THE COUNCIL FOR THE MATHEMATICAL SCIENCES

The Bologna Process and Master's Courses in the Mathematical Sciences

Executive Summary

Overview of the Process

The Bologna Process is a key tool within the European Higher Education Area (EHEA) and seeks to put into effect the original Bologna Declaration of 1999. An overarching Framework for Qualifications within the EHEA forms part of this process. Closely related is the development of the European Credit Transfer System (ECTS).

The Process recognises and defines First Cycle, Second Cycle and Third Cycle qualifications – what in the UK would generally be seen as Bachelor's Degrees, Master's Degrees and Doctorates. The definitions include many references to Learning Outcomes and to ECTS credits.

Overview of Master's Courses in Mathematical Sciences

Within the UK, Master's level qualifications in the mathematical sciences include *Integrated Master's* courses of MMath type which are enhanced undergraduate courses that typically take one more year to complete than a standard Bachelor's degree; and *postgraduate* courses of MSc type which are commonly of one calendar year (FTE) in duration. Courses of both these types are of great importance within the mathematical sciences in providing sources of well qualified people trained to substantially beyond the normal First Cycle level, well equipped both to enter employment and to go on to further study. It is vital that such courses meet international standards so that UK graduates are readily acceptable in other countries. Compliance may need some amendments to course design, but it is imperative that generic interpretations of the requirements for compliance evolve in such a way as not to cause unfortunate subject-specific consequences.

UK and European Credit Systems

In the UK, the Credit Transfer and Accumulation Scheme (CATS) is widely used to measure credit. It appears that there is agreement on an operational level that one ECTS credit is equivalent to two CATS credits. Thus a full-time academic year is reckoned as 60 ECTS credits and 120 CATS credits. Nevertheless, there are some inconsistencies in using this as a formal rate of conversion. Notably, it is current practice to represent a full-time postgraduate year of study (i.e. a calendar year) by 180 CATS credits; but current ECTS guidelines are that 52 weeks of full-time study with no holidays would give 75 ECTS credits. This has important consequences for postgraduate courses.

Learning Outcomes

The UK has generally welcomed the development of Learning Outcomes as course descriptors, rather than relying solely on numerical credits; this approach should be supported. Nevertheless, as with credits, there are some current inconsistencies between different statements of Learning Outcomes. A particular difficulty in the mathematical sciences is the tendency for some statements to insist that M-level work includes some "which is at the forefront of knowledge in a field of work". This is wholly unrealistic and must be strongly resisted. Statements to the effect that M-level work "is informed by the forefront" are entirely acceptable, as are statements in which the concept of "research" is given a broad meaning. On that basis, current Master's courses in the mathematical sciences (both MMath and MSc type) broadly meet the descriptors of Learning Outcomes for the Second Cycle.

Implications for Integrated Master's Courses

In terms of credits, and using the 1 ECTS = 2 CATS exchange rate, Integrated Master's degrees offer 240 ECTS = 480 CATS credits: four academic years at 60 ECTS or 120 CATS each. (The obvious amendments need to be made to describe the situation in Scotland.) As would be expected, this is 60 ECTS (120 CATS) above the minimum required for a First Cycle qualification. This is insufficient to merit a *separate* Second Cycle qualification on the basis of a typical value often quoted as 90 ECTS (180 CATS). However, there is a sound argument that the *integrated* nature of these courses implies that they should not be viewed as separate First and Second Cycle programmes – indeed, there is often no clear break-point between the two cycles in these courses – and on that basis the total number of credits is ample. Further, there are some documents which could be interpreted as indicating that 60 ECTS (120 CATS) is sufficient anyway. Arguments that the final academic year should be extended to a calendar year by teaching in the summer vacation (either before or after it) must be resisted. This would militate against research activity in departments that by their nature are research-intensive, and there would be no funding available to support the students. A smaller issue is to ensure that there should be at least 60 ECTS (120 CATS) of M-level material. This is fully accepted as necessary, commonly exists already and will be easy to implement if there are cases where it does not.

"Badging" of Integrated Master's degrees presents many problems unless a form of combined award is given so as to indicate that the recipient has achieved both a First Cycle and a Second Cycle qualification. This is best done by a dual award (such as BSc.MMath). Uniformity of practice between institutions is highly desirable.

Implications for postgraduate courses

For postgraduate courses (i.e. courses of MSc type), the usual UK practice is to offer a one-year programme containing 180 CATS credits with at least 120 at M-level. This is compliant with the Bologna Process where a Second Cycle qualification typically requires 90–120 ECTS credits with at least 60 at M-level – *unless* cognisance is taken of the apparent limitation of a full calendar year to only 75 ECTS credits. Clarification of this issue is urgently needed.

Funding the Second Cycle

Funding for students taking Master's level qualifications is problematic. For Integrated Master's courses, real difficulties now arise with the extra fees to be paid and loans needed for the additional year. For postgraduate courses, there is normally no funding available for students at all – and yet, from the students' perspective, these courses share many of the characteristics of First Cycle courses. Issues of ensuring a sufficient supply of well qualified graduates, and of fair access to courses, demand urgent consideration, and this must be at government level.

Impact on Doctoral Study

Finally, for those who will proceed to Doctorates, there is the key factor of the total length of time from leaving school to submission of the thesis. There is now a consensus that 8 years should be the norm in the mathematical sciences. This can be split in various ways: 4+4 as MMath + four years Doctoral studies; 3+1+4 as BSc + MSc + four years; and others. A different model of 3+2+3 (BSc + two-year MSc + three years Doctoral) seems likely in many european countries. This last model would be very damaging to the future of MMath courses and highly unattractive to UK students if they had to fund themselves for two years of an MSc course. The importance of proper funding structures is again evident. It is also important that some flexibility of approach to the organisation of Doctoral study be maintained.

The Council for the Mathematical Sciences

The Bologna Process and Master's Courses in the Mathematical Sciences

The working group was established by the Council for the Mathematical Sciences (CMS) in collaboration with the Heads of Departments of Mathematical Sciences in the UK (HoDoMS) to consider Master's Courses, primarily but not exclusively Integrated Master's Courses. The group prepared a briefing note in March 2006, intended for immediate circulation to university departments, to other science subject groups, and also as a background note for CMS officers meeting the Secretary of State for Education and Skills.

The replies of other groups, developments in some universities, and clarifications provided by the DfES in the wake of the Secretary of State's meeting with CMS, allowed the working group to develop its position and a further note was circulated in May 2006.

The present document is a fuller report giving more of the background and detailing the remaining issues which need to be addressed. It also makes short-term and longer term recommendations.

The members of the Working Group do not speak for their institutions; members of the group, however, came from most of the universities with large cohorts of students on MMath and similar programmes. Not all members were able to attend all meetings.

The members of the Working Group are:

Martin Bridson (Imperial)
H. Garth Dales (Leeds)
Kenneth Falconer (St Andrews)
Peter Giblin (Liverpool)
Gerald Goodall (RSS)
Jane Hutton (Warwick)
Tom Körner (Cambridge)
Alice Rogers (KCL)
David Salinger (Leeds)
Nigel Steele (IMA)
Brian Stewart (Oxford)

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The Bologna Process and Master's Courses in the Mathematical Sciences

1 Background

This report is about, firstly, Integrated Master's courses in the mathematical sciences[1] in the UK, that is, undergraduate courses (MMath, MMathStat, MSci etc.) which typically take one more academic year than those for Bachelor's degrees but are subject to the same funding arrangements. Secondly, the report considers Master's courses (see §8), that is, postgraduate courses (MSc etc.), which usually follow an undergraduate degree, are often in the UK one calendar year in duration, and are subject to different funding arrangements.

'Integrated masters' courses in the mathematical sciences were introduced in the mid-1990s, following the report [1] of a group chaired by Peter Neumann working under the auspices of the London Mathematical Society and published with the approval of the Councils of the Royal Statistical Society and the Institute of Mathematics and its Applications. The report does not use the phrase 'integrated masters' but refers to an 'integrated programme' over the last two years of the proposed degree—outside Scotland the third and fourth years. Among the reasons for change which the report identifies are the need for comparability of UK degrees with those in continental Europe, and the need to make the then existing Bachelor's degree accessible to a wider cohort of students. This leads naturally to the concept of a degree programme which covers more material, in a relatively broad way, than Bachelor's programmes, and which takes one more academic year to complete.

Another significant factor is the reduced level of mathematical experience, sophistication and fluency of those entering universities. This was evident in 1992 and remains so, though there are some promising signs, such as the revival of Further Mathematics through the government funded MEI initiative. The additional year after a Bachelor's degree is then seen as a bridge to research or to employment as a mathematician.

The Neumann report [1] also notes that Master's (e.g. MSc) programmes often provide a more specialized and focussed training than was envisaged in the new Integrated Master's degrees, and that this was a good reason why they should continue.

At the present time MMath and similar programmes are of 4 years (full-time) duration outside Scotland and 5 years in Scotland (see §6). Approximately 700 students graduate from them each year[2]. For those universities offering integrated masters degrees this represents about 20% of the total numbers graduating in mathematical sciences. Integrated

[1] As usual, this term has the connotation 'MSOR' or 'Mathematics, Statistics and Operational Research'. Theoretical or mathematical physics can also be included in this list for present purposes.

[2] For present purposes 70 of the Cambridge Tripos Part III total of 180 is included in this count. These are the students who take Part III as a fourth year after the Tripos Parts I and II.

Master's degrees are widely regarded within the mathematical community as performing a very useful function in preparing students for further study or for employment[3].

> (1A)[4] *In the absence of widespread funding for Master's degrees, Integrated Master's degrees greatly increase the number of students in the UK studying to a level beyond that of a Bachelor's degree. The loss of this well-qualified stream would undermine the national strategy adopted in response to the Roberts report 'SET for success'* [4].

The introduction of fees and now from 2006 top-up fees (outside Scotland) has changed the financial situation of undergraduates choosing between a Bachelor's and an Integrated Master's degree programme. If Integrated Master's degree registrations are not to fall significantly, students will need to be convinced that the extra year, with its attendant debt, will prove to be a good investment in improving their prospects for employment or further study. A direct entry from an Integrated Master's degree to a doctoral programme funded by a research council or other body has until now been a cheaper route than via separate Bachelor's and Master's programmes, but possibly this situation is changing. In any case the Integrated Master's route has to be one which meets international standards.

For direct entry to employment, especially outside the UK in other EU countries, it is important that the Integrated Master's degree should carry a weight beyond that of a Bachelor's degree. The normal, and entirely appropriate, route to the crucial profession of school-teaching is via a Bachelor's degree and PGCE; in these circumstances too an Integrated Master's degree should carry additional weight.

Bologna Declaration

The 'Bologna Declaration' is a Joint declaration of the European Ministers of Education convened in Bologna on the 19th of June 1999. It has 30 signatories[5]; however the European Higher Education Area (EHEA) has currently 45 signatory countries, and the Bologna Process—the name given to the follow-up actions of the Bologna Declaration—is a key tool within this Area. The original Declaration includes the following, in which ECTS stands for European Credit Transfer and Accumulation System; see §2 below.

> The action programme set out in the Declaration is based on a clearly defined common goal, a deadline and a set of specified objectives:
> • a clearly defined common goal: to create a European space for higher education in order to enhance the employability and mobility of citizens and to increase the

[3]However, there do not appear to be statistics which quantify the advantages of Integrated Master's over Bachelor's degrees in the job market.

[4]In §n, the displayed and italicized paragraphs (nA), (nB),... state the working group's position. The most important of these are restated in the Conclusions at the end of this report.

[5]Austria, Belgium (French community), Belgium (Flemish community), Bulgaria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, Swiss Confederation, United Kingdom.

international competitiveness of European higher education;

- a deadline: the European space for higher education should be completed in 2010;
- a set of specified objectives:

  – the adoption of a **common framework of readable and comparable degrees**, "also through the implementation of the Diploma Supplement"[6];

  – the introduction of **undergraduate and postgraduate levels in all countries**, with first degrees no shorter than 3 years and relevant to the labour market;

  – **ECTS-compatible credit systems** also covering lifelong learning activities;

  – a **European dimension in quality assurance**, with comparable criteria and methods;

  – the **elimination of remaining obstacles to the free mobility** of students (as well as trainees and graduates) and teachers (as well as researchers and higher education administrators).

The Bologna Process[7] uses the terms 'First Cycle', 'Second Cycle' and 'Third Cycle' to describe Bachelor's, Master's and Doctoral level qualifications, respectively. Since 1999 there have been several meetings of Ministers. The most recent was in Bergen in 2005, and the communiqué from this meeting includes the statement:

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

The 'credit ranges' referred to here are ECTS credits (§2). The next meeting of Ministers is due to take place in London in 2007.

If student mobility between universities in different european countries is to be a reality then First and Second Cycle qualifications gained in the UK need to be accepted elsewhere as appropriate preparation for a doctorate. Quite apart from considerations of credit levels and length of study, it is true that academic traditions are somewhat different in the UK from those in most other european countries. In a report to the Institute of Physics [5, p. 13], referring to the situation in Physics, the author notes that 'in the UK realistic problem solving, practical skills and applications are probably developed better whereas, in the rest of Europe, the theoretical foundations and advanced theoretical methods are developed better.' The same is generally true of mathematical sciences. It is worth noting that the UK has been on the whole more successful in maintaining the numbers

[6]This refers to a note attached to a diploma, explaining the diploma in a way that should be understandable by all employers and HE institutions and written in a widely understood EU language.

[7]A useful summary is given in the Introduction to the Universities UK Europe Note [15], November 2005. There is also a dedicated DfES webpage [18].

of students entering university to study mathematics than have other european countries: numbers have declined relative to the whole university cohort, but not as dramatically as elsewhere.

In principle the difference in academic traditions should not be a bar to mobility but it is something that universities in the UK and abroad have to take into account. This applies not only to students proposing to study to the next higher level, but also to students who spend a year of their Bachelor's programme in an EU country.

2 The European Credit Transfer System (ECTS)

Credits

A good general guide to ECTS is the *Users' Guide* [9], produced by the European Commission and dated 17 August 2004; however the ECTS system is still under negotiation and the EC Guide is currently being revised. According to the EC Guide:

(2.1) (p.4) 60 ECTS credits measure the workload of a full-time student during one academic year.

(2.2) (p.4) The student workload is 1500-1800 hours per academic year.

(2.3) (p.6) 52 weeks of full-time study with no holidays would give 75 ECTS credits.

From (2.1) and (2.2), it follows that one ECTS credit stands for 25-30 working hours and, at 40 hours per week, one academic year is 37.5 to 45 weeks. Note that (2.3) is compatible with this since, using 27.5 hours per credit, 52 weeks at 40 hours per week works out at 75.6 credits.

The EC Guide also contains the following:

(2.4) (p. 44, Glossary) FIRST DEGREE: A first cycle qualification, as defined by the Bologna Declaration, normally awarded after successful completion of a minimum of three years or 180 ECTS credits is designated a first degree.

The Guide does not specify numbers of ECTS credits for a second cycle (Master's) degree. However, according to the UUK Guide to Bologna: [12, p.15]

(2.5) The Bologna Process seminar on Master'-level Degrees in Helsinki, Finland, in 2003 recommended that there should continue to be flexibility in the definition of second-cycle/Master's programmes and that these should be defined in ECTS terms as programmes from 60 ECTS credits to 120 (i.e. one academic year to two academic years).

(2.6) Those UK institutions which are currently using ECTS for their Master's Programmes and which have Master's lasting for one calendar year or, in some cases, slightly longer, tend to use 90 ECTS credits.

There is clearly a problem if (2.6) is compared with (2.3). In addition, the range 60–120 ECTS in (2.5) does not agree with the next quotation. At the Bergen meeting in May 2005, according to the UUK Europe Note [15, §4]:

(2.7) Ministers adopted the proposal for the overarching Framework for Qualifications of the European Higher Education Area. This comprises three cycles (Bachelor's, Master's and Doctoral levels) and generic qualifications descriptors for each cycle (the so-called 'Dublin Descriptors'[8]) which will act as reference points for the HE qualifications of the signatory countries. *Typical* ECTS credit allocations associated with the end of the first and second cycles are included in the Framework as follows:

- First Cycle – typically 180–240 ECTS credits
- Second Cycle – typically 90–120 ECTS credits, "with a minimum of 60 credits at the level of the 2nd cycle"
- No typical credit allocations were included for the third cycle.

In the 2005 *Framework for Qualifications* [13, p. 72] essentially the same is found:

(2.8) First cycle qualifications may typically include / be represented by 180–240 ECTS credits;

Second cycle qualifications may typically include / be represented by 90–120 ECTS credits—the minimum requirement should amount to 60 ECTS credits at second cycle level.

The 'minimum requirement' in the last sentence could possibly be interpreted as meaning that 60 ECTS at second cycle level is sufficient in itself for a second cycle qualification; perhaps that is what (2.5) is referring to.

Another document which mentions 60 ECTS as the minimum for Second Cycle qualifications is *Tuning* [14, p. 49]; however elsewhere in this document (p. 116) it is suggested that, in view of the requirement for a thesis or dissertation, 90 to 120 ECTS is the more appropriate range.

(2A) *If the interpretation with a minimum of 60 ECTS for Second Cycle qualifications is not accepted outside the UK then inevitably Integrated Master's programmes, as now constituted, will lose credibility in other EU countries.*

Learning outcomes

It is also important to note that the *Framework* for the European Higher Education Area [13] makes many references to **learning outcomes**:

[8] See (2.11) below for the Second Cycle descriptors.

(2.9) (p. 13) The conclusions of the Berlin conference (September 2003) of the ministers in charge of higher education included:

Degree structure: 'Ministers encourage the member states to elaborate a framework of comparable and compatible qualifications for their higher education systems, which should seek to describe qualifications in terms of workload, level, learning outcomes, competences and profile.'

(2.10) There are also strong links between credit and learning outcomes in the *Framework* [13, pp. 29, 44, 46]:

Learning outcomes: statements of what a learner is expected to know, understand and/or be able to do at the end of a period of learning.

Credit: a quantified means of expressing the volume of learning based on the achievement of learning outcomes and their associated workloads.

A credit framework is a way of valuing, measuring, describing and comparing learning achievement, and credits themselves are a quantified means of expressing the volume of learning based on the achievement of learning outcomes and their associated workload.

Workload is defined for this paper as: a quantitative measure of all learning activities that may feasibly be required for the achievement of the learning outcomes (e.g. lectures, seminars, practical work, private study, information retrieval, research, examinations).

Although the link between notional workload, measured in hours, and the achievement of learning outcomes cannot be made precise, these quotations do emphasize that, in the context of the Bologna Process, the link is regarded as a very strong one.

The Learning Outcomes appropriate to Second Cycle degrees, as defined in the Dublin Descriptors [7] and quoted in the *Framework* [13, pp. 66 ff. or Appendix 8] are as follows[9]

(2.11) Qualifications that signify completion of the second cycle are awarded to students who:

(i) have demonstrated knowledge and understanding that is founded upon and extends and/or enhances that typically associated with the first cycle, and that provides a basis or opportunity for originality in developing and/or applying ideas, often within a research[10] context;

(ii) can apply their knowledge and understanding, and problem solving abilities in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their field of study;

[9]These are somewhat less demanding than the corresponding statements by the Quality Assurance Agency in the UK
www.qaa.ac.uk/academicinfrastructure/FHEQ/EWNI/default.asp#annex1
some of which do not appear to apply easily to mathematics, especially pure mathematics.

[10]'research' is to be understood in a broad sense: 'the term is used here to represent a careful study or investigation based on a systematic understanding and critical awareness of knowledge.'

(iii) have the ability to integrate knowledge and handle complexity, and formulate judgements with incomplete or limited information, but that include reflecting on social and ethical responsibilities linked to the application of their knowledge and judgements;

(iv) can communicate their conclusions, and the knowledge and rationale underpinning these, to specialist and non-specialist audiences clearly and unambiguously;

(v) have the learning skills to allow them to continue to study in a manner that may be largely self-directed or autonomous.

(2B) *These learning outcomes are broadly in line with Integrated Master's and Master's programmes, bearing in mind the broad interpretation of the word 'research'.*

Thus (i) should be satisfied by a demanding project in the final year; (ii) would normally mean that a broad range of subjects will be studied, which in some cases will be multidisciplinary (such as statistics applied to medicine, or advanced mathematical methods applied to practical problems in engineering); the last part of (iii) seems not to be generally relevant to mathematics (except perhaps statistics), while the first part would apply to statistics and to certain areas of applied mathematics, but rarely to pure mathematics at this level; (iv) should be satisfied by the inclusion of one or more presentations within the structure of the programme; and (v) is something which students at this level should be developing, particularly through extended project work.

Conversion courses at Master's level may have more problems satisfying the criteria above unless they proceed at a rapid pace towards advanced material.

An important development is the Proposal [19] for a *Qualifications Framework covering European Union countries* (EQF)—note that the EU is much smaller than the European Higher Education Area, the subject of the Framework [13] quoted above[11]. In [19] there is no mention of working hours or numbers of credits; the criteria for the different cycles are based on learning outcomes only.

(2.12) (p.10) The description of the 8 EQF reference levels[12] is based on learning outcomes—in the EQF understood as the statements of what a learner knows, understands and is able to do on completion of a learning process. This reflects an important shift in the way education, training and learning is conceptualised and described. The shift to learning outcomes introduces a common language making it possible to compare qualifications according to their content and profile and not according to methods and processes of delivery. In the EQF learning outcomes are defined by a combination of knowledge, skills and competence.

[11]It should also be noted that the EQF covers not only Higher Education but also Vocational and Technical Education (Further Education).

[12]Levels 6, 7 and 8 represent First, Second and Third Cycles respectively.

The learning outcomes envisaged by the Proposal [19] are somewhat more stringent than those in the Dublin Descriptors quoted in (2.11) above; they resemble more the QAA descriptors. For instance, at Level 7 (Master's level, Second Cycle) under the 'Knowledge' which students qualifying at this level are expected to attain, [19, p. 19] reads:

(2.13) highly specialised knowledge, some of which is at the forefront of knowledge in a field of work or study, as the basis for original thinking.

(2C) *In some areas of mathematical sciences this could be an unrealistic expectation at M level, where knowledge attained is more commonly described as being 'informed by' the forefront of knowledge than 'at' the forefront.*

The Proposal [19] recommends that member states in the EU 'use the EQF as a reference tool to compare qualification levels of different qualifications systems', 'designating a national centre to support and coordinate the relationship between the national qualifications system and the EQF'.

(2D) *In the UK this national centre would need to draw together the experience of a number of bodies with responsibilities for qualifications in Further Education and Vocational Education and Training and ensure that the experience, expertise and interests of the HE sector are also adequately represented.*

The Proposal also endorses the Commission's intention to 'establish a European Qualifications Framework advisory group (including representatives of the national centres, the European social partners and other stakeholders, as appropriate) in order to monitor, co-ordinate and to ensure the quality and overall coherence of the process of relating qualifications systems to the European Qualifications Framework'.

3 The Credit Accumulation and Transfer Scheme (CATS)

The CATS scheme is widely adopted in the UK for measuring credit. The version called NICATS (Northern Ireland CATS) is described as follows on their webpage http://nicats.ac.uk/mainindex.html:

(3.1) At present NICATS is a credit system developed for Northern Ireland by a consortium of providers in further and higher education. Its primary purpose is to establish a workable system for recognising and comparing learning achievement within Northern Ireland. The system used is, however, identical to that proposed by the various consortia of higher education institutions operating throughout the UK. In this way it is fully readable and transferable within the UK system.

In the 2001 report [3][13] the following appear (pages 6, 11 and 13).

(3.2) Credit provides a means of quantifying learning achievements, achievable in notional learning hours at a given level. One credit equates to 10 notional hours of successful learning activity. Notwithstanding the link between credit and notional learning time, the emphasis of assessment should be upon learning achieved and not time served. Credit is awarded for the achievement of specified learning outcomes. No additional credit can be awarded for achievement above the threshold level (although such achievement can be recognised through the award of marks or grades).

Note that, if 1 CATS credit requires 10 notional working hours and, from (2.1–2), 1 ECTS credit requires 25–30 working hours, then the conversion rate is 1 ECTS = 2.5 to 3 CATS. This is in conflict with a conversion rate of 1 ECTS = 2 CATS required by the next statement.

(3.3) An academic year is reckoned as 120 CATS credits and

- an Honours degree requires a minimum of 360 CATS credits (at least 90 at 'Honours' level and at most 30 at 'pre-University' level);
- a Master's degree requires a minimum of 180 (with at least 150 at Master's ('M') level and at most 30 at 'Honours degree' level) ;
- an Integrated Master's degree requires a minimum of 480 (with at least 120 at M level and at most 30 at 'pre-University' level).

The following statement (p. 12), justifies the choice of 120 CATS credits at M level for Integrated Master's:

(3.4) The Scottish framework requires that at least 120 credits must be achieved at M Level [Level 7] with the consequence that the entire final year of the undergraduate programme is pitched at M Level. It is recommended that England, Wales and Northern Ireland should adopt the same position as Scotland. Some have argued that the Integrated Master's Degree should be given the same credit value [minimum 150 credits at Level 7] as the other Master's Degrees, while others have pressed for a lower credit value [just 90 credits needed at Level 7]. Increasing the credits needed at Level 7 would have serious implications for the programme designers. Reducing the credits needed at Level 7 to 90 would raise doubt that the award satisfies the QAA criterion of substantial achievement at M Level.

Another important source of information on credit is the 2004 Burgess Report [10], and also the 2006 Consultation [16]. Two of the recommendations from the 2004 report are:

[13] prepared jointly by the 'England, Wales and Northern Ireland (EWNI) Credit Bodies', namely CQFW (Credits and Qualifications Framework for Wales Project), NICATS, NUCCAT (Northern Universities Consortium for Credit Accumulation and Transfer) and SEEC (Southern England Consortium for Credit Accumulation and Transfer). SEEC, for example, states that its members include over 25% of HEFCE funded universities and colleges. The Scottish scheme SCQF (Scottish Credit and Qualifications Framework) is mentioned in (3.4) below.

(3.5) Recommendation 11: following agreement on a credit system, a concerted effort should be made to achieve a more consistent and widespread use of credit in higher education. The developments should take into account current developments in Wales, Northern Ireland, Scotland and in further education in England

Recommendation 12: the sector should closely monitor and engage with the development of the European Credit Transfer System (ECTS) as the common European credit system.

The Consultation [16] contains the statement and recommendation (p. 10):

(3.6) UK credit practice has converged on the use of 120 [CATS] credits to represent the equivalent of a year of full-time equivalent study (typically over 8 to 9 calendar months), with 180 credits for the typical postgraduate full-time equivalent year, reflecting the additional weeks of study in such programmes. By contrast the European Credit Transfer and Accumulation System (ECTS) uses 60 credits per full-time equivalent undergraduate year and (there are proposals for) 75 credits for the longer postgraduate study year.

Recommendation 4: that a normal full-time year of undergraduate study is represented by 120 [CATS] credits, and a full-time postgraduate year by 180 [CATS] credits.

This is to be compared with (2.3) which states that 75 ECTS credits is a full calendar year without holidays. As noted in §2, however, the ECTS system is currently under discussion. The Consultation [16, p. 17] also contains the recommendation (Table 1, p. 17):

(3.7) An Integrated Master's Degree should normally be 480 CATS credits with normally 120 at M level.

4 Summary of credits and learning outcomes

(4.1) (See §2.) In documentation on ECTS, an academic year is reckoned as 60 ECTS credits and about 37.5 to 45 weeks, with Second Cycle (Master's) qualifications being typically 90–120 ECTS credits with a minimum of 60 at M level. The maximum ECTS credits obtainable in a 12 month period is 75.

(4.2) (See §3.) In documentation on CATS, an academic year is reckoned as 120 CATS credits and about 30 weeks, with Second Cycle qualifications being typically 180 CATS credits for calendar year Master's programmes. For Integrated Master's degrees a total of 480 CATS including a full academic year (120 CATS) of M level work recommended.

In guidance issued by Universities UK [15, §6], it is stated that '90–120 ECTS credits is generally accredited to 180–240 credits as defined in UK HE'. In terms of the academic

year this is indeed the case, a factor of 2 converting 60 ECTS to 120 CATS. But it is clear from the above that there are still discrepancies in regard to working hours and the length of the academic year. It is also frequently stated that the UK's position is strongly in favour of an emphasis on *learning outcomes* as a measure of academic achievement. For example a letter[14] from Keith Andrews at the DfES addressed to the secretariat of the Council for Mathematical Sciences on 7 April 2006 states: 'We have consistently argued in the context of the Bologna declaration for an approach to qualifications frameworks based on learning outcomes, rather than on course input hours or duration.' However learning outcomes and ECTS credit allocations are also closely linked; see (2.10) above.

Learning outcomes for Second Cycle (Master's) degrees, as defined in the Dublin Descriptors, are given in (2.11).

> (4A) *The Working Group believes that both Master's and Integrated Master's, as currently delivered, broadly meet the learning outcomes as listed in the Dublin Descriptors. However, there is a lack of clarity in the conversion between ECTS credits and CATS credits, in working hours and in the length of the academic year. It is important to ensure that it remains possible for graduates to move easily to other institutions for further study, and that employers have a clear idea what to expect of a graduate from an Integrated Master's course. To avoid confusion, then, no matter how the process develops, Integrated Master's degree courses in mathematical sciences must remain aligned across the sector, particularly those courses in which the majority of the cohort is enrolled.*

5 Integrated Master's outside Scotland

Integrated Master's programmes in mathematical sciences are commonly called MMath or MSci or MMathStat[15], although Part III at Cambridge has features in common with Integrated Master's and part of its cohort—those who stay on at Cambridge for a fourth year after Parts I and II of the Tripos—can be included under the same umbrella term. The current situation outside Scotland is that these programmes normally take four years to complete, regarded as '2 + 2' in the sense that the first two years are common to Integrated Master's and Bachelor's programmes and the last two years are, in the sense envisaged in the 1992 report [1], an integrated programme. Some universities, especially those with relatively small numbers for Integrated Master's, spread the M level material over these last two years, and indeed allow very well qualified final year Bachelor's students to take a limited amount of M level material in their final year.

The issues are the following, adopting for the current purpose the exchange rate 1 ECTS = 2 CATS, noting as in §4 that there is some doubt as to its validity.

[14]This letter followed a meeting between the three presidents of the CMS societies and the then Secretary of State for Education and Skills, on 28 March 2006.

[15]But there are a number of variants such as MMORSE and indeed MMathPhys programmes can be primarily mathematical or theoretical physics.

(5.1) The Integrated Master's does not fall exactly into the category of First Cycle or Second Cycle qualification; at the end of four years a student will have achieved a First Cycle (Bachelor's) qualification and an additional academic year's study. However, the last two years have an integrated structure; indeed there may be no clear point at which the First Cycle ends and the Second Cycle begins.

(5.2) In terms of credits the total is 240 ECTS = 480 CATS, which is 60 ECTS = 120 CATS above the minimum (see (2.4), (2.7)) for a First Cycle degree. According to this, the additional credit may be insufficient to merit a Second Cycle qualification, the typical value for which is 90 ECTS = 180 CATS (see (2.7)), although some documents appear to suggest that 60 ECTS = 120 CATS is sufficient; compare (2.8).

(5.3) A more minor issue is the amount of credit at M level. A full academic year (60 ECTS = 120 CATS) is proposed (see (3.3)) and has been accepted in the UUK Europe Note [15, p. 3]. This only becomes an issue if all the M level credits must be delivered in the final year. If M level credits may be delivered during the final two integrated years, as is often the case now, it would require a minor change or, in some institutions, none at all.

The 2005 UUK Europe Note [15, §6] makes the following proposal:

(5.4) HEIs are urged to consider teaching during the summer vacation, extending the timescale for submission of the dissertation and incorporating industrial placements with assessed learning outcomes into such programmes. While these measures would clearly have implications for HEI resources and administration, the credit rating of such activity would bring the duration of such qualifications closer in line with continental equivalents and so facilitate their acceptance in the EHEA.

(5A) *In the opinion of the Working Group providing additional Integrated Master's credits during the summer vacation is not a practicable option for the mathematical sciences without significant additional funding both for students and for university departments.*

Those departments offering Integrated Master's degrees are very research-active, and on average 20% of each year's cohort is studying for this degree. Indeed, in order to maintain a good and up-to-date Master's level programme, a department needs to be strong and reasonably diversified in research terms. A diversion of resources from research to teaching on the scale needed to supervise additional work during the summer would be very difficult to justify.

The reaction of universities offering Integrated Master's degrees to the problems presented by (5.1) and (5.2) has been a strong defence of the degrees as they exist currently. It is generally accepted that the requirement for 120 CATS credits at M level (5.3) can be implemented relatively easily. The defence of existing degrees has been made on a number of grounds. The following points are summarized from a robust defence put forward by

the University of Warwick and from the UUK Europe Note [15, §7]; wording has been changed to reflect the different terminology of the current report.

(5.5) (a) The Integrated Master's degrees fit the UK Treasury strategy for the supply of highly qualified science and mathematics graduates [8]. The EU Lisbon Agenda [2] also emphasizes the importance of science and mathematics graduates, as does the G8 Summit Declaration of July 2006 [17]: 'We will strive for high standards in particular in mathematics, science, and technology to provide strong foundational elements for the global innovation society.'

(b) Integrated Master's programmes are demanding qualifications meeting exacting output standards. They are integrated degrees allowing rapid progression to Master's level. They are not Bachelor's programmes with a 'bolt on' Master's programme. Furthermore, the entry to the programmes is very selective even within the UK. The Universities which offer integrated Master's are strongly research-led universities, and then entry is normally limited to students who achieve an upper second class at the end of their second year. (This is often a more stringent requirement than entry to MSc or similar programmes, which can allow weaker students to improve their qualifications.) Because the last two years are integrated there is no lead-in time to the fourth year and students start this year with a common grounding. The work of the Burgess Committee supports a 480 CATS Integrated Master's degree. [See (3.7).]

(c) Integrated Master's degrees in Mathematical Sciences are part of a large family of similar degrees in Chemistry, Engineering, Physics etc. which have proved their worth. Their graduates are in high demand.

(d) The Berlin meeting on the Bologna Process explicitly recognises that Bachelor's and Master's programmes should be described on the basis of content and quality of learning outcomes [see (2.9)], and this is echoed in the UUK briefing note [15, §7]: '... learning outcomes are the most important measure of a study programme rather than a crude measure of duration.' The learning outcomes of integrated Master's programmes are consistent with the generic qualification descriptor for second cycle (Master's level) in the Bologna Process Framework for Qualifications of the EHEA. [See (2.11).]

(e) Science departments admit students with Integrated Master's degrees as PhD research students: in fact, an integrated Master's degree has become a standard route to a PhD.

Many of the major providers of Integrated Master's and similar degrees in mathematical sciences in the UK, having considered the matter, are not proposing to make any significant changes in their regulations, apart from, where necessary, implementing the 120 CATS credits at M level rule (see (3.3), (3.7)). Some universities have taken special steps: for example Imperial College has formed a 'cluster' of a dozen universities throughout Europe for mutual recognition of degrees for progression from Bachelor's to Master's to Doctoral studies.

Providers of Integrated Master's degrees need to be aware of possible resource implications arising from the necessity of having at least 120 CATS credits of M level material. This material can be divided between Years 3 and 4, though providers need to be ready to defend the practice of allowing students to take some M level material after only two years of study.

6 Integrated Master's in Scotland

In Scotland, an Integrated Master's degree normally takes 5 years from leaving school, though very well-qualified entrants can gain entry directly into the second year—an 'accelerated' degree programme—thus taking 4 years over the degree with 'advanced standing credits' as allowed by the SQA for students with qualifications above Scottish Highers. (In some Scottish universities nearly all students take the accelerated programme.) The number of CATS credits is 120 per year[16], so a 5 year programme will accumulate 600 CATS credits, and 120 of these are at M level (compare (3.4)).

Provided the 600 CATS credits are converted to 300 ECTS credits and 270 of these are allowed at degree level, this meets the minimum requirements (2.7) of 180 ECTS credits for a First Cycle and 90 ECTS credits for a Second Cycle qualification, with 60 ECTS credits at M level. The situation for students on an accelerated programme needs to be clarified.

Another significant factor in Scotland is the absence, at present, of top-up fees for students from Scotland and from EU countries outside the UK. This means that these students choosing between Bachelor's and Integrated Master's degrees will be influenced to a lesser extent by financial considerations than students in England, Wales and Northern Ireland.

7 Badging of the degree

The Integrated Master's degree combines First Cycle and Second Cycle qualifications. This raises a problem: if, for example, a student is awarded an MMath—a Master's level qualification—after four years[17], then to outward appearance the student does not have a First Cycle qualification, that is a Bachelor's degree. The Diploma Supplement should clarify the situation, once it is introduced throughout the HE sector, but the matter has been taken up for example in the UUK Europe Note [15, §6], and some universities in the UK have also been considering the question of re-badging. It is likely that the question of correct badging will be discussed in detail by the Burgess Committee following the consultation [16].

[16]In the past some students have taken 180 CATS credits in each of the final two years of a 4 year programme for an MMath, thus accumulating 600 credits in 4 years.

[17]For simplicity, the number of years is based on degrees outside Scotland.

A second problem is that, for funding purposes, Integrated Master's degrees are *undergraduate* degrees; indeed they are sometimes called 'Undergraduate Master's' degrees. This terminology is very unfortunate in the context of the First and Second Cycle qualifications. It is suggested in [15, §6] that the term should be dropped and 'Integrated Master's' used exclusively.

A third problem is that, if a Bachelor's degree is awarded after three years of study, the student then becomes a graduate, and the funding mechanism changes: the student will no longer be eligible for a student loan or undergraduate bursary to cover the fourth year.

One solution that has been proposed is to award a single degree, say BSc.MMath, after four years, to reflect the fact that the student has achieved both First and Second Cycle qualifications. Another is to award *both* degrees after four years: BSc, MMath.

For the 'dual award' single degree such as BSc.MMath, one class would be awarded, based as now on the student's work over the final three years, or in some cases the whole four years, of study. This designation reflects the integrated nature of the qualification: the First and Second Cycle elements cannot be separated.

For the award of two separate degrees, such as BSc, MMath, it is necessary to decide whether separate classes should be awarded for the two components, for example BSc Class 1, MMath Class 2.1, or whether the two degrees should automatically be given the same classification. There are clearly associated problems connected with failure in Year 4, fortunately a rare phenomenon since there are fairly stringent requirements for entry into the final two years of the integrated degree.

It is normal practice in UK universities to allow a student to graduate with a Bachelor's degree on the basis of the first three years of an Integrated Master's degree, should the student choose to withdraw from the programme at the end of the third year or during the fourth year. The class of degree would then normally be determined in the same way as for a Bachelor's degree candidate, though depending on the timing of the withdrawal the student may be too late to graduate with that year's cohort of Bachelor's degree students. The integrated nature of the final two years normally means that there is no formal requirement for admission to the fourth year, though the very occasional student who is unlikely to benefit from a fourth year can be encouraged to 'cash in' their Bachelor's degree after three years.

> (7A) *Uniformity in the badging of degrees amongst universities offering Integrated Master's programmes is desirable to prevent further confusion as to the exact meaning of the degree. In order to award both First and Second Cycle degrees, indicating that the recipient has achieved both these levels, a combined award is needed. The dual award better reflects the integrated nature of the degree.*

8 Master's degrees

Most Master's programmes in mathematical sciences in the UK are of one calendar year's duration, with a total of 180 CATS credits, at least 60 of which are awarded for a final dissertation written as the last element of the programme. If we accept the exchange rate 2 CATS credits = 1 ECTS credit, then the 180 CATS credits does bring such a programme within the range of Second Cycle degrees (see (2.8)) provided at least 120 CATS credits are at M level. In the UK, approximately 1100 students are awarded Master's degrees which are predominantly MSOR each year[18].

(8A) *This is indeed a welcome indication that Master's programmes in the UK are in principle compliant with the Bologna Process.*

However, as noted above in §2, there are anomalies in the conversion of ECTS into CATS, and according to (2.3) it is not possible to fit 90 ECTS credits into one calendar year. In the view of the Working Group an MSc or similar programme which was spread over two academic years, or more than one calendar year, is likely to be a very unpopular option with UK students. In continental Europe many Master's degrees are of 2 years duration, though there is an emerging trend of 1 year Master's.

On the other hand it is clear that Master's degrees perform a vital function, as a preparation both for research and for employment. The latter is particularly true of the many successful Master's degrees in Statistics, Operational Research and related disciplines.

The DfES, via HEFCE, is responsible for funding of undergraduate degrees, including Integrated Master's degrees, and the DTI, via the Office of Science and Technology and the Research Councils, is responsible for funding of the majority of doctoral degrees. The position of Master's programmes is unclear: many are self-funded, while some have Research Council or other support. Master's courses in mathematics (and probably all the sciences) share many of the characteristics of the First Cycle, and most of their graduates proceed directly to employment; for funding purposes they should be regarded as pre-research. This strongly suggests that the DfES is the appropriate funding body.

(8B) *It is the opinion of the Working Group that, in the short term, Master's degrees should continue as now. However, it is essential that the mechanisms for funding Second Cycle degrees are reviewed at government level: funding issues raised by the need for conformity with the Bologna Process have to be resolved. Until a proper funding regime for the Second Cycle is put in place, there will undoubtedly be an increase in the number of students who cannot find a reasonable pathway to a Second Cycle qualification in mathematics. Important issues of fairness and fair access require the funding structures to be put in place as soon as possible. Furthermore, as for Integrated Master's degrees, the relationship between credits, learning outcomes and study time must be clarified.*

[18]For present purposes, 110 of the Cambridge Tripos Part III total of 180 is included in this figure: these are students who take Part III having obtained a Bachelor's degree elsewhere.

The likely effect of top-up fees on Integrated Master's degrees has been mentioned in §1. It is possible that, in the new situation, calendar year Master's degrees may prove competitive with Integrated Master's degrees. Work needs to be done on the comparative costing, using commercial loans as opposed to undergraduate loans through the Student Loans Company.

> (8C) *Indeed it is possible that the long-term future of Second Cycle degrees in the UK lies more with Master's degrees, but, as above, this should be accompanied by a carefully thought out government funding package. In the current climate where science and technology, including mathematical sciences, are at the forefront of the UK government's agenda, every student who can benefit from Second Cycle education should have access to it.*

9 Cognate disciplines

Engineering One important way in which engineering differs from mathematical sciences, other than statistics, is the greater use of accreditation by professional bodies. This is likely to put more constraints on the MEng than exist, in general, for Integrated Master's degrees such as MMath. (There may be some accreditation considerations for MMathStat degrees.) Another difference is the greater use of work experience, which can be used to supply additional credits, if this is felt to be necessary. Work experience, or additional project work in the vacation between years 3 and 4, or major project work assigned after Easter in Year 3 and delivered early in Year 4, have been suggested as a possible option. There is a potential difficulty in assigning compulsory work during the summer vacation, even if this is work experience and an official part of the degree programme.

Physics The Institute of Physics published a discussion paper [5] in 2003 and has set up a working group on the Bologna Process. The paper [5] makes many of the points which are also made above, including the following (p. 12):

> The situation for the four-year integrated Master's degrees, MSci, MPhys, MEng, etc. is still unclear. They have the advantages of integration and coherence over separate Bachelor's and Master's and are also more efficient because the gap between the end of the Bachelor's and the start of the Master's, particularly if there is a change of institution, is wasteful. However, steps should be taken to ensure that there are at least 60 ECTS credits at genuine Master's level and also that some Master's level work starts before the fourth year. More may be needed. Strong student selection at input is definitely a helpful feature as this enables faster progress to higher levels but this may not be valid for all universities. The issue is still unresolved but some modification to existing programmes will probably be required. The greatest danger would come from an undermining of the UK position by MSci, MPhys programmes which manifestly do not reach Master's level.

Chemistry The website [6] contains links to documents issued by the Royal Society of Chemistry. The current position, as the working group understands it, is that the RSC has initiated a revision of the QAA benchmark for Bachelor's degrees and has submitted to the QAA a draft M level benchmark, based on the Dublin Descriptors (see (2.11)), the purpose of which is to defend the MChem degree. The chemistry community strongly supports the use of outcomes for measuring the level of degree programmes, and not hours of work. A move to a 3 year First Cycle and 2 year Second Cycle is under discussion. Note that most european Master's degrees are of two academic years duration.

10 Doctorates

Integrated Master's and Master's degrees are preparations for employment, but they also serve a crucial role in preparation for doctoral studies, Third Cycle in the language of the Bologna Process.

One key factor as regards Third Cycle degrees in the UK is the total length of study from leaving school to submission of a doctoral thesis. The International Review of Mathematics [11] noted the relatively short time taken in the UK (sometimes as little as 6 years) and the resulting high degree of specialization. The EPSRC is seeking to address the latter concern by funding (but not generously) collaborative provision using electronic and other means. Most doctoral programmes involve some 'coursework' whether formal or informal; this initiative may lead to an honest re-assessment of the place of taught courses in the first year of research training in mathematics. The courses offered in this way are likely to be at M level. As such they will in some cases be offered as part of Master's courses, or even Integrated Master's courses: this development may offer (for some students) a wider choice in their final year, and will certainly (for some departments) spread the costs.

As for the total length of studies from school to doctorate, there is a consensus in the mathematical sciences community that 8 years should be the norm. One way in which this can be split up is '$4 + 4$', with an Integrated Master's degree followed by four years of doctoral studies, which may well include some additional taught courses as indicated above. A variant of this would be, say, BSc.MMath over 4 years (see §7) followed by MSc.PhD over four more years. Alternatively, with a one year Master's degree, '$3 + 1 + 4$' would be appropriate.

On the other hand the european model in most countries is likely to be '$3 + 2 + 3$', with a three year Bachelor's degree, a two-year Master's degree, and a three year Doctoral degree. In the UK this would amount to abolition of the Integrated Master's degrees, expansion of Master's degrees to two years—resulting, almost certainly, in a substantial drop in the number of Master's students and a consequent drop in the number of Doctoral students—and a return to the three year doctorate. Without proper funding of Second Cycle qualifications such a move, for the UK, would be very damaging. The damage would not be limited to a decline in the production of Second and Third Cycle graduates: the viability of some mathematical sciences department would be called into question.

As a comparison from outside Europe, consider the University of California at Berkeley. There, graduate students attend courses and take examinations over about two years. Provided that they are successful in these examinations, they then begin work on their doctoral dissertation research (obtaining an MA along the way if they wish). If they have a full fellowship, which is rare, it may take them a further two years or so to obtain a PhD. However, most doctoral students serve as Teaching Assistants for a substantial part of their stay in Berkeley; this work requires up to 20 hours per week of their time during the terms. Consequently, the length of time taken to receive a PhD after passing the examinations is usually longer than two years. Indeed, the official estimate of the average overall time from the completion of a bachelor's degree to the completion of a PhD is 5.5 years. (The Department feels that some service as a Teaching Assistant is an important part of a student's training, and that such service is very helpful for students when they are seeking an academic position after receiving the PhD.)

11 Conclusions and Recommendations

The UK needs to play an active part in ensuring that the emerging interpretation of what Bologna requires does not damage the national interest by rendering some important current arrangements untenable. Integrated Master's degrees and Master's degrees are a proven and vital source of well qualified people, trained in mathematical sciences to a level substantially beyond that of the First Cycle. Both give an important exit point from education to employment as well as a foundation for further study. Master's degrees are particularly valuable for enhancing the qualifications of students already possessing Bachelor's degrees, and for converting from one discipline to another at an appropriately high level. However there is, for example, currently no funded provision for a student with a Bachelor's degree in mathematical sciences to upgrade this to a Master's degree in a specialized branch of the same subject.

Approximately 700 graduate from Integrated Master's programmes in mathematical sciences in the UK each year, and 1100 from Master's programmes which are predominantly MSOR; loss of either of these cohorts of graduates would significantly reduce the science base in the UK. Cooperation across the EU and the wider European Higher Education Area, including the Erasmus/Socrates scheme, is highly desirable, and indeed UK degrees need to be recognized throughout the world in employment and further study. The recommendations below are made in the context of an evolving Bologna process; some comments about the medium and longer term are made in the Additional Conclusions.

Recommendations

R.1 All Integrated Master's programmes in the UK should include 120 CATS credits of M level material, which can if necessary be split between Years 3 and 4 (Years 4 and 5 in Scotland). The final two years of the programme should remain as academic years, totalling 240 CATS credits, neither being extended to a calendar year.

R.2 Institutions should make a dual award (First and Second Cycles) at the end of four years (five years in Scotland), such as BSc.MMath, with a single classification. The

years of the degree programme on which this classification is based can vary between institutions, but must include the final two years. See §7.

R.3 One calendar year (full-time) 180 CATS credits Master's programmes should continue to operate as now, with a minimum of 120 CATS credits of M level material. Part-time programmes with the same number of credits should continue to be taken over a correspondingly longer period.

Additional Conclusions

AC.1 Integrated Master's degrees of (outside Scotland) 480 CATS credits of which 120 are at M level fall outside the *typical* credit range of Bologna First *plus* Second Cycle qualifications, which would (using 1 ECTS = 2 CATS as the conversion rate) require an additional 60 CATS credits, not necessarily at M level. Nevertheless there are good reasons, some of which are presented in §5, for arguing that the integrated nature of the degrees allows an award of both First and Second Cycle qualifications. We do not believe that in any case it is practicable to give Integrated Master's students an additional 60 CATS credits, for example by work during one of the vacations, without a proportionate increase in resources both for students and for universities.

AC.2 One year Master's programmes, normally 180 CATS, (and corresponding part time Master's programmes) do meet the minimum requirements for Second Cycle qualifications (assuming that the problem highlighted in §2 concerning the maximum number of credits in 12 months can be resolved), and it may be that in the medium and long term a move from Integrated Master's degrees to one year Master's degrees following a Bachelor's degree would be desirable. *But this is not to be contemplated without a change in funding and/or loan arrangements, allowing access to Second Cycle qualifications for everyone who can benefit from them.*

AC.3 We welcome the move on the part of EPSRC to extend the normal time for PhD studies to $3\frac{1}{2}$ years. We would support any further move to extend this to 4 years, possibly including an element of initial training or coursework. We believe that a total of 8 years (full-time) is normally the correct length of time in Higher Education from leaving school to obtaining a Doctoral (Third Cycle) degree. This could be spread as $4+4$ starting with an Integrated Master's degree, or $3+1+4$ starting with Bachelor's and Master's degrees.

AC.4 There remain serious discrepancies between different official documents relating to the credit systems, ECTS and CATS, and to working hours, as detailed in §2 and §3 and summarized in §4. Resolving these is an important task for the Bologna process itself, and has to be done at Government level.

AC.5 A move to learning outcomes as the primary measure of the level of a qualification, as envisaged in the European Qualifications Framework (EQF) [19] (see §2) is to be welcomed and will certainly help to resolve the discrepancies, but a close watch is needed on the appropriateness of the learning outcomes for mathematical sciences. Only the subject community is qualified to judge the appropriate level of learning outcomes in a particular discipline.

AC.6 Because they cover Vocational and Technical Education, as well as Higher Education, the learning outcomes for Second Cycle in the EQF differ from those in the Dublin Descriptors, which are currently adopted by the larger European Higher Education Area, as described in [13]. See (2.11). The Dublin Descriptors do broadly apply to existing Integrated Master's and Master's qualifications in the UK. Until the inconsistencies are resolved, the mathematical sciences community should take care that any statements of learning outcomes for Integrated Master's or Master's programmes cannot be confused with those of the EQF's first cycle descriptors.

AC.7 We welcome Erasmus/Socrates exchanges as being of great value, and encourage departments of mathematics to participate in these schemes, and to formulate their regulations to facilitate such exchanges.

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