Chemistry Studies in the European Higher Education Area

Dresden, June 14th and 15th, 2004

Report

Preamble

The backdrop to this conference was perhaps best provided by the following quote from the Communiqué (www.bologna-berlin2003.de/pdf/Communique1.pdf) signed by the 40 higher education ministers who met in Berlin in September 2003:
"***Ministers encourage the member States to elaborate a framework of comparable and compatible qualifications for their higher education systems, which should seek to describe the qualifications in terms of workload, level, learning outcomes, competences and profile. They also undertake to elaborate an overarching framework of qualifications for the European Higher Education Area".***
The elaboration of such a framework of comparable and compatible qualifications requires both an advance in structures and a common understanding about what has to be learnt in the different fields of competence. The introduction of the two-tier system of studies, which at the last ministerial meeting was extended to become a system of three cycles, Bachelor, Master and Doctoral Studies, together with the use of ECTS as a credit system and the issue of an explanatory Diploma Supplement, are at the heart of the concept of structures of the Bologna Process. However, the application in different subjects, starting out from more or less long-standing and successful national traditions, remains the central challenge in making the European Higher Education Area a reality. This conference attempted to tackle this central question by considering the example of one of the most important natural sciences.
Chemical, pharmaceutical and biotechnology industries play a vital role in the European economy (the chemical industry alone with its 25,000 companies employs around three million people and had total sales in 2002 of around €370 billion), so that it is of paramount importance that university chemical education in Europe continues to be of the highest possible standard. This includes rapid integration of novel fields of knowledge which are evolving in chemistry and neighbouring disciplines. Thus within the Bologna framework, which invokes the increasing transparency and comparability of degree qualifications, there is a real need to redefine the established patterns of university education in the natural sciences

in order to provide young graduates with the tools they need in order to be able to make their contribution to the Europe of Knowledge. In order to achieve this aim, a number of paradigm shifts are required.
One shift that has already gained significant momentum in the Bologna area is the change from teacher-oriented to student-oriented study programmes. A second involves focussing study programmes on the requirements of professions in society and industry rather than purely on scientific excellence.
And a third is to recognise that it is no longer enough to be educated in a single discipline, for example chemistry, biology or physics, but that the Bologna first cycle graduate (who will generally, but not in all countries, be awarded the degree of "Bachelor") should have a more broadly-based education which will allow him or her to choose between directly entering a job outside the university and specialising further within the framework of a Master and/or doctoral study programme.
A further important shift will result from the request that qualifications should be described in terms of workload, level, learning outcomes, competences and profile. Such descriptors can certainly be used to design systems which facilitate the transition from education to work and from one country to another. The underlying task, however, is to spell out basic rules for the content of study programmes, since learning outcomes, competences and profiles cannot be divorced from content. The conference therefore tried to develop the vision of a landscape where the massive foundations are constructed, where the high points become visible, where bridges and climbing-irons are offered, and where the new and the unknown keep promoting curiosity and eagerness to study and do research.

The First Cycle

In the chemical community it is generally accepted that the classical chemistry "core" of organic, inorganic and physical chemistry (with the necessary background knowledge in physics and mathematics) should continue to be the cornerstone of any chemistry first degree (whether this be in chemistry, biochemistry, or other chemical disciplines). In addition there should be a range of semi-optional modules/course units to provide jumping-off points for specialisation in other sub-disciplines.
Some redefinition of the core is also necessary: thus analytical chemistry and biological chemistry are so important today for the chemist that they should both be included in the core.
The Helsinki consensus (2002) was that Bachelor programmes should correspond to between 180 and 240 ECTS credits (3-4 years of full-time study). In the case of chemistry, it seems advisable to aim for 180 credits as the norm, so as to make mobility at the end of the first cycle easier. The European Chemistry Thematic Network ECTN, an organisation with over 130 members which include seven national chemical societies, has within the scope of the ongoing EU project "Tuning Educational Structures in Europe" (www.relint.deusto.es/TuningProject/index.htm) developed the so-called "Eurobachelor" framework (www.chemistry-eurobachelor.net) which is designed for a 180-credit qualification, and those countries or universities who decide to standardise their first cycle education at 240 credits might like to consider creating a 180-credit Eurobachelor intermediate qualification for those who intend to move to another country on graduation. The Eurobachelor framework was approved at a general meeting of the Federation of European Chemical Societies FECS held in Barcelona in October 2003. The ECTN Association will in the second half of 2004 offer interested institutions the possibility of applying for the "Eurobachelor Label", which will certify that they have reached certain internationally defined standards in their first cycle qualification. It is hoped that this process will be supported by the European Commission.

There are significant differences between European countries in the expected employability of first cycle graduates in chemistry. This reflects differing levels of education and scope, and differing lengths of study.
Institutions should do all that is possible to improve students' employability; one of the important aspects is that the training should not follow political demands blindly at the expense of practical employability. The diminishing amount of chemistry in pre-university schooling contrasts with the increasing importance of chemistry in the world at large.
Training placements in industry can certainly improve employability prospects, though placements shorter than 6 months are likely to have only limited value. It must be remembered that at least as many chemistry graduates are employed in SMEs as in the major chemical companies, and the bachelor is likely to be better-accepted in such enterprises.
It has been recommended that a BSc course should involve either a Bachelor Thesis or a corresponding industrial placement; in some cases a "practical" thesis (for example in a partner SME) may enhance employability of the graduate.

The Second Cycle

A Bologna first cycle qualification must give access (in the sense of the Lisbon Recognition Convention: www.bologna-berlin2003.de/pdf/Lisbon_convention.pdf) to second cycle qualifications. This right of access must however not be seen in a narrow sense: one major advantage of the short first cycle is that graduates can change direction when moving on to a second cycle study programme. Thus entry requirements for second cycle degrees must be flexible so as not to make transitions from (for example) chemistry to chemical biology or physics impossible. They must also cater for graduates from countries which do not have the same length of the first cycle (a minority seems likely to require 240 ECTS credits rather than 180) and from outside Europe.
One important feature of the emerging two-tier system will be the diversity of second cycle courses. It can be imagined that there will be both courses following directly on from the first cycle and others taken by so-called "mature students" who have some years of professional experience. Other courses will be aimed more precisely at specific functions in the labour market or at strengthening the research capabilities of graduates. Many combinations and interdisciplinary profiles of these courses can be imagined. The second cycle will thus be a hotbed of experimentation and flexibility.
At the same time it must be taken into account that many European countries have parallel higher education pathways, those in traditional universities and in "polytechnic"-type institutions (Hogeschool, Fachhochschule etc.). At the end of the first cycle it must be possible for suitably qualified graduates to move (in either direction) between these two types of institution.
Furthermore, of course, the right of access is not a national but an international right, and institutions must see themselves in terms of international competition for the best graduates.
The conference was concerned with Chemistry Studies in the *European* Higher Education Area (EHEA), but one must not make the mistake of thinking in terms of creating a "Fortress Europe" in tertiary education. By going down the "Bachelor/Master path", Europe is at last making itself visible in a global context.
European graduates will rapidly realise that the Bologna process opens doors which were previously not locked but often at least jammed, and will take the opportunity of using their Bachelor qualifications as an entry permit to, for example, graduate schools in the USA. While welcoming this, chemists must consider how to entice the best graduates from

anywhere in the world to come to Europe to continue their studies after graduating as Bachelors.

Linking the Second and Third Cycles

How will chemistry departments in the EHEA treat the second cycle? It is a well-known fact that almost any *chemist* who gains a Master qualification from an institution in the USA carries the stigma of in fact being a "failed PhD". Naturally it is necessary to avoid establishing such a situation in Europe. The question must however be posed as to whether it is absolutely necessary that *every* European PhD must have *both* a BSc and an MSc. The Bologna decisions allow direct transition from a Bachelor degree to doctoral studies.
There will be second cycle qualifications which are gained in the sense of continuing professional development, and which may be full-time one-year courses or perhaps two-year part-time courses of a relatively specialised nature, and graduates of such programmes must (again in the sense of the Lisbon Recognition Convention) also have the right of access to doctoral programmes, although they may not wish to exercise this right.
Most second-cycle qualifications will however involve 90-120 ECTS credits and build directly on the foundations of the first cycle; these will be designed as prerequisites for doctoral programmes. The conference considered that 120 ECTS credits should be the reference point for Master programmes.

It is also vital to consider the needs of two classes of student whose interests have until now been somewhat neglected: the excellent student on the one hand and the student entering from a foreign institution on the other.
The excellent student must be rewarded in the Bologna framework. He or she must be allowed to proceed faster than the majority. Why? These are young people who may well become the leaders, and/or the university professors, of tomorrow. They must be offered a "fast-track option".
Students from foreign institutions may well have qualifications different from both a European bachelor and a European master; their needs must be catered for.
This is why the conclusions of the Helsinki Bologna Seminar on Master Degrees (2003) state clearly that "A transition from master level to doctoral studies without the formal award of a master's degree should be considered possible if the student demonstrates that he/she has the necessary abilities" (www.bologna-berlin2003.de/pdf/Results.pdf) .
The Dresden conference made it clear that institutional regulations must be written in such a way that this is indeed a real possibility.

The Needs of Students from Outside Europe

Why is it so necessary to think in detail about the needs of the student coming from a foreign institution? If Europe does things properly, mechanisms such as the Eurobachelor Label will lead to the establishment of uniformly high standards at the Bachelor level. But it has been noted above that the goal must be to attract good graduates from all over the world. And these will not have the benefit of bringing with them the standardised European Diploma Supplement. Thus it will not always be possible to make good judgements of their quality on the basis of the documentation supplied.
Their acceptance will lead to the responsibility of giving them the best possible chance, even if they do not turn out to be as good as had been hoped. But of course standards cannot be debased by the automatic award of a PhD!

Thus the pragmatic UK/Irish idea of the "Master of Philosophy" qualification, intended to be a degree which is not often awarded (but if so then it really *is* a "failed PhD") is a good one. The MPhil is intended as a "transitional" programme, during which decisions can be taken about the suitability of the candidate for continuing to a PhD. Transfer to the PhD will (hopefully) be the norm, but if this is not advisable the student can continue to the end of the MPhil and at least go home with an additional qualification *which is not the "standard" one of MSc*.

Joint Degrees

So far the concept of joint degrees, which form part of the Bologna framework, has not been sufficiently discussed with respect to its application in chemistry. To quote from the Berlin Communiqué:
"Moreover, they [the Ministers] stress the necessity of ensuring a substantial period of study abroad in joint degree programmes as well as proper provision for linguistic diversity and language learning, so that students may achieve their full potential for European identity, citizenship and employability.
Ministers agree to engage at the national level to remove legal obstacles to the establishment and recognition of such degrees and to actively support the development and adequate quality assurance of integrated curricula leading to joint degrees".
Mobility is always the litmus test of international compatibility of study programmes. A tight work programme at the Bachelor level or a shortened Master course may hamper the mobility of free movers. The desired mobility therefore needs support. Joint international programmes at all levels and joint degrees can be a way of boosting exchanges and popularising the beneficial effects of the exposure to the study environment in another country. At the second and third levels in particular, such programmes for joint degrees will be important building blocks for the EHEA.
Politically it has furthermore been made clear that the European Higher Education Area should not be seen independently of the European Research Area. Research normally plays an important role in Master programmes, so that the link can be established at this level as well as at the doctoral level. And *if* the "Euromaster" is to be defined as the pendant to the Eurobachelor then this might most effectively be done at the level of joint Master programmes, programmes run by small or large groups of universities and leading to the award of only one degree (in contrast to double degrees, where two diplomas are issued). The new ERASMUS MUNDUS programme should be a good incentive to the conception of such joint degrees.

The Third Cycle

Research is global. Researchers have to be mobile, now more than ever. The European Research Area must become a reality. But, at the same time, Europe is marked by a wide variation in the way PhD degrees are gained. The Berlin Communiqué of September 2003 therefore makes it clear that the third cycle is really to become a part of the Bologna process, with the concomitant need for looking for transparency and comparability in doctoral qualifications. To quote:
"Ministers consider it necessary to go beyond the present focus on two main cycles of higher education to include the doctoral level as the third cycle in the Bologna Process.
……
Finally, Ministers state that networks at doctoral level should be given support to stimulate

the development of excellence and to become one of the hallmarks of the European Higher Education Area".

The debate on the third cycle is only beginning, although the Joint Quality Initiative has already formulated descriptors for PhD graduates. The Dresden conference felt that coursework (measured in ECTS credits and clearly documented in a transcript) should be a feature of chemistry doctoral programmes (which should normally be 3 or 4 years in length), but that the dominant research component of such programmes should not be expressed in ECTS credits. It appears necessary to look for a consensus on the pathway leading towards the award of doctoral degrees in chemistry, taking regard to points such as the nature of the examinations to be taken, the role of external examiners (who should be involved as often as possible), and the nature of the "jury" (e.g. the role of the supervisor in the examination process). And it will also be vital to link the second and third cycles, as referred to above.

The attractiveness of European institutions will be enhanced if they develop "Graduate School" structures at departmental, interdepartmental or regional level in order to increase their national and international visibility, to increase their research potential and to foster cooperation both between staff and between students.

National structures for setting up research networks should be extended in order to internationalise such networks, which should share agreed procedures. But even for chemistry departments which are not involved in networks it seems vital to find ways to allow as large a number of doctoral students as possible to carry out part of their research at an institution in another country, so that the concept of the "European PhD" can become an established one in chemistry.

Chemistry and the European Credit Accumulation and Transfer System ECTS

The reforms implicit in the construction of the EHEA will involve transparency, and one vital tool in establishing and demonstrating transparency is ECTS. ECTS was devised and developed as a credit transfer system, but because of its simple structure it can readily be adapted for use as an accumulation system which will in the near future be used and accepted across the EHEA. But not only there: interest in the ECTS system has been expressed by countries and regions across the world, so that ECTS is likely to become a hallmark of the European education system.

If, however, this is to be so then it is vital that ECTS must be implemented *correctly*. As part of the Bologna process a conference was held in November 2002 in Zürich; the result of this conference was the preparation of a document called "ECTS Key Features", which will soon be available in all the Bologna area languages (www.eua.be/eua/jsp/en/upload/ECTS%20Key%20Features.1068807879166.pdf).

ECTS is a workload-based system. The shift from teacher-centred to student-centred learning means that the students must be *fully involved* in the process of workload definition and checking.

ECTS, used properly, is a vital tool for quality enhancement at the programme level.

Teaching, Learning and Assessment

The traditional tools which find the most use in chemistry teaching are lectures, seminars and practical courses. While these will remain irreplaceable in the future, the student of today is used to working with computers and the Internet, and probably expects to find multimedia support of various kinds available in his studies. While teaching staff have no problem in

teaching using "chalk and talk", the *student* does seem often to have problems with this traditional approach.
It sometimes seems to be necessary to teach the student how to learn!
Multimedia tools of many types are being developed throughout Europe, often at great cost, and these need to be made available as widely as possible. Correctly used, these tools seem likely to make learning easier. Unfortunately, much time and money has often been spent in devising multimedia tools which were devised in a national context and where the programming was carried out in such a way that translation into languages other than the original is a non-trivial or even impossible task. This approach must be changed in future to an international approach. The setting up of a European clearing house for such multimedia tools seems advisable.
Oral or written examinations are still the standard ways of assessing any student's performance. In chemistry, there is still no real alternative yet to written “paper and pencil” tests/exams, since - mainly for technical reasons (e.g. the problem with the input of structural formulas) - the available internet-based platforms only allow for the assessment of a rather limited spectrum of competences.
Nevertheless, computer-based testing/examination platforms (“e-ChemTests”) are slowly reaching the stage of becoming serious tools, not only for e–learning/training but also for the assessment of individuals as well as of whole classes of students (general statement: “there can be no learning without testing”).
It is obvious that e-testing/e-assessment will gain importance as a tool for training and (self-) assessment in the context of both university curricula and Life Long Learning activities non-outside universities. Thus e-testing is clearly of relevance for the Bologna process.
In principle, e-Tests open some novel possibilities for designing questions and thus offer interesting new opportunities to evaluate knowledge and understanding of students. Their didactic value is greatly improved by the provision of feedback to the person who performs the test, and questions may be linked directly to e-textbooks etc. Such supplementary tools can add enormous value to e-assessments.
There is one crucial precondition: the success and persistence of all e-learning, e–teaching and e-testing activities will depend on their integration into courses (curricula), i.e. into “everyday university life”. While many textbooks offer some supporting e-learning/e-testing materials (online or on CD), only a few academic institutions have begun to exploit such new opportunities in a meaningful fashion. It will be important that institutions have access to the developed systems without having to spend too much money.
To improve the existing platforms and to overcome some of the obvious limitations, new software needs to be developed and filled with modern content. There is a need for staff with knowledge in both chemistry and information technology. Optimum use of web-based techniques can only be made by experts (professionals).
It could be an important action for the European commission to initiate (and finance) a program aiming at the development of meaningful e-testing platforms in chemistry.
ECTN has devised an internet-based tool for self-assessment, the "EChemTest", which was presented during the conference. This will be made available in many European languages and at several levels. Participation in its development by many institutions is involved, and two possibilities are envisaged for the future. Firstly it is hoped to introduce self-testing centres in European countries where interested persons (not only students presently enrolled in programmes, but in the sense of lifelong learning *anyone*) can test their knowledge at various levels. Secondly its continued development will, as new Bachelor and Master programmes are introduced across Europe, provide feedback with curricular developments and thus help to optimise chemical education at university level. The strength of the ECTN EChemTest results not only from its “European dimension” but also from the powerful software platform which allows its use as a real e-assessment tool.

Though various institutional approaches to e-teaching and e-learning exist, the German “Vernetztes Studium - Chemie” (which was presented during the conference) represents probably the only national approach in this area. It is planned to make this project sustainable in the form of the "Chemistry eBachelor" and to provide the available material in various European languages. Integration with the ECTN EChemTests appears feasible and should be investigated further. Information on the project (at present available only in German) can be found under www.vs-c.de.

To prevent unnecessary spending of taxpayers' money the ongoing national activities in the various Bologna countries should be linked, so that synergies can be exploited in the future and the existing products and experiences from the nationally funded projects can be bundled. ECTN could possibly serve as a coordinating organization for such joint activities.