifications are still not seen as important as research, in terms of promotion and staff development schemes in Danish departments.

A particular aspect of the Danish system is the extensive use of PhD students as teachers in the first and second years. These PhD students are considered an institutional teaching resource since fulfilment of a teaching obligation is a condition for receiving a (full) PhD scholarship. While students broadly welcome the opportunity to be taught by someone who has a not-too-distant recollection of the difficulties of the particular subject, the possibility of weak PhD student teachers is a risk. This problem is hard to solve completely, but very early pedagogical courses for PhD students would help to minimise it.

The majority of the UK departments (but not all) have in place a strong emphasis on the continuing development of teaching qualifications for new and existing staff. Nevertheless, one of the

institutions also showed room for improvement in this area, as there was no formal mechanism for the development of pedagogical qualifications among either new or existing staff.

In one of the departments, teaching quality plays a key role in the promotions procedure, as the department operates a staff review and development scheme. This process explicitly seeks to identify and remove barriers to better research and teaching performance. It also provides a mechanism for the assessment and improvement of teaching and research, and the identification of staff training needs.

Another example in one of the UK departments is that of the introduction of a peer-review scheme as a means of exchange of good teaching practice between lecturers. Each lecturer is observed by a colleague in a lecture or other teaching activity at least bi-annually. They then discuss any issues arising and complete a form to confirm that the observation has taken place.

The Panel concludes

The panel considers it positive that pedagogical development for new teachers is offered at both Danish and UK departments, although some could be more targeted towards science staff. The panel finds the example from one of the UK institutions of allowing teaching quality to play a key role in the promotions procedure of a staff review and development scheme an interesting example to follow.

3.3.5 Learning support

Laboratory facilities
In chemistry, one of the most important prerequisites for a good teaching and learning environment for the students is the quality of the laboratory facilities.

The Panel concludes

The panel noted a marked difference between the quality of laboratories and the management of safety in the labs between Danish and UK departments. Most of the Danish labs were not up to international standards (in one case working practices appeared to be positively dangerous), which the panel felt was due to the effect of a lack of external/internal funding and interest in

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this area. This point has previously been made in the chemistry evaluation of 1998. Two universities have established a strategy to improve the facilities, and at one of them there is a specific departmental focus and explicit strategy for providing chemistry students with up-to date lab facilities.

The panel felt that the national support of a chemistry centre at one of the UK universities was an excellent example of how an investment of external funding could lead, not only to the refurbishment of laboratories, but also to an improvement in the student learning experience through a new dynamic laboratory manual which could be introduced for each course as part of the extension project. Greater emphasis could be placed on pre-laboratory work to enable students to get the most out of their time in the laboratory. It could also include virtual equipment to allow students to practice techniques before they enter the laboratory, as well as exercises and other material to help develop and test the students' understanding of the theoretical chemistry principles behind the practical work.

Other physical facilities

Apart from the lab facilities, the students were generally satisfied with the physical facilities at the Danish chemistry departments. The computer facilities are regarded as adequate - however, this is partly explained by the fact that students themselves bring lap-tops to university. However, at one university, students pointed to the severe lack of IT facilities in the department and the standard of the current IT facilities in relation to handling the complexity of the experimental problems. Nevertheless, the standard of IT-facilities has improved since the last chemistry evaluation where inadequate computer facilities was an issue of concern for the panel.

The Panel concludes

The panel notes a considerable difference between the quality of laboratories and the management of safety in the labs between Danish and UK departments. The panel is strongly concerned that the majority of the Danish labs do not fully live up to international standards due to lack of external/internal funding. The panel recommends very strongly that a serious effort is made to address this issue, as it has a remarkable effect on the quality of chemistry education. No national system can avoid its responsibilities in the area of student and staff safety. The UK is in a better position, but even here, there is no room for complacency. The Panel visited some labs in which the criteria for a safe working environment were barely met.

Student guidance
Guidance can be divided into three categories: entry guidance, academic guidance and career guidance. Furthermore, there is a distinction between guidance from academic staff and that provided by welfare staff or their equivalent.

Based on the self-evaluations and the site-visits at the Danish and UK departments, it is evident that there is a different approach towards the need for such guidance.

in general. At the UK departments, the students are often both provided with a personal tutor, to whom they can turn with personal issues, and an academic tutor. At some institutions the students even see their tutor on a weekly basis to discuss progress. Student progress is also monitored by a Progress Officer. The Progress Officer has both a monitoring and a pastoral role. He/she receives feedback from tutors, laboratory supervisors on absenteeism or late work, they deal with day-to-day problems and collect and monitor information on the progress of all students.

At one UK University, student progress is also monitored through a progress file, through which the student keeps track of his/her individual achievements and discusses these with their tutor.

In the Danish departments students can seek advice by approaching teachers concerning the technical issues of their courses and how to structure their programme. In addition they can seek advice from older students, formally appointed as student advisers and employed by the director of studies, or from the central student counsellor's office.

Despite the differences in the level of guidance and the approach - whether to seek guidance yourself or have it provided - both Danish and UK students were satisfied with their guidance system. At the Danish site visits, the students commented that being a university student involves being able to make your own choices and being able to actively seek information. They preferred a guidance system which promoted independence and they felt that their teachers' doors were always open.

The UK students were also very satisfied with the guidance they received from the departments and the personal tutor system worked well.

The strength of the self-help guidance system is that it supports the development of generic competences such as independence. However it also risks missing weaker students who may be more reluctant to seek guidance or who are less knowledgeable about where to seek it. Also the age of students plays an important role. In the UK system, where students are younger and are often also a long way from home, close monitoring and active support for students are advantages. Also, more extensive guidance is an instrument to reduce drop-out rates, a problem for

many of the chemistry programmes. With an increase in the level of individual academic guidance with the new block structure in some of the Danish programmes, there are the first signs of a reduction in drop-out rates.

Career guidance is well established in the UK departments, and students are well informed about career opportunities. This is also supported through the large number of students that take an industrial placement year as part of their degree.

In the Danish departments, most of departments arrange career-days, but these are often at a very general level which involves the whole natural science faculty. The students expressed dissatisfaction with the lack of information about career opportunities in the chemistry field beyond university. A more intensive and departmental career-guidance could help students to be introduced to the labour market and open up job possibilities.

The Panel concludes

The panel notes the differences between the Danish and UK systems, but considers that the differences in approaches reflect the age and maturity of the students, which differ between the countries. However, the panel recommends that the career guidance in the Danish departments is strengthened in order to introduce students to the chemistry labour market and open up job possibilities.

3.3.6 Public information

According to the ESG, universities should make impartial information publicly available to students and other stakeholders. Both Danish and UK departments make information concerning the programmes and awards available through the Universities' websites and study information systems. Information is also available to students via course handbooks which are available both on the web and as published hard copies. However, the UK system of making information publicly available is far more extensive and comprehensive.

In the UK, in line with national requirements from the Higher Education Funding Council, specific information about the chemistry programmes is posted on the national Teaching Quality Information (TQI) website[12]. This includes publicly available programme specifications, comments from external examiners, and results of the National Student Survey and Departmental reviews that have taken place. To some extent, Danish legislation requires the same openness, but the level of

[12] *www2.tqi.ac.uk*

information is not equivalent to the UK situation. The Danish departments publicise all grades and results on their web-page as required by law.

The Teaching Quality Information (TQI) website brings together key sources of official information about the quality of higher education in UK universities and colleges. It is part of an initiative to make more information available and accessible to applicants and their advisers. The TQI website is intended to help students compare institutions and subjects, and make a more informed choice of where to study. Most of the information on the site is available for each subject taught at each HE institution. The site provides the most recent data available for students in HE, for each subject taught by each institution. The data is collected by the Higher Education Statistics Agency (HESA) and includes information on student qualifications on entry, information on the number of students continuing their studies and, with the exception of Scotland, information on the numbers of students graduating and with what type of award.

The site also shows what kind of employment or further study students go on to. This includes the numbers of students employed in graduate and non-graduate jobs and their most common job types. This information is taken from a UK-wide survey which is conducted approximately six months after graduation. Finally, the site also includes the National Student Survey, that was conducted in 2005, where students near the end of their studies in England, Wales and Northern Ireland were asked for their views on the quality of the education they had received. The results are available for each subject taught by each institution.

The Panel concludes

The panel considers the UK Teaching Quality Information (TQI) website an interesting national initiative, as information is made accessible to students and stakeholders at one website and is able to provide an overview of programmes across the different universities. With the existing mechanisms for detailed reporting from the universities to the Ministry of Science, Technology and Development, it should not be difficult to establish a Danish equivalent.

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4 The Danish Chemistry Programmes

The procedure of publishing individual feedback does not apply to the UK institutions; furthermore the participation of the UK institutions was voluntary. Consequently, the feedback to the UK institutions is not included in this report, but has been delivered individually.

This chapter focuses on the five Danish chemistry programmes. The first part of the chapter concerns employability of graduates, and the second part provides specific feedback to each of the 5 participating Danish Universities regarding key strengths and developmental opportunities.

This chapter does not serve as a conclusion to the report, and not all relevant focus areas are addressed. Rather it seeks to give feedback on the main points considered by the panel as it sought to familiarise itself with chemistry as organised and taught at the individual universities, the student learning experience offered and the quality assurance of the chemistry programmes.

The selection of the points for consideration was thus determined by those aspects which were particularly evident at each institution. This approach is accentuated by the fact that the strengths and developmental opportunities of each programme have, to some extent, been reviewed in relation to the specific context of the institution. Furthermore, the variation in feedback to the programmes is also a reflection of differences among the self-evaluation documents.

The chapter provides the institutions with an accessible guide to the significant strengths and developmental opportunities of their individual programmes, which should also serve as an inspiration to other programmes.

4.1 Employability

This section focuses on the employability of the chemistry master graduates from the period 2001-2003. It is divided into two parts: socioeconomic status and labour market affiliation. The reason why employability figures for the bachelor graduates are not included in this section is that very few Danish students leave university with only a bachelor degree. One explanation for

this is that the Danish labour market has not yet established a tradition for employing BSc graduates.

The data on the graduates was gathered from Statistics Denmark and included master graduates from 2001-2003, as mentioned in section 3.5.4. The data contains information on graduates from the universities of Copenhagen, Aarhus, Roskilde and Southern Denmark. The University of Aalborg is not included, due to the fact that they did not have any master graduates in chemistry during that period. Due to a relatively low number of graduates it is not possible - in general - to break the data down by institutions, as it is important to protect individual anonymity. However, this is done where possible, and in these cases the number of graduates is given in parentheses. The table below shows the number of graduates from each of the four institutions for the period 2001-2003.

Table 3
Number of master graduates 2001-2003*

	2001-2002**	2002-2003**	2003-2004**	In total
The University of Aarhus	19	11	20	50
The University of Copenhagen	31	26	17	74
The University of Roskilde	3***	8***	9***	20***
The University of Southern Denmark	17	11	28	56
In total	70	56	74	200

Source: Statistics Denmark

**The University of Aalborg is not included in the table, as they did not produce any master graduates in chemistry between 2001 –2003.*

***Please note that the period covered is from October 1st till September 30th.*

****At Roskilde the two subjects are equal and graduates are therefore both candidates in chemistry and other subject.However the Statistics Denmark number only counts those graduates that write thesis in chemistry. RUC numbers are respectively, 13,13,16.*

The table shows that the University of Copenhagen in total has produced most master graduates during this period. However in 2003-2004 both the University of Aarhus and Southern Denmark produced more graduates than the University of Copenhagen. It is also interesting that that the number of graduates fell at all universities, except Roskilde in 2002-2003. For the University of Copenhagen, the number of graduates dropped further in the following year of 2003-2004, whereas the numbers for the universities of Aarhus and Southern Denmark both show a significant rise in the number of graduates in the subsequent year. The University of Roskilde differenti-

ates itself from this development, as the number of graduates has slowly increased since the period 2001-2003.

4.1.1 Socioeconomic status

It is evident from this section that graduates from master programmes in chemistry from 2001-2003 have a high employment rate and a correspondingly low unemployment rate. The following section will focus on the socioeconomic status of master graduates in chemistry.

From table 4 below, it is evident that the majority of the Danish master graduates in chemistry from 2001-2003 are employed in the autumn of 2004 – 84%.

Table 4
Socioeconomic status in autumn 2004 for master graduates in chemistry from 2001-2003

Employed	84%
Unemployed	7%
Others	10%
In total	100%
	(200 graduates)

Source: Statistics Denmark

** The table includes master graduates for the universities of Copenhagen, Aarhus, Southern Denmark and Roskilde*
*** The category "others" includes graduates who are not a part of the work force and graduates where it is not possible to find a match between their social security number and the data file. Finally it includes graduates on leave and sickness benefit.*

The table also shows that 7% of the graduates are unemployed. The differences between the Danish universities in relation to both employment and unemployment are not very significant. However the employment rate for graduates from 2001-2003 at Aarhus University is 76% (comprises 38 graduates) and at the University of Copenhagen it is 89% (66 graduates) – both differ somewhat from the 84% average. The employment rates for the University of Southern Denmark and the University of Roskilde are 84% (47 graduates) and 80% (16 graduates), respectively.

Even though numbers do not reach 100 percent this is not only due to unemployment, the difference also covers the category "others". This category includes graduates who are not a part of the work force and graduates where it is not possible to find a match between their social security number and the data file. Finally it includes graduates on leave and sickness benefit

4.1.2 Labour market affiliation

It is evident from this section that the majority of the chemistry graduates from 2001-2003 have a job within education – especially at higher education institutions and upper secondary schools. This section will focus on the labour market affiliations of the graduates.

Table 5 provides an overview of the labour market affiliations of the chemistry graduates from 2001-2003. It is important to emphasise that the table only shows where the graduates are employed, not what they do.

Table 5
Labour market affiliations in autumn 2004 for master graduates in chemistry from 2001-2003

Education, institutions of higher education	37%
Pharmaceutical industry	14%
Education, upper secondary school	13%
Research and development	11%
Other working areas*	9%
Consulting	8%
Education, other	4%
Chemical industry**	3%
In total	100 % (178 graduates***)

Source: Statistic Denmark

**The category "other working areas" includes graduates employed in the following areas: extraction of oil and gas, production of food, wholesale trade, transportation, mail and telecommunication, finance, software industry, public administration, health services, cleaning of soil and museums.*

***The category "chemical industry" includes: production of colouring agent, organic chemicals, paint, pharmaceutical materials and cleaning agents.*

****Please note that only graduates from 2001-2003 with a labour market affiliation are included in this table.*

The table shows that the majority of the graduates from 2001-2003 (54%) work within education; 37% of the master graduates are employed within institutions of higher education, which includes both Universities and Colleges. A possible explanation for this is that this category also contains PhD students, and that may be the reason for this relatively high number. Another explanation could be that some master graduates get jobs as teaching assistants while waiting for a longer term position.

Another 13% work within upper secondary school, while 4% have a job at other educational institutions, including the primary/lower secondary school system.

14% of the graduates are employed in the pharmaceutical industry, and another 11% and 8% work within research and development and consulting. Finally 3% work within consulting.
From the register-based survey, it is also evident that there are differences between the four universities. At the University of Aarhus for instance, 33% (14 graduates) work within institutions of higher education. At the University of Copenhagen 47% of the graduates (32 graduates) work within higher education institutions. The numbers for the University of Roskilde and Southern Denmark are 41% (7 graduates) and 26% (13 graduates), respectively.

4.2 Feedback to the Danish institutions

4.2.1 The University of Aalborg

The self evaluation group at the University of Aalborg has prepared an informative self-evaluation report which formed a good basis for the review. The document describes the characteristics of the organisational and academic structure of the university, which differs from traditional universities, as well as their particular style of problem based learning, which is a cornerstone of the university.

Besides problem based learning, another characteristic of the programme is that bachelor students within the natural sciences follow a one-year interdisciplinary basic study programme.

The master programme in chemistry shares many courses with the chemical engineering programme taught at the same institution. The chemistry master programme is targeted towards students who wish to become upper secondary school teachers. The structure and the curriculum of the programmes are aimed at providing potential upper secondary school teachers with an empirical and contextual understanding of chemistry, based on fundamental chemical disciplines, with physical chemistry as a core subject. The chemistry programme is, in terms of student numbers, extremely small, and the host department is of modest size.

On the basis of the self-evaluation report and the site visit, it is the panel's impression that considerable thought seems to have gone into the programme design and delivery. However, the panel believes that the department faces challenges with regard to providing sufficient staff resources and student numbers. In the following, some points regarding the student learning experience and quality assurance will be made by the panel for the department to reflect upon and to assist in the future development of the programme.

Student learning experience

Positive features

- It was evident to the panel on the site visit that there is a realistic and frank attitude towards the chemistry programme, its advantages and disadvantages. This is very positive, especially when the programme is very small.

- The panel is impressed by the enthusiasm and ambition that drive both teachers and students at the department. It was also evident to the panel that the problem based learning approach gave the students the skills to tackle different types of problems, which prepare the students for working in industry.

- The panel was impressed by the assessment procedures which they consider to be thorough and fair, though time consuming. The assessments thus evaluate both the students' generic and subject specific competences in a way which complements the principles of problem based learning and the students' project work.

- The panel noted that the pedagogical courses are supplemented by peer training for the teams of teachers/supervisors who teach the two first years of the bachelor programme.

Developmental opportunities

- The panel was concerned with the narrowness of the research focus; a situation which is strongly linked to the modest size of the department. The panel noted during the site visit that the department expected to hire 3-4 new staff members, and the panel recommends that when the new staff members have been appointed, they teach and research in areas not already being offered at the department.

- The panel is concerned that there are insufficient (core) chemistry courses taught in the programmes presently, and recommends that the department address this issue.

- It was evident to the panel during the site visits that some students would prefer another balance between individual and group work. They would like the opportunity of doing more individual work during the programme. The department states in its self evaluation document that it is possible for the students to do individual work, but on the site visit, it became apparent that most students were persuaded to work in groups.

- The panel noted from both the self-evaluation report and the site visit that the university is still in the process of formulating outcome descriptors for its programmes.

Quality assurance

Positive features

- The department has implemented the faculty's quality handbook in its own manual. Furthermore, the department and the study board, as well as the university, has a strong tradition for internal monitoring.

- Student course evaluations take place systematically, and feedback is considered regularly by the study board and action taken.

- The panel is impressed with the informal training of examiners (project supervisors act as examiners also) that takes place at Aalborg University, as younger staff members during their first years of teaching normally function as co-supervisors on projects and participate in the examinations together with an experienced teacher (the responsible project supervisor).

Developmental opportunities

- The panel is very concerned at the apparent lack of appropriate safety procedures in the laboratories and recommends that the organisation of the laboratories be improved in order to make the environment more structured. For example, elementary safety procedures, such as compulsory eye protection for all persons in a laboratory, appear to be completely lacking. Furthermore, the panel found the number of fume cupboards available for student use to be insufficient.

- Although there are formal policies for quality assurance, the implementation and use of different formal quality assurance mechanisms could be improved. The panel considers that the programme takes an active approach to the systematic use of external feedback, collection of statistical data for annual monitoring and development of the programmes.

- In the self evaluation document, the department states that it gets regular feedback from the external examiners who must complete a questionnaire after each exam. However, the panel noted that there did not seem to be systematic contact between the programme and graduate employers. This may be understandable considering the current extremely small number of graduates from the program, but the panel finds it important for the future development of the program that the department develops procedures that ensure the use of systematic feedback from different external stakeholders in order to develop the programme.

4.2.2 The University of Aarhus

The department has prepared an informative and thorough self-evaluation report that gives a good insight into the structure and content of the programmes.

The chemistry programmes have, since 2003, been organised in a quarterly structure as part of a common revision introduced by the Faculty of Science. The first bachelor students under this new system graduate in the summer of 2006. At the time of the site visits, no master students had yet entered the new programme described in the self-evaluation document. The Faculty of Science is currently conducting an evaluation of these revisions which involves students, teachers and heads of departments.

The self-evaluation report and the site visits at Aarhus University signify that the degrees offered at Aarhus University are solid and very good. In the following, some points regarding the student learning experience and quality assurance will be made by the panel for the department to reflect upon.

Student learning experience

Positive features

- The chemistry department is well run, and at all levels the department showed ambition and confidence with regard to research, teaching levels and outcomes.

- Students expressed great satisfaction with the programme and with the milieu at the department. All supervisors, teachers, PhD's, etc. make an effort to maintain close contact with the students and are available for informal guidance and support in all aspects raised by students.

- The site visits revealed an international focus at the department, which is regarded very positively by the panel. This was also emphasized in the 1998 review of chemistry programmes. Key individuals at the department make a significant effort with regard to student exchange, and it is the recommendation of the panel that this effort be encouraged and enhanced.

Developmental opportunities

- It is the view of the panel that the department needs more integration between the overall structure of the programmes and the individual courses. The programmes would benefit from involving teachers more in the overall strategies of the department. This would also address the problems of consistency of the supervision and possibly balance out the strong element of individualized instruction and supervision which is the cause of significant variation in the supervision and level of support for students.

- The quality of the programmes is highly dependent on the individuals responsible for key parts of the programmes. This condition is not robust in the face of change and points to the need for formal systems to safeguard against staff retirements or staff and discipline expansion. Preferably, precise and formal systems for general student supervision and support should be established in order to preserve the current good results and minimise the inherent risks of existing systems being dependent on a few committed individuals.

Quality assurance

Positive features

- The current expansions of laboratory facilities are supported and applauded by the panel. The panel would wish to emphasize that the department and the faculty in collaboration should make sure that all the core subjects of chemistry are provided with up to date laboratory facilities.

- The panel supports and commends the planned formalization of quality assurance mechanisms at university level. This includes the strategy regarding the establishment of a framework for accreditation of the main scientific areas of the university and the planned combination of audits of the five faculties with selected programme evaluations.

Developmental opportunities

- A recommendation from the 1998 evaluation of chemistry emphasized the need to prioritize the teaching responsibility of the researchers and create lasting solutions to the need for pedagogical training of the teaching staff. These recommendations are still relevant, and the panel recommends that the department/faculty offer teaching courses for assistant professors and PhD's. The panel wishes to point out that pedagogical and didactic training is a faculty responsibility which is to be prioritized in order to supplement the strong research base.

- The student course evaluation procedure was seriously lacking a formal framework. The application of the results of the evaluations was weak, and students were not made aware of the outcomes of the evaluations. The panel considers that the formalisation of the student feedback mechanism – part of the development of a more systematic and formal approach to quality assurance – could be improved, where systematic use of external feedback, collection of statistical data is used for annual monitoring and development of the programmes.

- The students pointed to the severe lack of IT facilities at the department, which stems from the lack of funds being directed towards IT and other general and structural learning support systems. The current IT facilities at the department cannot keep up with the complexity of the experimental problems, and the panel recommends that this area be prioritized.

- It was not evident how the department ensures that students are informed of what is expected of them in order to achieve a certain grade. There is an implicit understanding between staff and external examiners about level determination, but this is not explicitly communicated to students and new staff.

- The panel recommends that courses in laboratory safety are placed earlier in the BSc programme. The importance of advanced safety procedures are too relevant for the advanced course to be placed so relatively late in the programme. While the panel appreciates and commends the procedure in which general safety instructions are given to students before they enter labs, the panel also finds that this practice should be supplemented by more substantial courses.

4.2.3 The University of Copenhagen

The department has prepared an extensive and thorough self-evaluation report. It contains descriptions and critical self-analysis of strengths and weaknesses, which can be very useful in the department's ongoing developmental efforts.

The department of chemistry has recently undergone extensive changes, which are particularly evident at bachelor level. The implementation of a flexible block structure and a common entry year for both chemistry and environmental chemistry have been designed to meet current societal and political challenges as well as address problems inherent in the previous programme structure. Implementation of a new master programme is planned for September 2007, and in the same year, an internal review/evaluation of the new bachelor programme from 2004 will be conducted.

Based on the self-evaluation report and the site visit, the panel finds that the chemistry programmes at Copenhagen University provide the students with a traditional and solid education. In the following, some points regarding student learning experience and quality assurance will be made by the panel for the department to reflect upon and to assist them in the future development of the programmes.

The student learning experience

Positive features

- The panel recognises the changes made in the organisation of the programmes and the thorough preparation and implementation processes which involved both internal and external stakeholders. Many significant issues and challenges have been considered and approached, e.g. completion time, subject accumulation in the curriculum, the needs and demands for educational flexibility and student mobility, as well as the general issue of academically narrow vs. broad training and competences.

- The panel is convinced that the restructuring of the bachelor programme with its revision of teaching and assessment methods is a positive development, and one which the master programmes should also undergo.

- The reform of the programmes is also positive because of the broadness of its implementation. The reform is leading to relevant changes within teaching, learning and assessment methods, as well as to the formulation of anticipated learning outcomes and competences. There have been signs of a reduced completion time within the last two years, which indicates that the block structure and the introductory courses help prevent delays in completion of the programmes by students.

- The panel commends the plans for master programmes for students with other bachelor degrees (non-chemists). The challenges of providing high quality chemistry master degrees to students with a bachelor in another natural science subject will become a reality due to the new legislative system allowing mobility of bachelor students. The panel strongly supports the discussion of this issue already taking place at both department and faculty level.

- The students were very satisfied with the introductory courses. They give them an idea of what the programme entails as well as a chance to identify themselves with the chemistry studies and to build up a social and academic network.

Developmental opportunities

- The department has considerable vision and ambition. It sees its comparators as departments of the first rank on the world scene. The panel finds this to be very laudable but cautions that considerable efforts will be required to make the departmental vision a reality.

- It was evident from the site visits that due to the recent changes in management structure the department found itself in a transitional stage. A clarification of this situation and the success-

ful implementation of strong and strategic leadership are essential for the future success of the programmes.

- The new master degree programmes could be beneficially designed with a more formalised introduction in order to facilitate the entry of students from other universities or abroad into what is in other respects a very flexible and free structure.

- The students regard the time spent in the laboratories to be insufficient; a situation that has been made more acute by the new structure.

Quality assurance

Positive features

- The study board showed a constructive willingness to improve the quality assurance mechanisms, and they consider the review of the chemistry programmes an opportunity to receive feedback for improvement. The reception of the university audit from 2004 has been positive, and there is a strong motivation at study board level to implement more comprehensive quality assurance mechanisms.

- The student course evaluation system is efficient, and both students and staff commented that follow-up was taking place and that courses were taking place as a reaction to feedback.

- There are signs pointing towards a more systematic and holistic approach to quality assurance, as the new programme structure commencing in 2007 will entail periodic evaluations of the programmes, where not only student course evaluation but also statistics on progression and completion as well as external feedback will be incorporated. The panel supports this initiative and suggests that these programme reviews are conducted as an on-going process within a set cycle.

Developmental opportunities

- The standard of the labs was of great concern to the panel which strongly recommends that that facilities for experimental work be brought up to standard as soon as possible, starting with the oldest labs. The infra-structure as it presently exists is not consistent with the department's ambition of being in the front rank internationally.

- Although there is an acknowledgement of the importance of quality assurance mechanisms, the current waiting for a centralised quality system should not prevent the department from engaging in an active approach to the establishment of quality assurance mechanisms at de-

partmental level. Useful initiatives could include a more formal approach to external feedback, collection of statistical data for annual monitoring, etc.

- Currently, feedback from external stakeholders is mainly based on informal feedback and external examiners. However, the comfort of the existence of a presently very favourable job market could perhaps lead to an over-reliance on unofficial procedures, and the panel, therefore, recommends that feedback mechanisms be formalised.

- In the previous review of the chemistry programmes it was recommended that career counselling and the vocational orientation were improved. There have been some positive developments in these areas, and career guidance is offered regularly at university level, and some guidance is provided by the industry itself. However, the panel wishes to stress the need to inform students more thoroughly on career and job opportunities. The department should offer guidance and advice to students on the chemistry specific opportunities and the relevant employment market and not depend on industry to provide the relevant information.

- Concerning assessment, the methods of assessment are made explicit to students. However, it was not evident how the department ensures that students are informed of what is expected of them in order to achieve a certain grade. There is an implicit understanding between staff and external examiners about level determination, but this is, according to students and staff, not explicitly communicated to students and new staff.

4.2.4 The University of Roskilde

The department has prepared a concise and frank self-evaluation report. The report includes useful descriptions of the particular teaching systems and structures of the programmes which are unique to the university. Although short, the self-evaluation report offers an objective picture of the current challenges and planned changes at department and institutional level.

Besides problem based learning, another characteristic about the programme is that bachelor students within the natural sciences follow a two-year interdisciplinary basic study programme.

Chemistry at Roskilde is distinctive because of the general nature of the initial stage of the bachelor programme and because of the significant emphasis in both bachelor and master programmes on problem-centred learning. The master programme with its emphasis throughout on two subjects, in the present context chemistry and a cognate subject, will result in graduates who have rather different attributes than those found elsewhere in the Danish system.

On the basis of the self-evaluation report and the site visit, it is the panel's impression that the chemistry programmes at the University of Roskilde are small but well thought out and seem to

provide the students with a good education. In the following, some points regarding student learning experience and quality assurance will be made by the panel for the department to reflect upon and to assist in the future development of the programmes.

Student learning experience

Positive features

- The panel was very impressed with the students. They showed a high degree of ambition, maturity, academic responsibility and reflection. At all levels, the department were devoted and dedicated to the institution, the research and the particular type of teaching and project based learning.

- The dedication to project based learning and the long experience with this type of teaching and learning was evident. Between teachers and students there was a coherent understanding of the aims and structure of project based learning, which bears witness to the efficient student introduction to the system as well as to the quality of student guidance during their project work.

- The system of project based learning is appropriately supported by the assessment methods. The panel wishes to point out the high quality of the examinations, which are thorough and fair and reflect the aims set out for the subjects and the degrees.

- The panel noted that the pedagogical courses are supplemented by peer training for the teams of teachers/supervisors who teach the two first years of the bachelor programme.

Developmental opportunities

- Currently, the department is facing reduced resources due to the general decline in student numbers in the chemistry programmes. In this light, the high number of subjects and student projects pose an increased burden on the staff with regard to teaching and supervision. This challenge is dealt with very professionally by the researchers/supervisors; however, a long term solution is expected to be high on the agenda of the recently employed university management. Furthermore, the department is currently in an indeterminate state with regard to many important issues including size, allocation of resources, departmental structure, the division of optional and compulsory courses as well as the strategic management at institutional level. However, the staff was very enthusiastic and confident, as were the students.

- The panel recommends that the department creates a stronger focus on formal systems and procedures, instead of the current reliance on implicit procedures and culturally borne princi-

ples. The current situation is not feasible in case of staff reduction. This area of vulnerability is a matter of concern to the panel.

- A significant issue in the current challenges faced at the department is the small number of students. In the near future, changes will be made to the structure of the programmes in order to address this issue, among others. The panel recommends that solutions are sought within a strategic and long term framework, which can uphold the distinctive features of the programmes while making the necessary changes in order to attract students, decrease drop-out rates, and improve completion rates.

- The panel is concerned that the high number of optional courses and student driven project work, in combination with the joint degree structure, will impact negatively on the students' level of factual knowledge and in-depth knowledge of core chemistry. The self evaluation group also mentioned these concerns, which attests to an awareness of the issue. It is the recommendation of the panel that the number of compulsory courses is increased in order to ensure adequate progression in all areas of core chemistry, as mentioned in the self-evaluation report. As far as possible, within the constraints of the two subject curricula, a balanced core element in the programme should be developed.

Quality assurance

Positive features

- There is evidence of a very close and beneficial informal contact between staff and students. The panel finds that this atmosphere of cooperation between staff and students enhances the quality of the general supervision and student support.

Developmental opportunities

- The panel wishes to stress the need for the department to monitor and control the students in the labs at all times. It is recommended that the department ensures that the written procedures are followed by students and staff.

- The panel considers that a formalised approach to quality assurance should be developed. The student evaluations are based on questionnaires which the individual teacher produces. The panel, as well as the students recommend that this procedure is changed and that formal and standardised questionnaires are used as a basis for the course/student evaluations. The panel considers that the formalisation of student feedback should form part of the general development of a more systematic and formal approach to quality assurance mechanism, where the systematic use of external feedback and collection of statistical data are used for annual monitoring.

- The thesis work of the MSc students is prolonged, and this should be addressed actively at all levels so that teachers and students cooperate in an attempt to shorten the completion time. Generally, a stronger emphasis on completion time within the set time frame for the degrees should be encouraged.

- It was not evident how the department ensures that students are informed of what is expected of them in order to achieve a certain grade. There is an implicit understanding between staff and external examiners about level determination, but this is not explicitly communicated to students and new staff.

- There is an informal supply of feedback from external stakeholders, PhD success rate and external examination is part of the quality assurance. However, a more formalised approach to external feedback would be beneficial.

4.2.5 The University of Southern Denmark

The department of chemistry at the University of Southern Denmark has provided the review with a reflective and thorough self-evaluation report. It is evident that the there has been broad involvement and discussion in the preparation of the report.

The departments' programmes are characterised by a broad entry profile and strong interdisciplinary focus. Though adjustments have been made over recent years, these aspects are still upheld. At present a single common foundation year, the Science Year, is in operation for the chemistry students and many other natural science students. The Faculty of Science initiated a new study programme in 2005, which replaced the semester system with a quarterly block structure. The new system will be fully implemented in the bachelor programme in 2008 and in the master programme in 2010. At the time of the site visits, only the first year students were studying under the new quarterly system.

Based on the self-evaluation report and the site visit, the panel finds that the chemistry programmes offered at Southern Denmark are sound and of good quality. In the following, some points regarding the student learning experience and quality assurance will be made by the panel for the department to reflect upon and to assist them in the future development of the programmes.

Student learning experience

Positive features

- The students were academically and professionally ambitious. They impressed the panel as being uncompromising in their choice of subjects and projects, not letting the popularity of cer-

tain supervisors or other social aspects take precedence over their subject specific interests. This is supported by the fact that, at all levels, there was strong and real commitment to chemistry and its subsets.

- The panel considers it a strength of the programme that there is a broad age distribution; young staff are well represented. Furthermore, a wide spectrum of disciplines are represented at the department.

Developmental opportunities

- The staff have been loyal in implementing the recent changes to programmes, but the panel also noted that restructuring has been a heavy burden and has resulted in signs of fatigue among staff. This could prove to be a challenge which should be addressed in order to maintain staff motivation and, with that, the quality of teaching.

- In restructuring the programme, staff could, with benefit, be involved in strategic management to a greater extent than has been the case during the recent changes in order to ensure a sense of ownership and commitment in the department. The panel recommends that the faculty management in future adopts a more democratic and broad involvement of staff in future changes that involve all levels of the department.

Quality assurance

Positive features

- There is a well-functioning course evaluation system at the bachelor level, and the department is waiting for the university-wide strategy for quality assurance and the new quality board to set out guidelines. However, the panel considers that the department could benefit from establishing some annual procedures already now, which could later be integrated into an institutional strategy – these could include a more formal approach to external feedback, the collection of statistical data for annual monitoring, etc.

- The panel found the laboratory facilities at the University of Southern Denmark to be good and, in some cases, excellent. This shows a commitment to the core practical and experimental aspects of chemistry, and the panel recommends that the currently adopted strategy for the ongoing updating of the laboratories is maintained.

- The department has good traditions for introduction and support for new students, including the allocation of tutors, student contact groups and the common science year. The panel would like to stress the positive attitude among students towards the helpfulness and effectiveness of the contact groups. Currently, new systems are being implemented for student in-

troduction, and the panel advises the department to use and, if possible, transfer the positive experiences from the contact groups to this system.

- The information available to students is a positive feature. Students pointed out that all relevant information was easily accessible on the university website and intranet. This effective and broad communication system should be allowed to continue to evolve.

- Course evaluation takes place systematically at bachelor level, and feedback is considered regularly by the study board and action taken.

Developmental opportunities

- Based on the student interviews, it was evident that course evaluation is not conducted systematically at master level. The panel recommends that the systematic approach to course evaluation at bachelor level is also applied to the master level. If course evaluation is difficult to implement due to individual study patterns and small course population, other methods such as annual evaluation of the programme or evaluation of supervision could provide valuable feedback.

- There is variation in the supervision and level of support in connection with the bachelor project, which the students consider unfair. Some students receive extensive feedback, whereas other students receive less. Students would prefer a uniform procedure where the same amount of feedback is available to all.

- There is an informal supply of feedback from external stakeholders, and external examination is part of the quality assurance. However, a more formalised approach to external feedback would be beneficial.

- Pedagogical training takes place for assistant professors. However, the staff mentioned that the courses were very general pedagogical courses and not targeted towards experimental science subjects, e.g. laboratory training could be more relevant for staff development. One possible route could be to establish a faculty specific pedagogical course, or at least a faculty-specific add-on module to the existing university-wide course. There is no strategy for the pedagogical development of lecturers, professors and PhD staff. The panel is aware that in addition to the pedagogical training of assistant professors other initiatives have been taken but recommends that the training and development of teaching methods be given a higher profile in the department in order to communicate the equivalence between education and research.

- Concerning assessment, the panel could not identify any department practices whereby the department ensures that students are informed of what is expected of them to achieve a certain grade. Students were not clear on the differences in levels between bachelor and master level. There is an unspoken understanding between experienced staff and examiners about what constitutes a good grade. However, staff noted that, especially for new staff, the grading scale and level definitions should be made more explicit and discussed among staff, and communicated to students.

Appendix A

Educational context

The Danish system of Higher Education[13]

The university sector
The university sector includes 12 universities, some of which are multi-faculty universities, while others are specialised in fields such as engineering, education, veterinary science, agriculture, pharmacy, and business studies.

Teaching at the universities must be research-based; this is a fundamental principle aimed at ensuring high academic standards in all programmes. The university sector only comprises institutions offering degrees up to the highest academic level, including doctorates. The majority of university programmes have implemented the so called 3+2+3 structure which entails three-year bachelor degrees, two-year master degrees and three-year PhD degrees. Mature researchers may obtain the traditional higher Danish doctoral degree (doktorgrad), usually after a minimum of 5-8 years of individual and original research and public defence of a dissertation. There is no formal study programme for this award.

Recent developments in Danish higher education
Danish University Education has been subject to a major university reform, and in January 2003, the Minister of Science, Technology and Development introduced a new University Act to the parliament. The Act is far-reaching in several areas: the Academic Council is replaced by a Board

[13] *The description of the Danish system of Higher Education is based on information from the following sources: The Danish Ministry of Science, Technology and Development: "Danish universities in transition - Background reports to the OECD examiners panel 2003", Government Bill for the University Act, The University of Copenhagen: Annual report of 2002.*

with a majority of external members; all managers are appointed rather than elected; and the status of each university is changed from government institution to non-profit institution.

The University Act states that, where the educational structure has not already been altered, it is restructured in order to ensure genuine implementation of the 3+2(+3) structure. Furthermore, the law introduces a modular structure for all bachelor and master programmes.
The Act also emphasises the role of quality assurance and clarifies the responsibility for quality assurance of higher education. The Act specifies that deans and, in particular, heads of departments are responsible for the quality assurance of education and the systematic follow-up on evaluations of education and teaching. The study boards and the heads of study programmes are included in the quality work and shall contribute to the systematic follow-up on the evaluations by the management, i.e. rectors, deans and heads of departments.

The universities are subject to evaluations in order to demonstrate that the programmes offered are relevant to the needs of society and of the highest educational standards. In connection with the evaluations and the development of the content of the educations, the universities are to contact relevant employers and postgraduates, as part of the quality assurance work, to ensure a common identity, level and relevance.

In their charter, the universities are to lay down clear guidelines for the documentation systems to be used in connection with the evaluations and follow-up plans. Together with the evaluations, the documentation systems are to provide a high quality resource for the educational activities, be a source of information available to the management in connection with decision-making, and are to constitute an active management tool.

Legal framework
The Ministry of Science, Technology and Development lays down the overall regulations for all 12 universities. The framework for the university activities is made up of the new University Act adopted in July 2003, the Appropriation Act and a number of other general acts. The former University Act was adopted in late 1992, and supplemented in 1998 and in 1999. A specific requirement states that the bachelor degree should not only prepare the graduates for further studies but also for employment. The legal framework also includes entry requirements for specific subject areas as well as the requirement that 1/3 of the exams should be subject to external examination. New programmes are approved by the ministry according to specific criteria for approval (including relevance to the labour market, etc.) and the ministry also determines the individual student funding rate for the new programme.

Additionally, since 1999, university development contracts have served as a tool to describe the core tasks of the university as defined by the individual university in consultation with the minis-

try. Contracts state the strategic areas the university intends to focus on for a given period of time as well as which instruments the university intends to apply to reach the set targets, but without an automatic relationship between reaching the set targets and the grants awarded.

Admission system
The admission procedure to university programmes consists of three elements:

- centrally determined rules specifying obligatory admission requirements, such as a qualifying exam;
- determination of the capacity of the annual intake, i.e. the number of student places;
- admission control to match the number of applications and capacity.

As a general rule, there is free intake at the universities subject to the above three elements.

The obligatory admission requirements to higher education in Denmark comprise 12 years of education, including one of the following secondary school leaving examinations or comparable qualifications:

STX – Upper Secondary School Leaving Examination
HF – Higher Preparatory Examination
HHX – Higher Business Examination
HTX – Higher Technical Examination

Additional and programme specific requirements concerning subject combinations, work experience, grade point average, and level of subjects taken also apply to a number of programmes.

Students apply for admission through a centrally coordinated enrolment system (KOT). Each institution is allocated students according to the general admission regulations.

Funding system
The state appropriates funds for the universities' teaching, research and other activities, including administration and buildings.

The intra-university distribution of resources is to an increasing degree characterised by the principles of activity steering. Funds are allocated as grants by central government to the institutions based on the actual levels of pupil/student activity, objectively measured in full-time semesters or years. All courses are given a politically determined rate ("takst"), published annually in the government's finance bill.

The UK system of Higher Education

General

Higher education institutions include universities, higher education colleges and a small number of university colleges. Higher education institutions are diverse, ranging widely in size, mission and history.

In the UK, academic qualifications at this level are not national awards, but are granted by individual institutions with degree awarding powers. All universities, university colleges and a small number of higher education colleges have the power to award their own degrees and qualifications. Degrees and other qualifications offered by higher education institutions without degree awarding powers are validated by external bodies such as another higher education institution with its own degree awarding powers (e.g. a university) or a national accrediting body.

Qualifications and titles of awards vary between institutions. Qualifications may include higher education certificates and diplomas, foundation degrees, bachelor degrees, bachelor degrees with honours, and higher (postgraduate) degrees, such as master degrees and doctorates.

Undergraduate programmes leading to bachelor degrees with honours (usually known as honours degrees) form the largest group of higher education programmes. Typical programmes leading to an honours degree last for three years (if taken full-time) although some programmes are longer.

The UK is currently working towards implementation of the Bologna Process reforms. The 'Europe Unit', a sector wide body under the aegis of the representative body 'Universities UK', is responsible for raising awareness of European issues affecting UK higher education and for coordinating UK involvement in European initiatives and debates.

Legal framework

The legal basis for individual higher education institutions varies. Older (pre-1992) universities were created and generally operate under a Royal Charter, whereas newer (post-1992) universities and certain other higher education institutions are based on and operate under Parliamentary Statute. The Privy Council is responsible, under the Further and Higher Education Act 1992, for approving the use of the word 'university' and may also approve an institution as competent to grant degrees. Whatever their legal basis, all higher education institutions are now legally independent self-governing institutions. The Education (Recognised Bodies) (England) Order 2003 (as amended by the Education (Recognised Bodies) (England) (Amendment) Order 2005) and the Education (Recognised Bodies) (Wales) Order 2003 lists those universities, colleges or other bodies which are authorised by Royal Charter, or by or under Act of Parliament, to grant degrees. All

higher education institutions have charitable status and are accountable through a governing body which carries ultimate responsibility for all aspects of the institution.

Admissions system
As autonomous institutions, universities and other higher education institutions determine their own admissions policies. Entry is competitive and specific requirements are set for each programme. However, overall student numbers are subject to a measure of central planning. Students may apply for admission to any higher education institution. The traditional qualification for entry to degree study has been two or three General Certificate of Education Advanced-level (GCE A-level) passes, as well as a minimum number of General Certificate of Secondary Education (GCSE) passes at grade C or above. These remain the most common form of entry qualification held by full-time undergraduate students. However, a wide range of other qualifications is acceptable for entry. This includes GCE A-levels in applied subjects (formerly Vocational Certificates of Education (VCEs) Edexcel BTEC National Qualifications and the International Baccalaureate. Many courses require some or all of the qualifications for entry to be in specific subjects or in a specific range of subjects.

Funding system
Under the Teaching and Higher Education Act 1998, undergraduate students beginning a course since 1998-1999 have been expected to pay tuition fees. Tuition fees are set at £1,150 for 2004-2005, (£1,175 for 2005-06) representing around a quarter of the total cost of tuition. The fees are means-tested and around 60 per cent of students get some or all of this paid for them by the Government depending on their income. Tuition fees are paid directly to the institutions.

Funding to HEIs from the relevant funding council follows the student. This is one of the reasons why planning for admissions is important – if the institution over-recruits it will be penalised by the funding council.

External examiner system/Quality assurance
Assessment of students is most likely to be by a combination of written examinations, traditionally at the end of each academic year, and assessment on the basis of work submitted during the course or of a large piece of work done in the student's own time. In courses where it is appropriate there are also practical examinations, for example in the sciences or in oral proficiency in languages. The actual assessment is normally carried out by the department in which the student is studying, but there will also be one or more external examiners from another institution or institutions, who will sample some of the work (course work as well as examination papers).

Currently, the UK Quality Assurance Agency (QAA) for Higher Education undertakes, on behalf of the funding councils, the assessment of the management of the standards of awards and the quality of learning opportunities offered to students in higher education institutions.

Specific

It should be noted that, for the purposes of this report, Wales and Northern Ireland are not referred to specifically since no HEI from either country participated in the project, However, as there was participation from a Scottish university, it is important to point out some of the differences in the higher education system in Scotland.

Legal framework

Scotland forms an integral part of the United Kingdom of Great Britain and Northern Ireland. The status of the office of Secretary for Scotland was enhanced in 1926 to that of Secretary of State. Throughout the 20th century the responsibilities of the Secretary of State for Scotland continued to expand and The Scottish Office finally comprised six Departments. Since the re-establishment of the Scottish Parliament in 1999, a number of significant changes have been made by the Scottish Executive in the organisation of the civil service departments. One of the major changes has been to separate pre-school and school education from post-school education, training and industry. Responsibility for the latter now rests with the Deputy First Minister, who is also the Minister for Enterprise Training, and Lifelong Learning. The Minister is supported by a Depute Minister. The Ministers are assisted by The Scottish Executive Enterprise, Transport and Lifelong Learning Department (SEETLLD) which emerged as the result of the Executive's decision in 1999 to separate pre-school and school education from post-school education, training and industry.

Admissions system

Much of what was said above regarding the UK admissions procedures apply also to Scotland. However, Scottish students may choose to enter university at 17 years old rather than 18. Traditionally, Scottish honours degrees last for 4 years rather than 3. The first year is commonly seen, therefore, as a general, rather than discipline specific year and those students who remain in secondary education for an extra year and thus enter university at 18 could, theoretically go directly into the 2nd year of a programme. However, many 18 year olds choose to complete the first year of study.

Funding

Scottish HEIs are funded by the Scottish Higher Education Funding Council (SHEFC). Students at Scottish universities do not pay tuition fees.

Appendix B

Terms of reference[14]

Background
The Danish Evaluation Institute (EVA) decided, as part of its action plan 2005, to initiate an international comparative review of first and second cycle chemistry programmes. The review is to be conducted in cooperation with the Quality Assurance Agency for Higher Education in the UK (QAA) and to include both UK and Danish universities.

Aims and objectives
The main aims of the review are, firstly, to identify and assist in the dissemination of good practice within the area of chemistry teaching in Danish and UK universities and, secondly, to develop and apply a method for peer-review of the student learning experience and the supporting quality assurance mechanisms. The review is to be based on experience gained from selected chemistry (bachelor and master) programmes run by Danish and UK universities.

The objectives of the review include describing and evaluating:

- the educational context for the programmes, to provide:
  - a factual basis to support an understanding of the programmes, and their self-evaluation by the departments involved;

- the student learning experience, to provide:
  - an assessment of the programmes in terms of content, intended learning outcomes, learning and teaching methods to support the achievement of the outcomes, and assessment methods used to demonstrate student achievement;

[14] *These are the original terms of reference, approved by the EVA board 23 January 2006.*

  - an assessment of the level of implementation of the first and second cycle degree structure, and whether the programmes have formulated goals for the bachelor and master degrees that match national and/or other descriptors, including the "Dublin descriptors";

  - an assessment of the critical differences between the first and second cycles, and particularly identification of those elements and expectations that distinguish the bachelor degree (and its graduates) from the master degree;

- quality assurance, to:
  - develop a better understanding of the quality assurance mechanisms used within chemistry programmes in the UK and Denmark, including the role(s) of external examiners;

  - examine quality assurance mechanisms applied to and within the programmes;

  - encourage reflection within the programmes on the effectiveness of their existing quality assurance mechanisms and consider what influence the recently published European Standards and Guidelines might have on their processes and activities.

Scope
The review involves five chemistry programmes in Denmark and four chemistry programmes in UK, at the following universities:
- Roskilde University
- University of Copenhagen
- University of Southern Denmark
- University of Aarhus
- Aalborg University

With those in the UK at:
- University of Aberdeen
- Nottingham Trent University
- University of Bath
- University of Bristol

The five chemistry programmes in Denmark are obligated to participate in the review, as part of the national cyclic review. Whereas the four UK chemistry programmes have volunteered to participate.

Organisation of the review
The panel of experts and the project team will both participate in the site visits.

The review is carried out as a joint project between the Quality Assurance Agency for Higher Education (QAA) and the Danish Evaluation Institute (EVA). QAA and EVA will appoint a project team consisting of evaluation officers from the two organisations. The project team is responsible for the methodological aspects of the evaluation and the initial draft of the comparative part of the report. The project team will also act as a secretariat for the panel of experts.
The expert panel will include:

- one UK chemistry expert (must command high peer-esteem and come from a research intensive department);
- one or two other chemistry experts from another European country;
- one Danish labour market representative.

To promote good practice between the programmes, there will be either a Danish or UK department represented as an observer at, respectively, the UK and Danish site visits.

Method
The review will be based on pre-defined and public criteria following the recently published European Standards and Guidelines for Quality Assurance in Higher Education (ENQA-standards).
Thus, the review process will include:

- self-evaluation: the participating institutions (programmes) write a self-evaluation report in which they analyse and assess their own strengths and weaknesses related to the areas of focus (student learning experience and quality assurance mechanisms);

- the Danish part of the review will include a labour market survey of the chemistry graduates;

- site visits: as part of the evaluation, the international evaluation panel will visit the involved institutions. The visits will be planned in cooperation with the institutions and will together with the self-evaluation reports constitute a substantial part of the background documentation for the findings and conclusions of the evaluation;

- reporting: the analysis, assessment and recommendations of the evaluation will be documented in a single report containing both a comparative and programme specific part. A draft report will be sent in consultation to the institutions involved in the review prior to completion of the final report.

Appendix C

Members of the expert panel

John Winfield (chair)
John Winfield was educated in chemistry at Imperial College (ARCS, BSc from University of London) and the Royal College of Science and Technology, Glasgow (now Strathclyde University, PhD from University of Glasgow). His first academic appointment was lecturer at the University of Glasgow. Subsequently, he rose through the ranks and was appointed a personal Professor of Inorganic Chemistry in 1995. He was Head of Department 1994 – 1999. Currently he is an Honorary Senior Research Fellow and continues to pursue research in fluorine and chlorocarbon chemistry, with particular emphasis on heterogeneous catalysis involving C-F and C-Cl species. Interests in tertiary level education have been pursued largely through Royal Society of Chemistry activities, notably as Chair of the Committee for Accreditation and Validation, 2001 – 2005.

Björn Pedersen
Björn Pedersen was educated in chemistry at the University of Oslo (cand. real. 1958, dr. philos. 1964). He was research associate in physics at Cornell University 1958-9, researcher 1960-7 and research director at the Central Institute for Industrial Research in Oslo 1968-78. He was part time professor in spin spectroscopy UiO 1970-78; professor of Chemistry UiO 1979-2003. His main field of research has been on the static and dynamic structure of solids by NMR-spectroscopy. He taught general chemistry for many years and has written several textbooks on chemistry both at university level and high school level. He is presently head of the history group within the Norwegian Chemical Society. He was elected chairman of the Department of Chemistry 1972-3; vice dean for the Faculty of Mathematics and Natural Sciences 1975 and 1980-2; and vice rector 1985-88. In the latter position, he was head of the central Committee for Education at UiO. He has an honorary degree from Uppsala university (fil .dr. h. c. 1989). He is member of the Royal Society of Sciences, Uppsala.

Michael Brorson

Michael Brorson was educated in chemistry at Copenhagen University from where he also obtained his PhD. He was from 1987-1995 lecturer at the Technical University of Denmark with with coordination chemistry as a research area. Since 1995, he has been an industrial research chemist with Haldor Topsøe A/S, and has here held positions as section head and project manager. His work is centred on the catalytic applications of inorganic and materials chemistry and on the exploration of catalytic reactivity. He was president of the Danish Chemical Society (2001-2004) and was in 2002 appointed member of the Danish Academy of Technical Sciences.

Appendix D

The participating universities

Aalborg University (AAU)
Aalborg University (AAU), situated in the northern part of the region of Jutland, was inaugurated in 1974 and is thus a young university offering education programmes and research in the fields of humanities, social sciences, natural sciences and engineering. Aalborg University differentiates itself from the older and more traditional Danish universities with its focus on interdisciplinary, interfaculty studies; an experimental curriculum based on an interdisciplinary basic course with subsequent specialization, and a pedagogical structure based on problem-centred projects.
The Department of Biotechnology, Chemistry and Environmental Engineering houses the Section for Chemistry and is placed under the Faculty of Engineering and Science.

For 2006, the total number of students at the university is 13,324, and the total number of staff is 1,655, including 925 academic staff members.

University of Aarhus (AU)
The history of the University of Aarhus dates back to 1928. Today, the university is the second largest in Denmark and is made up of 5 faculties. The Faculty of Science houses 8 departments, including the Department of Chemistry.

The total number of academic staff was in 2004 1,965, and a total of 20,547 students were studying at the university. Aarhus is also the second largest city in Denmark and the largest city in the region of Jutland.

University of Aberdeen
The University of Aberdeen was founded in 1495 which makes it the third oldest university in Scotland. The University is now organised into three colleges with twelve associated schools. The Department of Chemistry is thus placed under the College of Physical Sciences.

In 2004-5, just over 13,500 students were enrolled at the university.

University of Bath
The University of Bath was awarded its royal charter in 1966 and is currently structured into three faculties, two schools and a division. The Department of Chemistry is a department under the Faculty of Science.

As of December 2005, the university had approximately 12,000 students and 1,269 academic staff.

University of Bristol
The University was founded in 1876 as University College, Bristol and was awarded its royal charter in 1909. The University organizes its academic affairs in some 45 departments and 15 research centres, which are arranged in six faculties. The School of Chemistry falls under the Faculty of Science.

As of February 2005, approximately 2,700 academic staff were connected to the university and approximately 14,200 students were enrolled.

University of Copenhagen (KU)
With almost 33,000 students and more than 6,000 employees, including about 3,405 academic staff, the University of Copenhagen is the largest institution of research and education in Denmark. The University of Copenhagen was inaugurated on June 1st 1479, after King Christian I was granted approval for its establishment by Pope Sixtus IV.

The six faculties of the university are currently spread across the city of Copenhagen. The Faculty of Science, which houses the Department of Chemistry, is located in and around the University Park in the Northern part of Copenhagen.

Nottingham Trent University
Nottingham Trent University, in its current structure, was launched in 1992. The history of the university dates back to the opening of a Government School of Design and the establishment of a University College in 1881. The programmes of the university are organized in 10 schools with the chemistry programmes housed in the School of Biomedical Natural Sciences.

Currently a total of 25,471 students are enrolled at the university.

Roskilde University
Roskilde University is a state university founded in 1972 with the objective of reducing enrolments at the University of Copenhagen. The programmes were, from the very beginning, characterized by a strong emphasis on project and group studies, and project work in self-directed groups of students still makes up around half of the study load. The University was thus a pioneer in the development of Project Based Learning at university level.

Research and teaching activities at Roskilde University are organised in ten departments, while three separate units conduct the respective Basic Studies Programmes. In autumn 2005, approximately 9,186 students were enrolled at the university and the academic staff totals approximately 488.

University of Southern Denmark
The University of Southern Denmark was founded in 1966 and is the only university in Denmark with four campus towns. This current structure was established in 1999 when the University of Odense merged with a business school and a smaller university in southern Jutland. The current university has five faculties: Health Sciences, Science, Engineering, Social Sciences and Humanities, with the Department of Chemistry placed in the city of Odense in the Region of Funen, and part of the Faculty of Science.

Approximately 16,000 students study at the University of Southern Denmark, and there are approximately 1,200 academic staff.

Appendix E

Criteria

The student learning experience

Aims
- The aims of the programme are clearly defined.

- The aims are publicly available to internal and external stakeholders.

Degree and programme structure
- The contents of the programme are coherently structured and offer students the opportunity to obtain a set of learning outcomes/competences at the level that has been formulated.

- The programme can be completed successfully within the set time.

- The structure and content of the programme is quantified, typically using a credit system, e.g. ECTS (European Credit Transfer and Accumulation System)

Descriptors for learning outcomes, including competences
- The programme has established its own reference points using external, nationally or internationally agreed reference points.

- The programme encourages progressive and integrated development of the identified generic competences/intended learning outcomes.

- The programme ensures the development of identified subject-specific learning outcomes/competences/intended learning outcomes.

- The programme supports the attainment of labour market competences/recognised professional standards.

Teaching and learning methods
- The teaching and learning methods facilitate the achievement of the aims and the expected competences/intended learning outcomes of the programme.

- Teaching is largely provided by academics and researchers who contribute to the development of the subject area and are linked to research activities.

Assessment methods
- Assessment methods are designed to measure the achievement of the intended learning outcomes/competences and the aim of the programme.

- The assessment methods employed are appropriate to their purpose.

- The assessment methods employed have clear and published criteria for grading.

- The assessment methods employed are undertaken by people who understand the role of assessment in the progression of students towards the achievement of the knowledge and skills associated with their intended qualification.

- The assessment methods employed ensure that assessments are conducted securely in accordance with the institution's stated procedures.

- The assessment methods employed are coordinated across the whole programme to ensure that all of the competences/learning outcomes are achieved.

Criteria for quality assurance

Policies and procedures
- The programmes have developed and/or implemented quality assurance strategies. (Strategies may, for example, concern changes in student demand, external demands, developments in teaching and learning, and new research areas).

Approval, monitoring and periodic reviews of programmes and awards
- The quality assurance mechanisms include formal approval procedures by a body other than that teaching the programme.

- The quality assurance mechanisms involve students, staff and other stakeholders.

- The quality assurance mechanisms include regular feedback from employers, labour market representatives and other relevant organisations.

- The programme includes mechanisms for follow-up and continuous improvement.

- The programme providers monitor whether its aims are met and standards upheld, on an on-going basis.

- The programme is subject to regular periodic reviews (by both internal and external parties).

Quality assurance of teaching staff

- The staff is sufficiently qualified to ensure that the programme aims regarding contents, didactics and organisation of the programme are achieved.

- Opportunities for staff development are provided.

Learning support

- The resources available for the support of student learning are adequate and appropriate for the programme(s) offered.

- The effectiveness of the support services available to students are routinely monitored, reviewed and improved.

Information systems

- Relevant information for the effective management of the programme is collected, analysed and used. Relevant information might, for example, include data on student progression and success rates; employability of graduates; student satisfaction with the programmes; effectiveness of teachers; a profile of the student population; learning resources available and their costs; the institutions own key performance indicators.

Public information

- Quantitative and qualitative information about the programme is published and is up to date, impartial and objective. Published information might, for example, include the intended learning outcomes, details about the final qualifications, learning and assessment procedures and the learning opportunities.