BENCHMARKING STANDARDS

for

TAUGHT MASTERS DEGREES IN COMPUTING

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Foreword

A number of documents have been published to support the processes being employed to confirm the quality of educational provision in UK institutions of higher education. Noticeable among these have been the Qualifications Frameworks from the Higher Education Funding Council for England (HEFCE) and Scottish Funding Council (SFC), formerly the Scottish Higher Education Funding Council (SHEFC); these have identified criteria for a range of qualifications including honours degrees and Masters degrees. The benchmarking standards document for Computing published by the Quality Assurance Agency for Higher Education (QAA), produced originally in 2001 and revised in 2007, was another significant publication which provided greater guidance on the requirements for honours degrees in the general area of Computing.

Within the Computing community in the UK there has been a significant volume of activity at Masters level. There had been considerable demand for a document that would provide greater guidance (both to the community and to those engaged in the review process) on Masters degrees. In particular how can the complete spectrum of these courses be seen to fit with the Qualifications Frameworks?

In 2001 the Council of Professors and Heads of Computing in the UK took the initiative of setting up a Committee that would be charged with providing the necessary guidance. It seemed safer for the community to proceed with identifying benchmarked standards rather than have external reviews challenge the legitimacy of programmes offered at Masters level in individual institutions. Initial activity resulted in a draft document entitled *Towards Benchmarking Standards for Taught Masters Degrees in Computing*. This document, which addressed the requirements of Masters degrees in Computing, was used as the basis of discussion with institutions but also with the Quality Assurance Agency. A final agreed document was produced in April 2004.

The intention at that time was to create parity of esteem within Masters degree provision. It was intended that the term 'conversion degree' should pass into oblivion and be retired. In making this comment the intention was to provide an opportunity for institutions to review their Masters degrees to meet the requirements of the benchmarking statements. In its deliberations the Committee sought to avoid creating classifications of different kinds of Masters degrees; any classification could inhibit course innovation and development and in the rapidly changing context of computing that would be highly undesirable.

The 2004 document benefited from discussion and comment at a public meeting, which was held at Baden Powell House in London on 29th October 2003. This attracted some 80 participants from a wide variety of institutions. At the meeting a number of comments and observations were received; detailed reactions to the comments and a revised document were made available to the community for further scrutiny. The outcome was presented and agreed at the CPHC AGM that took place in Newcastle on 29th March 2004. Following consultation the 2004 document received formal support from the UK Academy for Information Systems (UKAIS).

Since 2004 and with encouragement from QAA, that document has been used within the community to underpin and guide the development of Masters courses. It has also been used by the British Computer Society in their accreditation activity involving Masters courses. This final document is an update of the earlier 2004 document. With the QAA now moving to formally approve Master provisions, it seemed timely to seek formal approval by QAA of these Computing proposals.

March, 2008

Section one The Background

Masters degrees are a feature of the provision of almost all Computing departments in UK universities. A considerable and varied range of possibilities has existed reflecting great activity and a great source of educational opportunity. Typically these are popular, serve a perceived need and provide a considerable source of revenue for their institutions.

1.1 Scope of Masters Degree Provision

Within this document the purpose is to define benchmarking standards for all taught Masters degrees in the discipline of Computing. This includes all full-time and part-time provision, degree programmes given exclusively in higher education institutions but also courses with industrial or other involvement all typically building on a first degree or equivalent. It also addresses MEng degrees in Computing. It does not address standards for Postgraduate Diploma or Postgraduate Certificate awards.

Computing can be described as the discipline associated with the structuring and the organisation of information as well as the automatic processing of that information. There is a rich set of aspects associated with this discipline, including (but not restricted to)

- theoretical considerations whose overall purpose is to ensure a sound logical basis for the discipline; complexity issues which address feasibility and efficiency concerns; as well as the formality which facilitates automation
- the concept of the algorithm, the techniques associated with software engineering and the concept of process
- distributed systems and pervasive computing including networks, the Internet and mobile computing systems
- concern for the human computer interface – seen to embrace matters such as multimedia, usability in its broadest sense, concern for users with disability in some form, and mobile computing
- information systems with its focus on problem identification and organisational issues and whose purpose is to address the integration of processes, people and technology in contributing to effectiveness and efficiency within organisations, e.g. by providing information access, modelling, control and decision making support; the ability to evaluate is crucial and has technical, societal and technology management acceptance dimensions.
- methods and techniques for information management and these are based around sound principles for updating and maintaining information
- computer engineering (which includes the design and development of computers to serve a range of different purposes and the special needs of diverse environments) as well as embedded and real time systems whose operation may have safety or security implications
- disciplines such as artificial intelligence and certain courses in linguistics, cognitive computing, etc
- systems concerns which recognise the need to take a holistic perspective in the development of computing systems
- professional, legal and ethical concerns

Essentially Computing is a technical discipline. It is challenging and creative involving the technical aspects of design and development of computer based systems or aspects thereof. This will typically involve understanding the underlying principles as well as principles of design and construction and being able to apply these in a variety of settings. The concept of process is fundamental, together with concerns for quality (in its many different interpretations) throughout the process. Masters

programmes will invariably choose to focus on particular aspects of Computing and / or its applications.

1.2 The Defining Principles of Computing

A study of Computing is typically characterised by

- knowledge and understanding of aspects of computer systems and their use
- a combination of theory and practice with practice being guided by theoretical considerations
- a strong emphasis on applications with usability being important
- the mastery of the practical methodology of the relevant area of Computing, whether for general application in software development or in specialised applications relating to the storing, processing and communication of information
- an understanding of and attention to the many and varied aspects of quality
- an understanding of professional, social and ethical issues related to Computing

1.3 On Conversion Degree Programmes

Prominent amongst the Masters degrees have been the so-called conversion programmes. These programmes came into prominence in the 1980s. With the demand for graduates to meet the employment demands of the time it was recognised that these one year long courses offered a relatively inexpensive and quick solution to the employment needs. Throughout the UK they have been heavily supported, and the students often found them challenging. In many institutions the number of students on such courses has been impressive and a considerable range of possibilities has existed.

Over the years some steps have been taken to address the issues of standards in Masters degrees generally. However, the more recent introduction by the Funding Councils of the concept of a Qualifications Framework has provided a challenge for many of these courses. In short, how can they be seen to fit with the stringent requirements of these frameworks?

1.4 Purpose of This Document

This document addresses the issue of benchmarking standards for the range of taught Masters degrees in Computing (including MSc, MEng, etc. degrees). It both defines standards (see section 5) and, without being prescriptive, provides elements of guidance and insights intended to be helpful and supportive to institutions (see sections 3 and 4). The publication of this document provides institutions with the opportunity to reflect on and to look closely at a range of degree programmes many of which might be re-focussed. Part of the challenge is to justify the view that all Masters degrees in Computing should be seen as equally prestigious.

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Section two The Context of Benchmarking

2.1 The National Qualifications Frameworks

Central to the Qualifications Frameworks are a set of levels that provide stages to higher levels of achievements and awards. An extract from the frameworks indicates that their purpose is:

- *to enable employers, schools, parents, prospective students and others to understand the achievements and attributes represented by the main qualification titles;*
- *to maintain international comparability of standards, especially in the European context, to ensure international competitiveness, and to facilitate student and graduate mobility;*
- *to assist learners to identify potential progression routes, particularly in the context of lifelong learning;*
- *to assist higher education institutions, their external examiners, and the Agency's reviewers, by providing important points of reference for setting and assessing standards*

There are two Qualifications Frameworks, one for England, Wales and Northern Ireland and the other for Scotland. In outline:

The Qualifications Framework for England, Wales and Northern Ireland

Central to this framework is a set of levels that represent different steps of attainment within higher education. Thus

1.	Certificate of Higher Education	level C
2.	Degree (non-honours)	Intermediate (I) level
3.	Bachelors degree with honours	H level
4.	Masters degree	M level
5.	Doctorate	D level

The Qualifications Framework for Scotland

The Scottish Credit and Qualifications Framework (SCQF) is, in some sense, more wide ranging than the previous one. It includes high school qualifications, from Standard grade through to Highers and Advanced Highers (roughly equivalent to A levels). But beyond this, and of most relevance to this study, there is (SHE denoting Scottish Higher Education):

SCQF level 7	Certificate of Higher Education	SHE level 1
SCQF level 8	Diploma of Higher Education	SHE level 2
SCQF level 9	Scottish Bachelors degree	SHE level 3
SCQF level 10	Scottish Bachelors degree with honours	SHE level 4
SCQF level 11	Masters degree	SHE level 5
SCQF level 12	Doctoral degree	SHE level 6

Within these frameworks there are certain stipulations about credits. For instance, 180 credits (at 10 hours of 'total learner effort' per 1 credit) are required for a Masters degree with at least 150 of these credits being at M level (Scottish SHE level 5).

Overview

In both the frameworks the requirements for honours degrees are similar and the requirements for Masters degrees are also similar. This happy state of affairs implies that the discussion that follows (and hence ultimately the comments on benchmarking) do not depend on which framework is applicable. Thus the rest of the discussion can be seen as independent of framework and hence of location within the UK.

2.2 Requirements of Masters Degrees

To avoid any possible ambiguity the following important extract is taken directly from the HEFCE Qualifications Framework; the requirements from the Scottish perspective are similar. It provides descriptors for a qualification at Masters (M) level:

Masters degrees are awarded to students who have demonstrated:

i) *a systematic understanding of knowledge, and a critical awareness of current problems and/or new insights, much of which is at, or informed by, the forefront of their academic discipline, field of study, or area of professional practice*

ii) *a comprehensive understanding of techniques applicable to their own research or advanced scholarship*

iii) *originality in the application of knowledge, together with a practical understanding of how established techniques of research and enquiry are used to create and interpret knowledge in the discipline*

iv) *conceptual understanding that enables the student*

- *to evaluate critically current research and advanced scholarship in the discipline; and*
- *to evaluate methodologies and develop critiques of them and, where appropriate, to propose new hypotheses*

Typically holders of the qualifications will be able to:

a) *deal with complex issues both systematically and creatively, make sound judgements in the absence of complete data, and communicate their conclusions clearly to specialists and non-specialists audiences;*

b) *demonstrate self-direction and originality in tackling and solving problems, and act autonomously in planning and implementing tasks at a professional or equivalent level;*

c) *continue to advance their knowledge and understanding, and to develop new skills to a high level;*

and will have

d) *the qualities and transferable skills necessary for employment requiring*

- *the exercise of initiative and personal responsibility;*
- *decision making in complex and unpredictable situations; and*
- *the independent learning ability required for continuing professional development*

Standing back from the details, a conclusion is that Masters courses must be characterised by an ethos of advanced work and scholarship.

Section three Reflections on Masters Provision

There are a number of issues associated with the implementation of the Qualifications Frameworks that merit reflection in the context of Masters programmes in Computing.

3.1 Learning Objectives

Many taxonomies of learning objectives now exist. These suggest a view that advanced level is achieved by employing assessment strategies based on the use of do-words at the higher end of the taxonomy scale. Thus 'analyse', 'synthesise', etc are deemed to be higher order skills than 'describe', etc. To rely on this alone as a discriminator of level can prove an inadequate response to the challenge to demonstrate Masters level provision. The Qualifications Frameworks demand that Masters level courses address advanced knowledge, advanced scholarship and position the graduating students at the forefront of development.

There is a dangerous view that a key to Masters provision can be found in delivering large amounts of undergraduate material at a rate or in a manner that reflects Masters level, and/or in assessing students in an appropriate manner. To take this view seems undoubtedly a risky strategy. The requirements of the Qualifications Frameworks are explicit about what is required. Presenting large amounts of undergraduate material (no matter how large) is inconsistent with the Framework documents and the requirements of Masters level outcomes.

3.2 The Nature of Programmes

In terms of the nature of Masters degree programmes in Computing there is a range of possibilities, for example

- degree programmes which build very directly on undergraduate honours degrees and provide a focus on some particular technology or aspect of Computing
- professional programmes where the emphasis is on current professional practice; such courses may serve to meet the requirements of professional bodies so providing a bridge to CEng recognition, for example
- interdisciplinary degree programmes which involve advanced scholarship in the use or applications of computing
- degree programmes with a particular applications focus or for particular employment sectors, e.g. focussing on particular sectors of industry or commerce

The Qualifications Frameworks also admit Masters degrees based on novel applications of underlying knowledge and understanding. In the context of Computing there are some relevant observations here

- the use of modern up-to-date software (languages, compilers, databases, tools, web-based software, etc.) can *very legitimately* be regarded as current and new technology
- using modern tools in novel applications represents very legitimate activity for a Masters degree programme
- addressing a range of such applications focussed on particular employment opportunities has its attractions

3.3 Masters Ethos

A clear requirement of any Masters degree programme is that it should exhibit an ethos that is associated with advanced study and scholarship, clearly distinguishable from an undergraduate ethos. Typically this will relate to degree programmes of the kind identified in Section 3.2 above. However, in general terms it is a requirement of any Masters programme that the nature of this ethos is clearly

identified. Having done so, the consequences of the decision need to be articulated in terms of the requirements and nature of the programme and the manner in which this is seen to fit with the Qualifications Frameworks.

One of the features of many Masters degree programmes is that they attract students from a wide variety of backgrounds. There may be some element of uniformity, e.g. they are all from a science or engineering background. But since the expectation is that students on Masters degrees will all have an Honours degree or equivalent, the associated descriptor from the Qualifications Frameworks (see Annex A) indicates that, among other characteristics, they possess skills such as the ability to manage their own learning, to make use of scholarly reviews and primary sources, and so on.

An implication of these observations is that within Masters programmes these skills and abilities should be further developed and refined. A common goal of all Masters programmes is that they should *add value* to undergraduate degrees. A reasonable strategy for addressing the varied backgrounds is likely to utilise these skills in the context of ready access to relevant resources to bring students quickly to some common level.

3.4 The Bologna Agreement

The UK is a signatory to the Bologna Agreement of 1999 and this will have implications for the nature of UK Masters degree programmes. Fundamentally the Agreement is concerned with the harmonising of degrees across Europe in order to facilitate the movement of citizens between countries; it focuses on the length of degrees and also the standards. It makes reference to two cycles; a first cycle relates to initial undergraduate degrees; the second cycle relates to the provision of Masters degrees. Issues associated with the second cycle are of most relevance here. For instance the duration of a Masters course should not be less than one year of full-time study. But the influences are likely to be more far reaching.

Developments associated with the implementation of the Bologna Agreement suggest that learning outcomes / competences are to be viewed as the points of comparison between different provisions. The terms learning outcomes / competences are seen to include knowledge and understanding, knowing how to act (this includes skills and practical activity) and also knowing how to be (thus including social, legal and professional issues as well as living with others in a social context).

These learning outcomes / competences are intended to:

- encapsulate the knowledge, understanding and skills, that a student is expected to demonstrate or achieve; at the more advanced levels this may involve the student in the selection of knowledge, skills, etc relevant for a particular purpose
- place an emphasis on what students can perform and hence the learning outcomes / competences can be seen as providing level indicators or setting standards
- accommodate diversity of provision as well as freedom and autonomy for institutions in terms of how implementation may occur
- importantly accommodate a *dynamic* aspect, by allowing reference to such matters as the changing needs of industry and the requirements of an evolving society.

The emphasis on these learning outcomes / competences is intended to address the issue of rapid change and is in accord with student-centred approaches since these place a premium on the student and the student's capacity to learn.

Generally learning outcomes / competences can relate either to individual programmes of study or they can relate to individual classes or modules. Viewed from a different perspective they can be seen as generic and so applicable across all degree programmes, or they may be subject specific and so applicable to Computing, for example.

The generic learning outcomes /competences that have been identified fall into three categories:

> *instrumental competences* which include the capacity to learn and understand, to develop and express thoughts, to solve problems, and to manage time

interpersonal competences which include the ability to express views as well as feelings, to be critical as well as self critical but also the ability to work effectively as part of a team

systemic competences where skills associated with entire systems are developed – the ability to assess systems, to recognise the individual components and to understand their interaction, to improve systems, to replace them and to create them

The kind of learning outcomes or competences associated with the second cycle (see reports from the Bologna process seminars at www.bologna-berlin2003.de) include the requirement that graduates

- *have a good command of a specialised field within the discipline at an advanced level. This means in practice being acquainted with the newest theories, interpretations, methods and techniques*
- *be able to follow critically and interpret the newest developments in theory and practice*
- *have sufficient competence in the techniques of independent research and be able to interpret the results at an advanced level*
- *be able to make an original, albeit limited, contribution within the canons of the discipline, e.g. the final thesis*
- *have developed competence at a professional level.*

Those charged with the development of standards for different subject disciplines will wish to place differing levels of emphasis on these.

Section four Towards Benchmarking Standards

In considering the requirements for benchmarking statements for Masters degree programmes it is important to build on the honours requirements of the Qualifications Frameworks and to focus on aspects that are Masters level.

4.1 Masters Degree Programme Design

There are fundamental requirements that should be associated with all Masters courses:

- the subject area should be carefully identified and defined
- degree programmes should be carefully designed to accommodate the students who enter with the required entrance qualifications (typically at honours degree level or equivalent)
- the relevant theoretical underpinnings (which may or may not be mathematical in nature) need to be identified and should result in emphasis on those fundamentals aspects of a subject which do not change in the context of rapid technological development
- there should be an apparent ethos that reflects an integration between theory and practice as well as the planned development of a set of attitudes and an appreciation of a range of applications
- there should be appropriate integration between a set of modules that exhibit cohesion in content and a planned approach to the topic of the Masters programme
- the majority of the material must be at Masters level and of necessity be positioned at the forefront of developments
- the relevant professional, legal and ethical issues should be addressed
- students should be provided with international perspective on developments in the subject
- a major component of each Masters degree programme should be a project that requires integration of material from across the individual modules and provides opportunities for students to demonstrate a range of Masters level abilities and achievements

Beyond these requirements all institutions will wish to provide courses that address the needs of local employers and / or catch the imagination of possible students. This will be reflected in a set of Masters level learning outcomes for the programme.

For all students electing for Masters degree programmes represents a real commitment and for some perhaps even a change of direction for their studies. For all students it is important that there is a high probability of progression through to employment or further study. Masters degree programmes ought to reflect this concern.

4.2 Transferable Skills Issues

Since admissions to Masters programmes tends to be on the basis of an honours degree, it can be assumed that students already possess a set of generic and transferable skills that can be utilised and reinforced throughout the Masters programme. Of course, the nature of the intake will determine the extent to which assumptions can be made about the technical skills of students.

For any Masters programme it will be essential to identify both the technical and the transferable skills that are particular to the programme of study. In this regard the developments associated with the Bologna Agreement are highly relevant; see section 3.4. For the technical much will depend on the orientation of the programme; but acquiring skills with a range of up-to-date software will often be a key requirement.

At a more general level a range of new skills ought to be identified, and these should build on the already acquired skills. Again much will depend on the programme but a range of possibilities includes:

- addressing the advanced stages of the development of lifelong learning and seeing these as being related to the creation of the lifelong learner who can set goals and identify resources for the purpose of learning, i.e. the self-directed learner

- group learning and all that this entails
- critical review of the literature which includes identifying all the key developments in a particular area of study, critically analysing these and identifying limitations and avenues for further development or explanation
- recognising and responding to opportunities for innovation
- the peer review process that involves the review of papers, software, proposals, etc. coupled with positive advice for improvement
- systems level skills which address appropriate learning outcomes / competences – see section 3.4
- acquiring professional level skills
- entrepreneurship which tends to involve acquiring resources to ensure the success of some technically sound endeavour; this may include a company start-up or placing a well argued resource request before an industrial concern, a research council or some such organisation
- leadership skills which tend to be characterised by acquiring a vision (based on sound technical insights) coupled with the ability to encourage others to share in that vision and to ensure that this will not be to their detriment

4.3 Learning, Teaching and Assessment

The three topics of learning, teaching and assessment are all intimately linked with the emphasis having to be placed on effective learning. Within any Masters programme there ought to be a coherent philosophy that addresses knowledge and understanding, practice, the acquisition of a professional approach and professional attitudes as well as appreciation of a range of wider applications with theory and practice being intimately linked. In many programmes the diversity and the richness of the backgrounds of the students provides excellent opportunities for self-directed learning (for instance, in the form of an independent study module) or group learning.

For any Masters programme there ought to exist an assessment strategy that reflects Masters level activity throughout the course and allows students to demonstrate the learning outcomes and so the acquisition of the skills of the course and their achievements. There needs to be a focus on high order skills such as synthesis, critical thinking, independent study and self-direction.

The cognitive skills associated with any Masters programme of study will be closely related to the subject matter of that programme and to its particular ethos. For instance, for research oriented programmes it will be appropriate to develop cognitive skills to research level and engage in activity which demonstrates insight into the research agenda for the area. For instance, one particular aspect of this might be generating a research proposal that is well founded and well argued; this very activity may involve some implementation so as to demonstrate 'proof of concept'.

For any Masters programme it is appropriate that these cognitive skills can be set out and explained with particular attention being paid to M level learning outcomes.

4.4 The Project and Variants Thereof

In many institutions final year undergraduate projects are seen as providing an opportunity for students to apply a disciplined approach to solving a substantial problem and this typically utilises material from a variety of courses. The range of skills required to successfully complete such a project is often considerable and students invariably benefit from the experience. In the context of Masters degrees such activity continues to provide a rich and interesting set of possibilities.

There are additional opportunities at Masters level and these can help to provide convincing evidence of truly Masters level activity. For instance, the requirement to produce

- ❖ a research proposal (as may be submitted to a research body for funding, perhaps modified to address issues of scope and scale) has the merit of emphasising the structure and content of such a document, the research dimension, research methods, critical literature review, research planning and costing and it could well entail some implementation activity to provide evidence of validity

- ❖ ideas associated with proof of concept, patenting, seeking entrepreneurship funding, etc all can be customised to provide Masters students with beneficial opportunities to demonstrate a range of higher order skills

- ❖ a well argued and technically sound case to attract industrial funding or support

These are just instances of possible approaches.

4.5 The Conversion Degree Issue

A spectrum of possible Masters degree formats is outlined in Section 3.2. Existing degrees will tend to fall into one of these categories.

In the context of the Qualifications Frameworks there is merit in institutions going back to first principles and ensuring that the learning outcomes for their degree programmes sit comfortably with the M level descriptors. One pertinent observation is that degree programmes that are currently excessively broad might be altered with benefit to address specialist application areas, for instance. It is desirable that in general there should be a change of terminology so that connotations associated with the term 'conversion Masters' are removed. The concept of parity of esteem and equivalence of standards between different Masters degrees is a concept that should be fostered.

Having made these statements the discipline of Computing should be able to celebrate that fact that it is possible to offer Masters courses that

- do not require a first degree in Computing (though a reasonable pre-requisite for any Masters degree would be some level of computer literacy), and
- are on a par academically with other Masters awards

In the broad scope of Masters provision the terms 'generalist' and 'specialist' are being applied, indicating different balances between breadth and depth. These terms can legitimately be applied in the context of Masters degrees in Computing.

For the generalist degree it remains important that

- ❖ in their conception there is a focus on employment needs
- ❖ skills from first degrees as well as IT skills are built upon
- ❖ graduates will be able to demonstrate the relevance of broad knowledge and skills to bring about change and where appropriate, to develop cross-disciplinary insights, dependencies and links.
- ❖ M level learning outcomes are met

4.6 Departmental Implications

Institutions offering Masters level programmes must have access to the necessary expertise. Although there are other possibilities, this will often mean that they possess staff who are at the forefront of developments in the topic of the programme and engaged in related advanced scholarship. Staff teaching on these programmes need to be provided with the opportunity as well as the tools and support to deliver courses of high quality.

In most cases the availability of a range of up-to-date and modern software will be required. This will provide convincing evidence of attention to recent developments at the forefront of the subject.

Students on Masters courses typically enter from varied backgrounds. To enable them to become up-to-date there is merit in having an up-to-date Resource Centre that includes hardware as well as software related materials; in short there should be easy access to a set of resources from which students can learn and benefit.

4.7 Addressing the Needs of the Better Students

It is important to create incentives for students to strive to achieve their full potential. Different institutions will adopt different approaches to this and it would be unnecessarily constraining for any benchmarking statement to be prescriptive in this regard. However, many institutions allow the possibility of an award with distinction for students who do exceptionally well across all modules or units of study and all forms of assessment. Typically prizes (with carefully designed selection criteria) provide an additional other form of incentive.

Section five Benchmarking Standards

Benchmarking standards for Masters degrees are regarded as minimal standards required of a course leading to the award of Masters degree. The requirements of this are set out below under the threshold level. In addition there is an expectation that institutions will provide incentives for students to excel in their studies and to achieve their full potential. Accordingly the benchmarking standard includes comment on this important issue. See section 5.3.

5.1 Threshold Level

This is interpreted to mean that all students graduating with Masters degrees will have achieved this. In formulating these standards care has been taken to place emphasis on achieving Masters level learning outcomes associated with the programme of study.

Students who reach this level will be characterised by being able to

- demonstrate a systematic understanding of the knowledge of the domain of their programme of study, with depth being achieved in particular areas, and this should include including both foundations and issues at the forefront of the discipline and / or professional practice in the discipline; this should include an understanding of the role of these in contributing to the effective design, implementation and usability of relevant computer based systems

- demonstrate a comprehensive understanding of: the essential principles and practices of the domain of the programme of study including current standards, processes, principles of quality and the most appropriate software support; the reasons for their relevance to the discipline and / or professional practice in the discipline; and an ability to apply these

- consistently produce work which applies and is informed by research at the forefront of the developments in the domain of the programme of study; this should demonstrate critical evaluation of aspects of the domain including appropriate software support, the ability to recognise opportunities for (software or hardware) tool use as well as possible tool improvement, an understanding of the importance of usability and effectiveness in computer systems development, and generally the acquisition of well developed concepts

- understand and be able to participate within the professional, legal and ethical framework within which they would have to operate as professionals in their area of study and this includes being familiar with and being able to explain significant applications associated with their programme of study and being able to undertake continuing professional development as a self-directed life-long learner across the elements of the discipline

- demonstrate the ability to apply the principles and practices of the discipline in tackling a significant technical problem; the solution should demonstrate a sound justification for the approach adopted as well as a self-critical evaluation of effectiveness but also a sense of vision about the direction of developments in aspects of the discipline

5.2 Integrated Masters Degrees

MEng and other such Masters degrees are different from the more traditional Masters degrees. They are undergraduate degrees and are commonly referred to as *integrated* Masters degrees. As a consequence the benchmarking standards for such degrees must

- ❖ meet the generic standard for Masters degrees as outlined in section 5.1 above

- ❖ additionally meet the benchmarking standard for undergraduate degrees in Computing at the modal level, which is defined within the Computing benchmarking document

- ❖ possess a strong appropriate ethos (e.g. engineering for MEng) and orientation which includes attention to

- the underlying scientific principles
- relevant models (e.g. mathematical for MEng)
- current technologies and the trends in terms of their development
- relevant management and business practices including economic considerations and evaluation of commercial risks
- knowledge of a wide range of related products and systems, and the ability to review such items for appropriate (e.g. engineering for MEng) enhancement
- disciplined approaches to the problems of risk including such matters as safety and security
- knowledge of a wide range of relevant practice, processes as well as tools and components
- engagement in creative and innovative developments involving technology

5.3 Incentives for Excellence

There should exist incentives for encouraging the better students to reach levels of achievement in Masters degrees beyond the threshold level. These should reward excellent performance across the range of the programme of study and should encourage students to achieve their full potential.

Annex A

Honours Degree Level In the Qualifications Frameworks

Since the Qualifications Frameworks suggest that admission to Masters level courses should possess a qualification at honours degree level, it is important to have an eye to the descriptors provided for honours degrees. The following is taken directly from the HEFCE framework document, the Scottish requirements being similar :

Descriptor for a qualification at Honours (H) level:

Honours degrees are awarded to students who have demonstrated:

i) *a systematic understanding of key aspects of their field of study, including acquisition of coherent and detailed knowledge, at least some of which is at or informed by, the forefront of defined aspects of a discipline;*

ii) *an ability to deploy accurately established techniques of analysis and enquiry within a discipline;*

iii) *conceptual understanding that enables the student*

- *to devise and sustain arguments, and/or to solve problems, using ideas and techniques, some of which are at the forefront of a discipline; and*
- *to describe and comment upon particular aspects of current research, or equivalent advanced scholarship, in the discipline;*

iv) *an application of the uncertainty, ambiguity and limits of knowledge;*

v) *the ability to manage their own learning, and to make use of scholarly reviews and primary sources (e.g. refereed research articles and/or original materials appropriate to the discipline);*

Typically holders of the qualification will be able to:

a) *apply the methods and techniques that they have learned to review, consolidate, extend and apply their knowledge and understanding, and to initiate and carry out projects;*

b) *critically evaluate arguments, assumptions, abstract concepts and data (that may be incomplete), to make judgements, and to frame appropriate questions to achieve a solution - or identify a range of solutions - to a problem*

c) *communicate information, ideas, problems, and solutions to both specialists and non-specialist audiences;*

and will have

d) *qualities and transferable skills necessary for employment requiring:*

- *the exercise of initiative and personal responsibility;*
- *decision-making in complex and unpredictable contexts; and*
- *the learning ability needed to undertake appropriate further training of a professional or equivalent nature*

Annex B

Membership of the Committee

The members of the Committee producing the 2004 document were:

Professor John Lloyd, University of Newcastle

Professor Gillian Lovegrove, University of Northumbria

Professor Paul Luker, University of Bournemouth

Professor Andrew McGettrick (Chair), University of Strathclyde

Professor Keith Mander, University of Kent

Professor Barrie Thompson, Sunderland University

Professor Neil Willis, Staffordshire University