

## **Subject benchmark statement**

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**Master's degrees in computing**  
2011

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First published 2011

ISBN 978 1 84979 284 4

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Registered charity numbers 1062746 and SC037786

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## Preface

Subject benchmark statements provide a means for the academic community to describe the nature and characteristics of programmes in a specific subject or subject area. They also represent general expectations about standards for the award of qualifications at a given level in terms of the attributes and capabilities that those possessing qualifications should have demonstrated.

This subject benchmark statement refers to **master's degrees<sup>1</sup> in computing**. QAA also publishes a subject benchmark statement for bachelor's degrees with honours<sup>2</sup> in computing.<sup>3</sup>

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

Subject benchmark statements also provide support to HEIs in pursuit of internal quality assurance. They enable the learning outcomes specified for a particular programme to be reviewed and evaluated against agreed general expectations about standards.

Subject benchmark statements allow for flexibility and innovation in programme design and can stimulate academic discussion and debate upon the content of new and existing programmes within an agreed overall framework.

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

The relationship between the standards set out in individual subject benchmark statements and the requirements of professional, statutory or regulatory bodies will be a matter for individual HEIs to consider in detail.

This subject benchmark statement was produced by a group of subject specialists drawn from and acting on behalf of the subject community. The process was overseen by the Quality Assurance Agency for Higher Education (QAA). This subject benchmark statement will be revised no later than five years from its publication date, to reflect developments in the subject area and the experiences of institutions and others who have been working with it. The review process will be overseen by QAA in collaboration with the subject community.

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

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<sup>1</sup> Level 7 in The framework for higher education qualifications in England, Wales and Northern Ireland (2008) and level 11 in the Scottish Credit and Qualifications Framework (2001).

<sup>2</sup> Level 6 in The framework for higher education qualifications in England, Wales and Northern Ireland (2008) and level 10 in the Scottish Credit and Qualifications Framework (2001).

<sup>3</sup> Available at: [www.qaa.ac.uk/academicinfrastructure/benchmark/honours](http://www.qaa.ac.uk/academicinfrastructure/benchmark/honours).

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

The Equality and Human Rights Commission has published guidance<sup>4</sup> to help HEIs to implement the DED and provides illustrative examples on how to take the DED forward. HEIs are encouraged to read this guidance when considering their approach to engaging with components of the Academic Infrastructure,<sup>5</sup> of which subject benchmark statements are a part.

Additional information that may assist HEIs when engaging with subject benchmark statements can be found in the *Code of Practice (revised) for providers of post-16 education and related services*<sup>6</sup> and also through the Equality Challenge Unit,<sup>7</sup> which is established to promote equality and diversity in higher education.

In October 2010, the Equalities Act came into force, which brings together existing pieces of legislation for a range of protected characteristics, including disability. The key provisions of the Act include a new Single Equality Duty which will be placed on public bodies. This would replace existing statutory duty. The Act will also include a simplified definition of disability. The Government has published regulations for the proposed specific duties to accompany the new Equality Duty, which, at the time of writing, are under review. HEIs are advised to check the websites of the Equality and Human Rights Commission<sup>8</sup> and the Equality Challenge Unit for the latest updates.

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<sup>4</sup> Copies of the guidance *Further and higher education institutions and the Disability Equality Duty, Guidance for Principals, Vice-Chancellors, governing boards and senior managers working in further and higher education institutions in England, Scotland and Wales*, may be obtained from [www.dotheduty.org/sectoral-guidance.asp](http://www.dotheduty.org/sectoral-guidance.asp).

<sup>5</sup> An explanation of the Academic Infrastructure, and the roles of subject benchmark statements within it, is available at [www.qaa.ac.uk/academicinfrastructure](http://www.qaa.ac.uk/academicinfrastructure).

<sup>6</sup> Copies of the *Code of Practice (revised) for providers of post-16 education and related services*, published by the Disability Rights Commission, may be obtained from [www.equalityhumanrights.com/uploaded\\_files/code\\_of\\_practice\\_revised\\_for\\_providers\\_of\\_post-16\\_education\\_and\\_related\\_services\\_dda\\_.pdf](http://www.equalityhumanrights.com/uploaded_files/code_of_practice_revised_for_providers_of_post-16_education_and_related_services_dda_.pdf). The Equality and Human Rights Commission is currently consulting on a revised edition of the guidance – further details are available at: [www.equalityhumanrights.com/legal-and-policy/equality-act/equality-bill-consultations/#Live\\_consultation\\_Draft\\_Code\\_of\\_Practice\\_on\\_Further\\_and\\_Higher\\_Education](http://www.equalityhumanrights.com/legal-and-policy/equality-act/equality-bill-consultations/#Live_consultation_Draft_Code_of_Practice_on_Further_and_Higher_Education)

<sup>7</sup> Equality Challenge Unit: [www.ecu.ac.uk](http://www.ecu.ac.uk).

<sup>8</sup> Equality and Human Rights Commission: [www.equalityhumanrights.com](http://www.equalityhumanrights.com).

## **Foreword**

Within the computing community in the UK there is a significant volume of activity at master's degree level. For many years there has been considerable demand for a document that would provide guidance (both to the community and to those engaged in the review process) on master's degrees. In particular, around how the complete spectrum of these courses can be seen to fit with national qualifications frameworks.

This new subject benchmark statement should be seen in part as a culmination of many years of effort, but principally it should be seen as a new and fresh initiative. In its deliberations, the benchmarking group sought to avoid straightjacketing master's degrees, so as to avoid inhibiting course innovation and development, which, in the rapidly changing context of computing, would be highly undesirable. Given the broad range of master's degree programmes however, some attempt at a classification of types is attempted (in section 3). This new subject benchmark statement now provides an opportunity for institutions to review their master's degree programmes in computing, using the statement as a point of reference.

An earlier draft of the statement was subject to sector-wide consultation between November 2010 and January 2011. The benchmarking group is grateful to all those who responded and made a number of minor changes to the text as a result.

The publication of the draft new statement owes much to early support from the Council of Professors and Heads of Computing (CPHC) and from the BCS, The Chartered Institute for IT. It has also benefitted from guidance and support from the Quality Assurance Agency for Higher Education (QAA).

**May 2011**





# 1 Introduction

1.1 Computing is the discipline associated with the structuring and organisation of information as well as the automatic processing and communication of that information. The application of ideas from computing underpins innovation across a wide range of activity, including engineering, business, education, science and entertainment. The application of computer technology has altered lives and its continuing impact will be felt into the future. The term 'information technology' (IT) is often used to capture computing related to applications.

1.2 To maintain and ideally enhance the UK's capacity to innovate and to lead, companies and organisations need to be able to recruit well-qualified graduates who are at the forefront of developments in computing/IT and who can play a leadership role in sustaining and enhancing such developments across the wide range of industrial sectors. Master's degrees in computing/IT are an important vehicle whereby this can be achieved.

1.3 A considerable and varied range of possible master's programmes exists in UK higher education institutions (HEIs), reflecting great activity and a great source of educational opportunity. During 2009-10, there were 23,855 postgraduate students studying computing/IT in UK HEIs.<sup>9</sup>

1.4 This subject benchmark statement covers 'taught' master's degrees in computing/IT. It also covers integrated master's degree programmes, where study at master's degree level is combined with study at honours degree level in a single programme. All master's degrees are expected to meet the outcomes for the qualification described in the national qualifications frameworks - *The framework for higher education qualifications in England, Wales and Northern Ireland (2008)* and *The framework for qualifications of higher education institutions in Scotland (2001)*.<sup>10</sup>

1.5 The subject benchmark statement for honours degrees in computing, published by QAA in 2007,<sup>11</sup> may also contain useful information and will be especially relevant to providers offering integrated master's degrees. Further information and guidance on the nature and characteristics of master's degrees generally can be found in Master's degree characteristics, published by QAA in 2010.<sup>12</sup>

## The European context

1.6 Within a broader European context, the UK is a participant in the Bologna Process, that was intended, at its inception in 1999, to create a European Higher Education Area by 2010. The Bologna Process is intended to promote student and staff mobility across Europe and to enhance the attractiveness of European higher education worldwide. To assist with the adoption of a system of easily readable and comparable degrees, one of the original Bologna Process action lines, national qualification frameworks have been

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<sup>9</sup> Higher Education Statistics Agency (HESA) online statistics, available at: [www.hesa.ac.uk](http://www.hesa.ac.uk).

<sup>10</sup> Both available at: [www.qaa.ac.uk/academicinfrastructure/FHEQ](http://www.qaa.ac.uk/academicinfrastructure/FHEQ).

<sup>11</sup> Available at: [www.qaa.ac.uk/academicinfrastructure/benchmark/honours](http://www.qaa.ac.uk/academicinfrastructure/benchmark/honours).

<sup>12</sup> Available at: [www.qaa.ac.uk/academicinfrastructure/benchmark](http://www.qaa.ac.uk/academicinfrastructure/benchmark).

certified against a European framework. In the UK, *The framework for qualifications of higher education institutions in Scotland* (2001) and *The framework for higher education qualifications in England, Wales and Northern Ireland* (2008) have each been verified as compatible with the *Framework for Qualifications of the European Higher Education Area* in 2006 and 2008 respectively. This process means that the national qualification descriptor for a master's degree in the UK is compatible with the qualification descriptor for a second cycle award in the European framework (see also section 4.1).

1.7 Following a study of accreditation standards, the European Quality Assurance Network for Informatics Education (EQANIE) has been established to engage in accrediting degree programmes in informatics across Europe. The benchmark standard incorporates the EQANIE standard against which European accreditation takes place.<sup>13</sup>

### **Use of this document**

1.8 An important use of this subject benchmark statement is to guide and support colleagues as they seek to develop and evolve their master's degree programmes. Such programmes must reflect well on academic computing at this level in the UK.

1.9 The subject benchmark statement forms an excellent framework to support the accreditation process and as such forms part of the programme accreditation procedures used by BCS, The Chartered Institute for IT. The benchmark statement embraces the scope of the discipline and therefore accredited programmes are expected to meet the requirements as set out in the benchmark statement. Further information and guidance regarding programme accreditation can be found on the BCS website at [www.bcs.org](http://www.bcs.org).

1.10 The information contained in the subject benchmark statement may also be of interest to students, employers and others wanting to learn more about master's degrees in computing/IT.

## **2 Nature and extent of computing**

2.1 The discipline of computing/IT includes study of the nature of computation, effective ways to exploit computation, and the practical limitations of computation in application terms.<sup>14</sup> There is a rich set of aspects associated with the computing/IT discipline, including (but not restricted to):

### **Foundational issues**

- theoretical considerations intended to ensure a sound logical basis for the discipline; complexity issues which address feasibility and efficiency concerns; the existence of formal aspects which facilitate automation
- principles of programming languages, compilers and programming environments
- the concept of the algorithm, the concept of a pattern, and notions of re-use
- ideas of abstraction and design, applied in the context of the domain knowledge associated with particular applications and linked to problem solving

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<sup>13</sup> See [www.eqanie.eu](http://www.eqanie.eu).

<sup>14</sup> See subject benchmark statement for honours degrees in computing, section 2.

- life cycle and process concepts
- professional, legal, social, cultural and ethical concerns

### **Major technologies**

- techniques associated with software construction and development, including the development of socio-technical systems
- electronic/chip design and system level integration, including bio-inspired developments
- computing systems, including multi-core processors and their exploitation; parallel and vector processing systems; distributed systems, cloud computing, quantum computing and grid computing
- pervasive computing, including networks, the internet, mobile computing systems and social networking systems; the interface with telecommunications and the exploitation of modern communication systems
- the human computer interface - embracing matters such as digital media, usability in its broadest sense, personalised systems, concern for users with some form of disability, and generally applications of ubiquitous and ambient computing and their effects on user environments and behaviour
- methods and techniques for information management, based around sound principles for updating and maintaining information
- appropriate awareness of techniques to address concerns for security, integrity and safety

### **Illustrative specialisms and sub-disciplines**

- the established disciplines of computer science, software engineering, computer communications and networks, and information technology, as well as variants of these
- information systems, defined as 'what emerges from the usage and adaptation of the IT and the formal and informal processes by all of its users'.<sup>15</sup> A study of information systems thus includes addressing the integration of strategy, processes, people and technology in contributing to effectiveness and efficiency within organisations by providing information access, modelling, control and decision-making support
- computer engineering (which includes the design and development of computers, devices and associated technologies to serve a range of purposes within diverse environments) as well as embedded and real time systems whose operation may have safety or security implications
- artificial intelligence and computational aspects of linguistics, cognitive computing, evolutionary computing and associated areas, including simulation and modelling and decision support
- entertainment systems and computer graphics, including animation

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<sup>15</sup> Paul, RJ (2007) Challenges to information systems: Time to change, *European Journal of Information Systems*, volume 16, issue 3, pp 193-195.

- topics such as data warehousing, data mining, forensic informatics, and technical issues involving the exploitation of computer arts and media
- systems concerns, as a disciplined recognition of the need to take an holistic perspective in the development of computing systems.

### **3 Nature of master's degrees in computing**

3.1 This subject benchmark statement covers the range of master's degrees in computing/IT. Master's degrees in computing/IT may be designed to cover a particular specialism or sub-discipline within computing in greater detail, for example, computer graphics, information management, digital media, computer security, communications and networking, computing systems architectures, the internet, web science, mobile computing, data warehousing, and aspects of artificial intelligence and human computer interaction. Master's degrees may also be offered in areas such as e-science, bio-informatics, medical computing, software project management, e-commerce, and virtual environments, where, for instance, students with a first degree in science or mathematics, as well as some reasonable background in computing/IT, or relevant industrial experience, may enrol for study.

3.2 To generalise, the range of possible master's degree programmes in computing includes:

- degree programmes which build very directly on undergraduate honours degrees in some aspect of computing and provide a focus on some particular technology or aspect of computing in greater depth, e.g. as preparation for research
- professional programmes where the emphasis is on current professional practice
- interdisciplinary degree programmes which involve advanced scholarship in the use or applications of computing
- degree programmes which, through a substantial taught element, offer education in the fundamentals of research such as MRes degrees
- master's degrees may be based on specific applications of underlying knowledge and understanding. In the context of computing this may include:
  - the use of modern up-to-date software (languages, compilers, databases, tools, web-based software), which is essentially current and new technology
  - using modern tools in new applications
  - addressing a range of applications focused on particular employment opportunities
  - a software life cycle focus, for requirements, the evolution of software development and maintenance.

3.3 The terms 'generalist' and 'specialist' master's degrees are often used in this context and both possibilities are accommodated. The terms indicate different balances between breadth and depth; the generalist master's are broader in nature, the specialist master's deeper. For the generalist degree it is normally important that:

- in their conception there is a focus on employment needs

- skills from first degrees, which may include computing elements, are required and 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.

## 4 Programme design

4.1 The following are fundamental requirements associated with all master's degree programmes in computing:

- the topic and learning outcomes are identified and defined clearly, and their relationship to the subject of computing and its applications is carefully captured in the title of the award
- programmes are carefully designed to accommodate 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) are identified and should result in emphasis on those fundamental aspects of a subject which do not change in the context of rapid technological development
- the curriculum demonstrates 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 and their impact on users
- there is an appropriate integration between a set of classes that demonstrates cohesion in content and a planned approach to the topic of the programme
- the majority of the material and its assessment is at master's level and is positioned at the forefront of developments
- a major component is a substantial individual activity that requires an awareness of material from across the individual modules and which provides opportunities for students to demonstrate a range of master's level abilities and achievements
- all master's degree programmes will meet the outcomes of the qualification descriptor identified in *The framework for higher education qualifications in England, Wales and Northern Ireland (2008)* or *The framework for qualifications of higher education institutions in Scotland (2001)*
- where credit is used, national guidance identifies a typical minimum of 180 credits for a master's degree, of which at least 150 will be at master's level. A typical minimum of 480 credits (600 in Scotland) is identified for an integrated master's degree, with at least 120 at master's level.<sup>16</sup>

The European Credit Transfer System (ECTS), developed by the European Commission, is a system for the use of academic credit aimed at facilitating student mobility in Europe. Many UK institutions make use of ECTS for this purpose (see also section 1.6). The *Framework for Qualifications of the European Higher Education Area (FQ-EHEA)*<sup>17</sup>

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<sup>16</sup> See Higher education credit framework for England: guidance on academic credit arrangements in higher education in England; Credit and Qualifications Framework for Wales; Scottish Credit and Qualification Framework, all available at: [www.qaa.ac.uk/standardsandquality/credit](http://www.qaa.ac.uk/standardsandquality/credit).

<sup>17</sup> Available at: [www.bologna-bergen2005.no/Docs/00-Main\\_doc/050218\\_QF\\_EHEA.pdf](http://www.bologna-bergen2005.no/Docs/00-Main_doc/050218_QF_EHEA.pdf).

identifies master's degrees as having 90-120 ECTS credits (180-240 UK credits) with a minimum of 60 credits (120 UK credits) at the level of the second cycle. For the award of ECTS, the learning outcomes of a qualification must be consistent with the relevant outcomes identified in the qualification descriptor for the end-of-cycle award (the 'Dublin Descriptors') set out in the FQ-EHEA. For those seeking further information, a revised users' guide to ECTS was published in 2009.<sup>18</sup>

4.2 Integrated master's degrees (such as MEng or MComp) should possess a strong appropriate ethos and orientation reflecting professional practice and/or applications within the discipline, and this will typically include attention to:

- the underlying scientific principles
- relevant models
- 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 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.

4.3 All institutions will wish to provide courses that address the needs of employers and/or catch the imagination of students. This will be reflected in the learning outcomes for the programme.

4.4 For all students, choosing to study for a master's degree 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 strong opportunity for progression through to employment or further study. Approval of master's degree programmes by institutions should reflect this concern.

4.5 Finally, although this subject benchmark statement describes the threshold standard for a master's degree (see section 7), programmes should be designed to encourage all students to reach levels of achievement beyond the threshold level. Excellent performance should be recognised and rewarded and students should be encouraged to achieve their full potential.

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<sup>18</sup> ECTS Users' Guide (revised 2009) is available from: [http://ec.europa.eu/education/lifelong-learning-policy/doc/ects/guide\\_en.pdf](http://ec.europa.eu/education/lifelong-learning-policy/doc/ects/guide_en.pdf).

## **5 Subject knowledge, understanding and skills**

### **Subject knowledge and understanding**

- 5.1 The study of computing at master's degree level is typically characterised by:
- an ability to evaluate the technical, societal and management dimensions of computer systems
  - a knowledge and understanding of advanced aspects of computer systems and their use
  - a combination of theory and practice, with practice being guided by theoretical considerations
  - a strong emphasis on the underlying discipline and/or applications
  - 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, legal, social, cultural and ethical issues related to computing and an awareness of societal and environmental impact.

### **Subject-specific skills**

5.2 Master's degree programmes in computing/IT should seek to include the development of the following subject-specific skills:

- an ability to engage in a peer review process that involves the critical review of papers, software and proposals, coupled with positive advice for improvement and innovation
- competences at a systems level appropriate to the learning outcomes of the programme: the ability to assess systems (which may include software, devices, people, and so on), to recognise the individual components and to understand their interaction, to improve systems, to replace them and to create them; this includes socio-technical systems such as those relevant to aspects of healthcare and also computing systems used in specialised applications such as bioinformatics, e-science, virtual environments, financial services, and transport
- familiarity with codes of ethics and codes of practice specific to the specialism of the degree programme, relevant industrial standards and principles underpinning the development of high integrity systems (for safety, security, trust, privacy, and so on), while keeping in focus the benefits of, approaches to and opportunities offered by innovation
- 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
- translational skills which involve the necessary communication between technical and non-technical audiences.

## **Generic (transferable) skills**

5.3 Since admissions to master's degree programmes tend to be on the basis of an honours degree or equivalent, students should already possess a set of generic and transferable skills that can be utilised and reinforced throughout the programme. An aim of any master's degree programme will include the reinforcing and enhancing of the skills of all incoming students. Admissions requirements will determine assumptions that can be made about the basic technical skills of students.

5.4 For any master's degree programme it will be essential to identify both the technical and the transferable skills that are particular to the programme of study. The technical skills will also depend on the orientation of the programme, but acquiring new skills with a range of up-to-date software will often be a key requirement.

5.5 Master's degree programmes in computing/IT should seek to include development of the following generic skills:

- those required for the creation of the lifelong learner, who can set goals and identify resources for the purpose of learning
- an ability to critically review the literature, which includes identifying all of the key developments in a particular area of study, critically analysing them and identifying limitations and avenues for further development or explanation
- an ability to recognise and respond to opportunities for innovation
- 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.

## **6 Teaching, learning and assessment**

### **Programme delivery**

6.1 Institutions offering master's degree programmes must have access to the necessary expertise, and must be able to articulate the legitimacy of providing education in the particular topic area of the master's provision. Although there are other possibilities, this will often mean that the institution possesses 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.

6.2 In keeping with the nature of a continuously evolving subject, currency of a master's degree programme in computing/IT can be demonstrated through association with external points of reference, such as developments in pedagogy and/or subject research. Examples of external engagement of staff delivering programmes could include appropriate engagement with the industry, professional bodies, research activity and vendor qualification developments. An additional source of external reference could be engagement with the Higher Education Academy and associated subject networks and continuing professional development activity.

6.3 Students on master's degree programmes typically enter from a variety of backgrounds. In order to enable all students to become or remain up to date, there



is merit in having a resource centre that includes hardware as well as software-related materials. In most cases, a range of modern up-to-date software will be required. This will provide convincing evidence of attention to recent developments at the forefront of the subject. In short, there should be easy access to a set of resources from which students can benefit and learn.

### **Pedagogical considerations**

6.4 Given the diversity of possible master's degrees, there will be considerable scope for variety and variability in terms of pedagogy. Some degrees will be 'stand-alone' and will admit students from diverse backgrounds, while others will be integrated; some will be designed to enable students to focus on a particular aspect in greater depth than during previous study, others will explore interdisciplinary aspects, while others will emphasise the professional dimensions of the discipline (see section 3). In all cases, the pedagogical considerations need to prioritise a mode of delivery that places a focus on the motivation of the students, ensuring that they become fully committed to working towards achieving the programme's learning outcomes, and excelling and achieving their maximum potential. Often this will involve finding the right context in which to motivate and to thereby stimulate learning and teaching.

### **Learning and teaching**

6.5 Learning, teaching and assessment are all intimately linked, with the emphasis being placed on effective learning. Within any master's degree programme there should be a coherent philosophy that addresses knowledge and understanding, practice, and the acquisition of a professional approach and professional attitudes; there should be an appreciation of a range of wider applications, with theory and practice being very closely linked. In many programmes the diversity and the richness of the backgrounds of students provides excellent opportunities for self-directed learning (for example, in the form of an independent study module) or group learning.

### **Assessment**

6.6 The assessment criteria should include the learning outcomes for the programme which define the knowledge, skills and other qualities being assessed and the standard of achievement that must be met.

6.7 The assessment method will relate to the nature of the allocated task. This might be individual activity in project work, demonstration of an artefact or a set piece of work, group work or work-based learning. Using technology to enhance assessment and feedback, non-written forms of assessment, formative and summative assessment, peer assessment, negotiated assessment, portfolios and involving employers in assessment, offer opportunities for innovative and flexible means of assessment.

### **The major individual activity**

6.8 In many institutions, major projects are seen as providing an opportunity for students to apply a systematic approach to solving a substantial problem and this typically builds on a variety of classes/modules. The range of skills required to successfully complete such an individual activity is often considerable and students

invariably benefit from the experience. In the context of master's degrees, such activity provides a rich and interesting set of possibilities.

6.9 There are alternative ways in which students at master's level can demonstrate the achievement of master's level outcomes, for example:

- the production of a research proposal (as may be submitted to a research body for funding, perhaps modified to address issues of scope and scale); this has the merit of emphasising the structure and content of such a document, the research dimension, research methods, critical literature review, and research planning and costing, and could involve some implementation activity to provide evidence of validity
- ideas associated with proof of concept, patenting and seeking entrepreneurship funding that can all be customised to provide master's students with beneficial opportunities to demonstrate a range of master's level skills
- a well-argued and technically-sound case to attract industrial funding or support.

## **7 Benchmark standard**

7.1 This subject benchmark statement defines the threshold standard of achievement, which is the standard expected to be achieved by a student graduating with the award of a master's degree in computing covered by this subject benchmark statement.

### **Threshold level**

7.2 All students graduating with a master's degree in computing are expected to be able to have demonstrated:

- a systematic understanding of the knowledge of the domain of their programme of study, with depth being achieved in particular areas, 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
- a comprehensive understanding, and a critical awareness of: the essential principles and practices of the domain of the programme of study as well as current research and/or advanced scholarship; current standards, processes, principles of quality and the most appropriate software technologies to support the specialism; the relevance of these to the discipline and/or professional practice in the discipline; and an ability to apply these
- consistently produced work which applies to and is informed by research and/or practice 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

- understanding of the professional, legal, social and ethical framework within which they would have to operate as professionals in their area of study; 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 lifelong learner across the elements of the discipline
- the ability to apply the principles and practices of the particular programme's domain in tackling a significant domain related activity; the solution should demonstrate a sound justification for the approach adopted as well as originality (including exploration and investigation) and a self-critical evaluation of effectiveness but also critical awareness of current problems and new insights, and a sense of vision about the direction of developments in aspects of the domain of the programme.

### **Integrated master's degrees**

7.3 Students graduating with an integrated master's degree, such as an MComp, will:

- have met the threshold level generic standard for master's degrees as outlined above
- have met the benchmark standard for honours degrees in computing at the typical level, as defined in the subject benchmark statement for honours degrees in computing
- possess an appropriate ethos and orientation as described in section 4.

## **Appendix - Membership of the benchmarking group for master's degrees in computing**

Liz Bacon	University of Greenwich
Roger Boyle	University of Leeds
Laurence Brooks	Brunel University
Anne de Roeck	The Open University
Jeff Magee	Imperial College
Gerry McAllister	University of Ulster
Andrew McGettrick (Chair)	University of Strathclyde
Keith Mander	University of Kent
Laura Bellingham	QAA
Elizabeth Friend (co-ordinator)	BCS, The Chartered Institute for IT

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