Report of the Joint ACM and IEEE-CS Committee on Masters Degree Programs in Europe and the United States

General Introduction

Master’s level programs play a significant role in the preparation of academics and professionals in the computing disciplines[1]. These programs vary greatly within the wide variety of universities found in the European and American traditions, and across the increasingly broad range of computing disciplines. This report presents the conclusions of a joint committee of the ACM Education Board and the IEEE-CS Educational Activities Board. The committee was charged with identifying the characteristics of masters degrees in computing, with particular attention to the variations and similarities found both within and between Europe and the United States. We understand that this constraint limits the investigation, and that there are important characteristics of degrees from other parts of the world that would further inform the conversation. The limited scope is for practical reasons at this time.

Master's programs in computing must be defined first as master's degrees, and then as programs in computing. This report begins by defining the expectations for masters level programs, then applies that definition to the computing disciplines. The report is not a curriculum recommendation. Rather, it provides a framework for describing specific masters programs that can be used to compare programs on the basis of their characteristics. There is no implication that one program is superior to another. The eventual goal is to make it possible to present each program's characteristic features, so that students, faculty, and employers will understand what a particular program provides.

Masters Programs in Europe and the United States

Each European country has developed its own higher educational system, although there is often less difference between two national systems of higher education (HE) in Europe than between a European HE system and the US system. However, the differences between European systems has created barriers to professional mobility. Increased awareness of the difficulty posed by these barriers in a mobile world gave rise to a decades-long effort to harmonize and integrate European higher educational systems, by the European Union. This effort, generally called the Bologna process [2], has created a framework for higher education throughout Europe and now includes European states that are not members of the EU. The Bologna process recognizes three distinct levels of academic qualification called first-, second-, and third-cycle degrees, corresponding roughly to the bachelors, masters and doctoral degrees used in the United States and Canada. The Bologna accord defines second-cycle (masters) degrees in terms of outcomes and student effort.

In 2005, the outcomes of a European second-cycle degree were described as follows [3]:

Completion of the second cycle assumes a student can

- demonstrate knowledge and understanding that extends that of the first cycle and provides a basis or opportunity for originality in developing and/or applying ideas, often in a research context

- apply knowledge and understanding, and problem solving abilities in unfamiliar environments in multidisciplinary contexts related to their field of study

- integrate knowledge, handle complexity, and formulate judgements with incomplete or limited information, including reflecting on social and ethical responsibilities linked to the application of their knowledge and judgements

- communicate their conclusions, and the knowledge and rationale underpinning these, to specialist and non-specialist audiences

- demonstrate learning skills that can sustain further study which is self-directed or autonomous

Similarly, the United Kingdom's Quality Assurance Agency developed a framework for higher education qualifications in England, Wales and Northern Ireland [4]. According to this framework, Master's degrees are awarded to students who have demonstrated:

- *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*
- *a comprehensive understanding of techniques applicable to their own research or advanced scholarship*
- *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*
- *conceptual understanding that enables the student:*
    - *to evaluate critically current research and advanced scholarship in the discipline*
    - *to evaluate methodologies and develop critiques of them and, where appropriate, to propose new hypotheses.*

This framework states that holders of a Master's degree will be able to:

- *deal with complex issues both systematically and creatively, make sound judgments in the absence of complete data, and communicate their conclusions clearly to specialist and non-specialist audiences*
- *demonstrate self-direction and originality in tackling and solving problems, and act autonomously in planning and implementing tasks at a professional or equivalent level*
- *continue to advance their knowledge and understanding, and to develop new skills to a high level,*
- and they will have:
    - *the qualities and transferable skills necessary for employment requiring:*
    - *the exercise of initiative and personal responsibility*

- *decision-making in complex and unpredictable situations*
- *the independent learning ability required for continuing professional development.*

In the Bologna model, student effort is defined in terms of European Credit Transfer System (ECTS) credits. ECTS provides a common European currency of credits that is at the core of the Bologna process. By 2010, ECTS will have been implemented throughout the European Higher Education Area. ECTS credits are defined in terms of the amount of effort a student puts into study; one ECTS credit is approximately equivalent to 30 hours of study. A second cycle degree requires 90-120 ECTS credits, at least 60 of which must be earned at the second cycle.

The elements of the Bologna system facilitate the "translation" of academic achievements and qualifications across national and regional borders and the corresponding systems of higher education. More generally, the Bologna process makes it easier to implement student mobility within Europe and the standard framework and credit system is thought to be attractive to students living outside Europe. Moreover, such standardization potentially facilitates movement in both directions between Europe and the United States.

The United States does not have a centralized authority with control over higher educational institutions and programs. The 50 states exercise a varying degree of control over education; but, in general, both public and private institutions of higher education are permitted to operate (and create programs) with considerable independence and autonomy. U.S. universities are accredited by six regional organizations that enforce some expectations for programs at different levels[5]. For example, it is generally expected that a masters program will include 30-36 credit hours of instruction. In the US, credit hours represent classroom time, rather than student effort as in Europe. Specifically, one credit hour roughly corresponds to 15 hours of classroom instruction. Increasingly, programs are expected to have learning outcomes; but university-level accreditation teams have not so far looked at these outcomes in a discipline-specific fashion.

As a consequence, U.S. degree programs can vary widely in their character and quality. This is significant especially for computing programs, where no strongly established tradition sets patterns for higher education and where the discipline has been developing rapidly since its inception. For undergraduate programs in computing, the need for guidance has been filled by professional societies. Initiatives by the Association for Computing Machinery (ACM), the Institute of Electrical & Electronics Engineers Computer Society (IEEE-CS) and the Association for Information Systems (AIS) have provided faculty and institutions with guidelines for undergraduate computing education [6-17]. Since 1968, these guidelines, appearing as volumes collectively referred to as the "Computing Curricula" series, have provided major reference documents for the development of undergraduate programs in computing. With the exception of masters programs in infomation systems, no such guidance is available for masters programs in computing.

The introduction of the new European degree structure poses both challenges and opportuunities for the transatlantic academic and professional mobility of computing graduates and students. Schemes for the academic and professional recognition by U.S. authorities of decades-old "traditional" computing qualifications awarded by European institutions must now be adapted to Bologna Process degree cycles. Moreover, even though European degrees have now largely been harmonized, they still allow for some variation in duration and student workload. These issues still pose a potential obstacle to the academic and professional mobility of European students and graduates in computing disciplines, but at the same time, they create opportunities for international cooperation[3] .

Some work in progress to help solve this problem with respect to European first-cycle degrees may provide a preview of attention to second-cycle degrees. There are only a few European countries (e.g., Germany, UK) where accreditation of computing programs is based on field-specific standards. In other countries, assessment of degree programs is undertaken on the basis of more generic, institutional criteria. While this leaves more autonomy to the institutions, the lack of a tool for assessing the quality of degree programs on a national or transnational level has posed a potential obstacle to mobility. In response to this need, the recent initiatives undertaken by the German accreditation agency ASIIN [18] (in cooperation with the BCS and other partners) has developed a set of framework standards and procedural guidelines for computing degree programs that can be used across Europe. These materials can serve as a reference framework for program development by individual institutions.

Master's Programs in Computing

Master's degrees in computing disciplines vary along several dimensions:

- preparation of entering students,
- student goals and outcomes, and
- program content and presentation.

The first dimension can be explored by looking at the possible backgrounds and goals of students pursuing a Master's degree. These include

- Students with undergraduate degrees in a computing discipline who seek an advanced degree
- Students with undergraduate degrees in a computing discipline who need further learning in a particular specialization (e.g., software engineering, computer games)
- Students who have been working in a narrowly focused computing area and want to acquire a more broadly based qualification
- Students from non-computing disciplines who want to change career paths. These are further subdivided into two subcategories, distinguished by their mathematical backgrounds:
    - Students from science, mathematics or engineering
    - Students from business, humanities or social sciences

The second dimension deals with program goals and objectives. Some programs provide breadth in the discipline and serve to enhance the knowledge of students with undergraduate computing degrees or to bring students from other backgrounds into the field. Others aim for depth of coverage, building on students' undergraduate knowledge of the discipline. A program may be characterized as broadly encompassing the computing domain, emphasizing a relatively broad core area such as computer science, computer engineering, software engineering, information systems, or information technology; or as specializing in an particular area. Some examples of existing, very specialized programs are the following: Knowledge Management, Computer Security, Artificial Intelligence, Internet Applications, Digital Libraries, Health Informatics, Computer Animation, Mobile Systems, Human Factors, Data Mining, and Multimedia. Other programs are multidisciplinary in nature, such as bioinformatics, computational molecular biology, or computer forensics.

The context in which the program is offered may also influence its expected outcomes. For example, programs developed in an engineering context will differ from those developed in an Arts & Sciences, Business, or Library Science school. Institutional and national traditions will also affect the way the program is structured and the outcomes that are expected. Despite the variation arising from these influences, it is still possible to develop discipline-specific expectations for graduates of computing Master's programs. For computing in general, expectations might include some or all of the following:

- ability to investigate new and emerging technologies
- ability to learn and apply new levels of abstraction to models, systems, and technologies
- comprehensive understanding of theoretical and applied computing
- ability to proficiently practice selected techniques and processes
- awareness of current issues at the forefront of computing
- ability to deal with complex issues and demonstrate self-direction
- possession of skills applicable in the marketplace

For example, the following learning outcomes have been adapted from a proposed reference curriculum for software engineering Master's programs [18]

- mastering a specified body of knowledge
- mastering at least one application domain (e.g., finance, medical, transportation, telecommunications), and one application type (e.g., real-time, embedded, safety-critical, or highly distributed systems)
- mastering at least one knowledge area or sub-area from the body of knowledge to at least the Bloom Synthesis level
- demonstrating how to make ethical professional decisions and practice ethical professional behavior
- understanding the relationship between software engineering and systems engineering and being able to apply systems engineering principles and practices in the engineering of software
- ability to work effectively as part of a team, including teams that may be international and geographically distributed, to develop quality software artifacts, and to lead in one area of project development (e.g., project management, requirements analysis, architecture, construction, quality assurance)
- ability to reconcile conflicting project objectives

- understanding the importance of feasibility analysis, negotiation, effective work habits, leadership, and good communication with stakeholders in a typical software development environment
- understanding how to learn new models, techniques, and technologies as they emerge, and appreciating the necessity of such continuing professional development

ability to analyze a current significant software technology, articulate its strengths and weaknesses, and specify and promote improvements or extensions to that technology

In recent years, there have been several European efforts to develop skill frameworks that define the general characteristics of workers in the information and computing technology (ICT) fields. The Skills Framework for the Information Age (SFIA) [19] was developed in the United Kingdom. Other ICT skill frameworks have been developed in France (CIGREF) expectations regarding the European e-Competence Framework [20] and Germany (AITTS) [21]. More recently, the European Community has developed a meta-framework that can be related to each of the three frameworks mentioned above. [References: European e-Competence Framework 1.0, User guidelines for the application of the European e-Competence Framework, 2008 [22], When a program specifically references such a framework, that connection provides an important descriptive element to the program goals.

The third dimension distinguishes the ways programs are organized and delivered. Program formats can vary, ranging from a traditional academic format to an intense schedule of evenings and weekends, and possibly including elements of distance learning. Programs may be delivered by multi-institutional partnerships. Some programs consist entirely of coursework; others allow or require practical experience. Programs may require or permit an international component. Some Master's degrees are considered a step on the way to a doctorate; others are seen as terminal degrees. Regardless of delivery mechanism, evaluation of student achievement is generally based on coursework and written examinations. Beyond this, many programs require a significant project that allows students to demonstrate their skills, knowledge, problem-solving, and report-writing abilities. Some programs require independent research. Student evaluation also varies in the level of oversight provided. Evaluation may be controlled entirely by the faculty, may be reviewed by the college or university, may have review from outside the university, possibly including industry participation.

Program organization can be broadly characterized as follows:

Research: Students follow an academic path that leads toward doctoral (third-cycle) study. In some cases, students enter a second cycle program with the goal of a doctorate. There may be special degree titles for students on this path who leave before completing the doctorate.

Continuation/Integrated: Students continue their studies beyond an undergraduate (first-cycle) degree in the same discipline. Many countries, particulaly in Europe, seamlessly provide a continuation second-cycle (masters) following a first-cycle degree. The United Kingdom has an extended first degree that lasts a year longer than the normal first degree (four years rather than three). Many U.S. universities offer a 5-year integrated bachelor/master program in which a student takes some masters level courses during the undergraduate program. Students in these programs receive the bachelors degree after four years and the masters degree after a fifth year.

Professional/Industrial: Professional masters programs are designed to allow students to pursue advanced training while developing workplace skills. Some are designed for students who are working full time in their field; others allow full time study but have a definite focus on professional development and careers rather than on preparation for further study in the field. See http://www.sciencemasters.com for information about masters level degrees in science with a distinct career focus. These programs are developed in concert with employers. They may concentrate on a narrow spectrum of industrially-relevant topics, and often include internships. Since the research effort of a student enrolled in a professional/industrial program may include an employer's intellectual property, the degree will not necessarily require a thesis or project.

Conversion: These programs address the need of students changing disciplines. They must include the appropriate preparation of a student who has first-cycle work in a different discipline and is not ready for advanced work in a computing program.

The variations across the three program dimensions make it more complicated to assure that all students achieve expectations appropriate to the Master's level. In particular, since many students enter Master's degree programs in computing without a first-cycle (undergraduate) degree in the discipline, the expectation that the Master's degree will "extend and/or enhance that typically associated with the first cycle" represents a challenge not generally found in other science and engineering disciplines. Any program that is open to a variety of entry levels must have the ability to replicate the essential capabilities provided by a first-cycle degree. In other words, there must be a path that leads to the master's level, regardless of starting position. There are a variety of ways to accomplish this. Some programs require the entering student to spend time in first-cycle classes; others offer accelerated classes so that students can accomplish the equivalent of first-cycle course work at a greater speed. The outcome for all students must be achievement at masters level. Figure 1 illustrates a system that allows a variety of entry points and develops students to the expected exit level [23]. The approach provides students with an opportunity to acquire necessary background, requires a minimum level of depth, and allows electives. Students who require more background and breadth preparation have less opportunity for electives. The units cited in the figure are quarter-hours; one quarter-hour is equivalent to two-thirds of a U.S. credit hour or four-thirds of an ECTS credit . The significant point is that the effort spent in background and breadth reduces students' elective options; approximately half of the program is required of all students. The options in the Stanford program mean that it can be structured to represent a conversion or a continuation program.

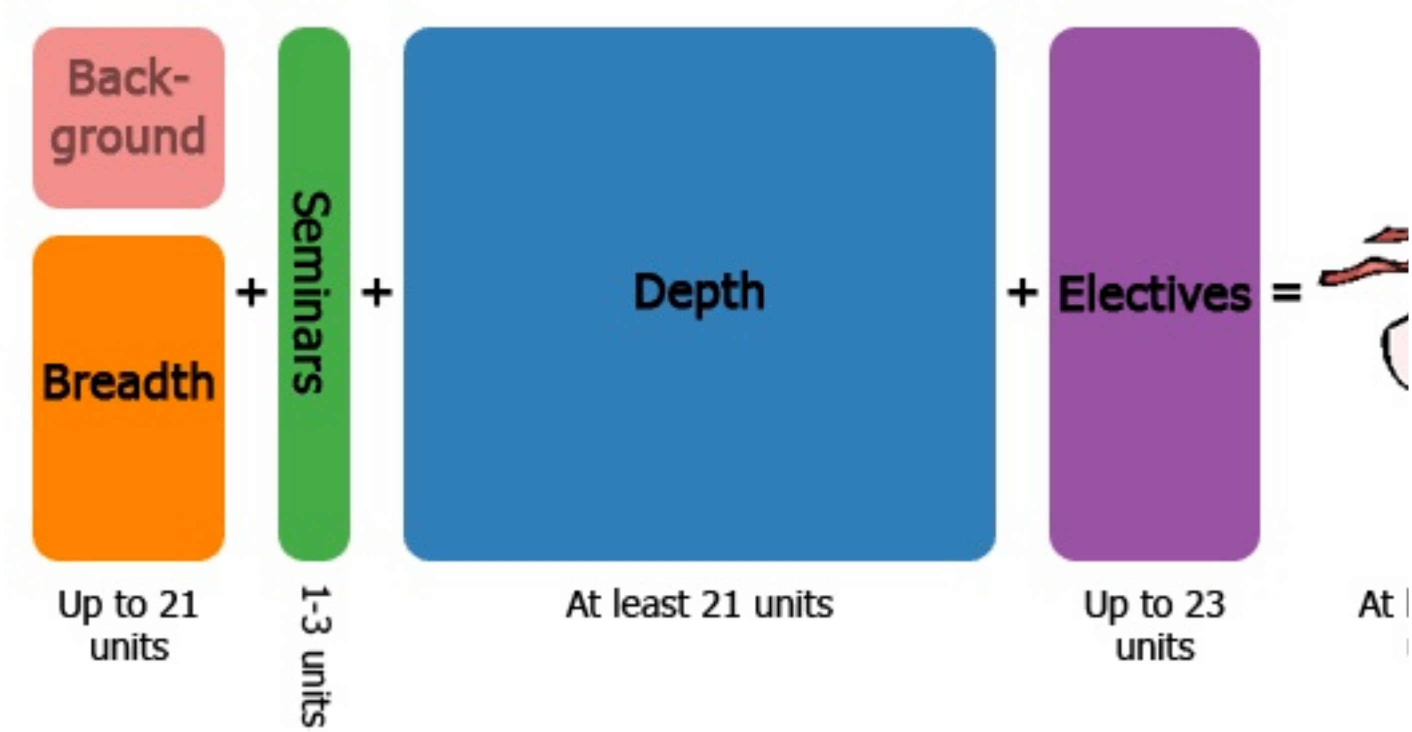

Figure 1 Stanford University Computer Science Entrance and Exit requirements

Computing Degrees and Professional Practice

As discussed earlier in this document, many master's degrees in computing focus on preparation for professional careers, rather than serving as a step toward further academic study towards a terminal degree. Particularly in the U.S., many master's degrees in computing are professional degrees. In Europe, the difference between the degree types appears to be less pronounced. For example, while most U.S. master's programs directed at professionals do not require a thesis, this requirement still exists in Europe. However, Germany now distinguishes programs at the master's level that are research-oriented (forschungsorientierte) from those that are applications-oriented (anwendungsorientierte)

One indication of the professionalism of a masters program is the degree to which it is recognized by a professional society. Although professional societies in computing have developed a variety of curriculum recommendations, only a few address masters level programs. One example is the MSIS 2006 curriculum document (developed by ACM and AIS), which specifically states that the curriculum corresponds to a "professional degree," and, furthermore, a professional degree that has been designed to build a bridge between the technical and business subcultures within an organization: "The MSIS is a professional degree that integrates the information culture and the organizational culture. We recognize the difficulties that people trained purely in one professional culture experience in communicating with each other. We believe that MS graduates should possess the knowledge and sophistication to bridge this chasm." [24]. A second example is the Graduate Software Engineering 2009: Curriculum Guidelines for Graduate Degree Programs in Software Engineering, developed by the Integrated Systems and Software Engineering group with participation by INCOSE (International Council on Systems Engineering), ACM, and IEEE-CS. This document gives curriculum recommendations for graduate programs in software engineering. The recommendations strongly support the professional status of degree recipients, recommend that students entering the program have at least two years experience as a practicing software engineer, and promote professional capabilities in teamwork, leadership, and planning. Built on the Software Engineering Body of Knowledge (SWEBOK) [25] GSWE2009 adds a knowledge area specifically addressing Ethics and Professional Conduct. [26]

The importance of the issues related to professional practice has been acknowledged in a number of contexts that support their significant role in many master's degrees in computing. These include codes of conduct, curriculum recommendations, documentation by accrediting bodies and government organizations, and academic research. The rest of this section will discuss each of these areas.

Codes of Conduct

Most professional organizations in computing have comprehensive codes of ethics and conduct/practice. Examples include the following:

ACM Code of Ethics and Professional Conduct [27]
ACM IEEE-CS Software Engineering Code of Ethics and Professional Practice [28]
BCS Code of Conduct & Code of Good Practice [29]
ACS Code of Professional Conduct and Professional Practice [30]

These codes include principles related to overall human conduct and to life as a computing professional. They typically "promote honesty, integrity, maintenance of high standards of quality, leadership, support of the public interest, and life-long learning."[9]. Many code items have far-reaching consequences related to preparation for careers in computing. For example, "achieving and maintaining a high level of professional and managerial competence" requires preparation in oral and written communication skills, teamwork, project management, as well as general problem-solving skills. Other items require in-depth understanding of the legal and regulatory environment in which one operates as an IT professional, or require capabilities that are related to addressing issues related to health, safety, and the environment.

The codes of conduct do not specifically address the capabilities that should be developed at the master's level. However, because these degrees typically lead to employment in either more challenging technical positions or in managerial roles, the work requirements related to professional conduct become more stringent and the demands for capability development become stronger.

Accreditation and Quality Assurance

The national and regional systems and practices related to accreditation and quality assurance vary significantly. For example, in the United States, federal and state government agencies have delegated institution-level quality assurance responsibilities to the higher education and professional communities ("accreditation by a recognized accrediting authority is accepted as the U.S. equivalent of other countries' ministerial recognition of institutions belonging to national education systems;"[31]) In the United Kingdom, the Quality Assurance Agency for Higher Education (QAA), an independent non-profit organization, is responsible for providing "independent assessment of how higher education institutions in the UK maintain their academic standards and quality" [32] and reporting to the governmental Higher Education Funding Council for England (HEFCE). In most countries in continental Europe, national ministries of education are responsible for quality assurance activities.

Program-level quality assurance also shows wide variation across countries. In Germany, all bachelor's and master's programs are required to be accredited by an approved agency. ASIIN is one agency in Germany responsible for accrediting programs in engineering, informatics, natural sciences, and mathematics. In the United Kingdom, the quality of computing programs is assured by BCS accreditation. In the United States, while there is no formal requirement for program quality assurance, this role is taken by professional societies. For professions that have a potential impact on public health or safety (e.g, medicine, pharmacy, engineering) professional society involvement is strengthened by statutory requirements for licensure.

In many countries, government-run quality assurance agencies, professional societies, and accrediting bodies consider professional practice to be very important for computing graduates, and it appears that the emphasis is even stronger for masters programs with a professional emphasis. Furthermore, the British Computer Society is "required to establish and maintain standards of competence, conduct and ethical practice for information systems professionals." [13]

Currently, accreditation for master's level computing programs does not exist in the United States, but the situation is quite different in Europe. In the United Kingdom, the British Computing Society (BCS) accredits master’s programs, while Germany requires that all bachelor’s and master’s programs be accredited by government-approved agencies, of which ASIIN is an example. The BCS accreditation guidelines emphasize the need for professionalism and professional practice: "The British Computer Society, under its Royal Charter, is required to establish and maintain standards of competence, conduct and ethical practice for information systems professionals. It also believes that students must gain a full appreciation of the wider issues of ethical standards, legislative compliance and the social and economic implications of information systems practice. One high level cognitive ability is specified as follows: "The ability to recognise the legal, social, ethical and professional issues involved in the exploitation of computer technology and be guided by the adoption of appropriate professional, ethical and legal practices" [33].

Specifically related to the masters level, BCS specifies the following cognitive abilities:

- 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 both foundations and issues at the forefront of the discipline and/or professional practice in the discipline [emphasis added]; this should also 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"
- 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"

The BCS criteria specify a number of practice-related skills: "The development of transferable skills that will be of value in a wide range of situations. These include problem solving, working with others, effective information management and information retrieval skills, numeracy in both understanding and presenting cases involving a quantitative dimension, communication skills in electronic as well as written and oral form to a range of audiences and planning self-learning and improving performance as the foundation for on-going professional development." [33]. Finally, BCS emphasizes the centrality of these issues: "Students should not perceive legal, social, ethical and professional issues as peripheral to, or less significant than, technical skills detailed in the syllabus. Topics which are not assessed may be seen by students as unnecessary. The Society considers that adequate coverage of legal, social, ethical and professional issues is important in the assessment and examination of accredited programmes and accepts that the requirements may be met in many ways." [33] This leaves no doubt about the importance BCS gives to professional issues.

The criteria of the German accreditation agency ASIIN also emphasizes professional capabilities. Already at the Bachelor's level, the criteria require that graduates:

- "are capable of communicating with colleagues and the general public about substantive issues and problems related to their chosen discipline, and can also communicate in foreign languages and at an intercultural level
- are aware of the social and ethical responsibilities that underpin their actions, and of the professional ethical principles and standards that apply to their chosen discipline
- are able to work either independently or as a member of international and mixed-gender groups, effectively organize and conduct projects, and assume corresponding leadership responsibilities
- are well-prepared upon entering the workforce for the social and work requirements of the industry or academic context, as their course of study was sufficiently practice-oriented, and
- are capable of engaging in lifelong learning." The ASIIN master's level social competence requirements go further by requiring that the students will have by

graduation "acquired scientific, technical and social competences (capacity for abstract thought, systematic analytical thinking, team and communication skills, international and intercultural experience, etc.), and are thus especially capable of assuming leadership responsibilities." (p. 13). One of the specific graduate level ASIIN criteria (2.1.4) requires "Industry focus, research focus, industrial placements, professional qualification conferred by the degree," which is explained as follows: "The competency profile described enables graduates to take up employment corresponding to their qualification. In general, an adequate connection to professional practice has been integrated into the program (external placements, laboratories, projects, etc.). Graduates are well prepared to commence work in existing or foreseeable professional fields and to face challenges in their (specialist) field." (p. 15-16). Finally, ASIIN requires that educational institutions applying for ASIIN accreditation address issues related to Professional Evaluation, which "requires institutions of higher education to show the extent to which specific professional contexts have been taken into account for the graduates of the degree programs to which the model applies." (p. 53)

In the United States, while ABET does not currently accredit master's programs in computing, the current Computing Accreditation Commission criteria [34] discuss the undergraduate requirements as follows:

- The program enables students to achieve, by the time of graduation: ... (e) An understanding of professional, ethical, legal, security and social issues and responsibilities, (g) An ability to analyze the local and global impact of computing on individuals, organizations, and society (h) Recognition of the need for and an ability to engage in continuing professional development" (p. 18)

- "The curriculum combines technical and professional requirements with general education requirements and electives to prepare students for a professional career and further study in the computing discipline associated with the program, and for functioning in modern society." (p. 18).

Summary

The discussions in the preceding sections of this report give rise to the following set of characteristics that can be used to describe any masters program in computing:

Disciplinary basis

- Broad-based informatics?
- Specialized informatics?
- Multi-disciplinary program?
- Core computing (e.g., software engineering)?
- Applications of computing (e.g., learning technology)?

Culture and context of the program

- Disciplinary roots (Computing, Engineering, Science, Humanities, Business, Library Science, ...);
- institutional and national contextual issues

Learning and/or skills outcomes

- Does the program specify explicit learning and/or skills outcomes? Which ones?
- Generic skills (e.g, teamwork, leadership, communication in written and spoken form)
- Specific skills: analysis in specific problem domains,
- Linkage to an IT skills framework?

Program nature

- Is the degree solely coursework-based?
- Does it require or allow a research or industrial component?
- Are there capstone events (thesis, exam, ...)?
- Is the degree regarded as an end product, or is it a step on the way to a third-cycle degree (Ph.D.)?
- Is the degree regarded as professional development?
- Size of the program
    - Number of faculty with primary focus on the program
    - Number of graduates per year (average over 3 years)
    - Full time/ part time ratio

Student assessment

- Does the same person do the teaching and the examining?
- Is there any review of student assessment?
    - Is it reviewed within the same department?
    - At the college or university level?
    - Outside the university?
    - Is there any industry participation in assessment?

Oversight of program quality

- None
- Accreditation
- Government review
- Other (describe)

Delivery of program

- Are students expected to be full-time?
- Is the program delivered on evenings or weekends?
- Does the program have a distance component?
- Is the program delivered by a multi-institutional partnership?

Entry issues

- Is the program accessible to people entering the computing field from another discipline?
- Other specific entry requirements (e.g. industry experience)

International component

- Required
- Optional
- Not available

Industry experience as part of the degree program

- Required
- Optional
- Not available

Conclusion

This report presents a framework for describing and comparing master's degrees in computing in Europe and the United States. The primary dimensions of the framework are preparation of entering students, student goals and outcomes, and program content and presentation. Examples of the use of the framework can be found at [URL for website]. Readers are encouraged to submit information about their programs.

This framework has been presented at SIGCSE, and ITiCSE on several occasions. It was presented at the IFIP workshop on Professionalism in Arnhem, NL in February 2009. Feedback has been received, reviewed and entered into the report.

Potential further work

There is a growing amount of information on second-cycle degrees and degree harmonization in Europe. New types of degrees are becoming more common in the United States. Additional details about these developments would be of interest to readers of this report.

The product of this work is a template for describing the characteristics of existing or proposed educational programs at the masters/second cycle level. The resulting descriptions allow potential students, faculty, and employers to understand the nature of each program and to see how distinct programs are similar and how they differ. The number and types of masters level degrees is growing rapidly. A set of curriculum recommendations for this level of programs would be impractical and perhaps impossible. What might be accomplished, however, is a set of templates for types of degrees. As a large number of programs are described, it should be possible to identify a manageable set of types. Guidance on developing curricula for programs of those types could be provided, and would foster a level of efficiency in new curriculum development. Groups who develop programs that adhere to the guidance would have some confidence that they have addressed all relevant issues, or have made a conscious choice that one or more element is not appropriate in their case. The resulting programs would be easily characterized and described in terms that would be meaningful to their intended audiences.

Of course, the most severe limitation of this framework is its limited scope. Although programs in Europe and the United States are a significant source of computing professionals, they are only part of the picture. Information about programs in Asia, Africa, Australia, and the rest of the Americas would make the picture more complete.

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