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Professional Accreditation Handbook For Computer Science Programmes

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1. FRAMEWORK OF ACCREDITATION

1.1 Introduction

The Hong Kong Institution of Engineers (the HKIE) is a professional engineering learned society and qualifying body and has a responsibility for setting and maintaining the professional and technical standards of its members. To this end, it evaluates the qualifications for admission to grades of Institution membership.

A computer science degree programme accredited by the HKIE shall meet the academic requirements for Member of the HKIE in the Information Discipline. The HKIE's process of accrediting such programmes is called professional accreditation. (A description of professional accreditation is provided in the Appendix.) This handbook sets out the HKIE's processes, mechanisms and criteria for the professional accreditation of computer science degree programmes.

The HKIE does not view the accreditation of degree programmes as discrete and limited exercises, but as part of a process to work with the universities on a continuous basis, to provide help, advice and support, to ensure that the quality of degree programmes is high and meets the needs of professionals, their employers and Hong Kong society in general.

In undertaking accreditation of computer science degree programmes, the HKIE shall seek to establish a mutual recognition agreement with other accrediting authorities in computer science degree programmes like the Seoul Accord.

1.2 Faculty based Visits

Essentially, the HKIE is concerned with the standards and quality of individual degree programmes. Consequently, it is the individual programme which receives accreditation. However, the process of professional accreditation also considers the appropriate Faculty in terms of its overall philosophy, objectives and resources. This has the advantage of taking into account the broad principles and policies of the development of computer science education in a university.

Furthermore, consideration of a range of programmes has particular advantages in relation to modular programmes and ones containing a number of elective courses.

Visits will normally be conducted by Faculty based with visits to individual departments within a Faculty for one or more programmes.

1.3 Initiation of Accreditation Exercises

The professional accreditation of computer science degree programmes in the universities is normally initiated by a university issuing an invitation to the HKIE's Accreditation Committee for Computer Science Programmes to carry out appropriate accreditation

exercises.

1.4 Consultation and Accreditation Visits

As mentioned in the introduction, the HKIE sees accreditation exercises as a continuous activity. Accordingly, any university planning new computer science degree programmes, or restructuring existing ones, is encouraged to consult the HKIE in order to ensure that the degree programmes are developed such that the requirements of all concerned are fully addressed.

1.5 Provisional and Full Accreditation

The HKIE undertakes provisional accreditation exercises to programmes which have yet to produce the first cohort of graduates and full accreditation exercises to existing programmes, whether they have been previously accredited or not.

1.6 Accreditation Decisions and the Accreditation Cycle

The HKIE can reach three accreditation decisions (section 1.11 also refers) as follows:

1.6.1 Provisional Accreditation

Provisional accreditation may be granted to developing programmes, and generally the relevant accreditation exercises will be completed during the second-half of the programme of the first cohort of intakes. Provisional accreditation provides an indication to both the university and prospective students that the programme is well structured and has very good possibilities of receiving full accreditation but should not be construed as a commitment to the granting of full accreditation.

1.6.2 Accreditation for a Period of up to Five Years

The HKIE may grant full accreditation for the normal cycle of accreditation of five years. Alternatively, the HKIE may grant full accreditation for a term of less than five years, either to bring it in line with the accreditation cycle of other programmes or to monitor a programme early in relation to any conditions which may have emerged during the accreditation process.

For a newly developed programme, a full accreditation exercise is mounted, at a time agreed with the university, after the first cohort of graduates is produced. Full accreditation, if granted, will be retrospective so as to apply to the first cohort of graduates.

1.6.3 Accreditation Refused or Withdrawn

If a programme is substantially at variance with the HKIE criteria (see section 2), then the accreditation can be refused or withdrawn.

1.7 The Accreditation Panel

The HKIE has an Accreditation Panel (not to be confused with visiting teams) which is a group of appropriately qualified experts, selected by the HKIE's Accreditation Committee for Computer Science Programmes, to participate in professional accreditation exercises, on behalf of the HKIE.

In addition, experts from overseas, with appropriate expertise are invited by the Accreditation Committee for Computer Science Programmes to be included on the Panel.

1.8 Visiting Teams

Visiting teams shall normally be selected from the Panel for each particular accreditation exercise. Team members are selected on the basis that they have no professional or any other association with the university, nor members of their families attending it. The Dean or Head of Department shall be informed of the names of the proposed chairman and members of a team, and objection to a team member may be made if there is a conflict of interest.

1.8.1 Team Size and Constitution

For a single discipline exercise, the team shall normally comprise four members including the chairman. All members shall be experienced in the discipline, or associated with it. For exercises involving two or more programmes, which may cover several computing disciplines, there shall be at least two members from, or associated with, each of the disciplines.

The accreditation visiting team shall have a good mix of academics and practising professional engineers or IT professionals. Whenever possible, members of the Accreditation Committee for Computer Science Programmes shall be invited to participate in the visits. In addition, the HKIE secretariat staff shall accompany the visiting team.

In general, to ensure continuity and expertise, team chairmen shall have considerable previous experience of professional accreditation, and most members of the team will be expected to have knowledge and experience of professional accreditation.

1.9 Accreditation Visits

Accreditation visits are an important part of an accreditation exercise. They enable the HKIE to assess, at first hand, qualitative factors, such as facilities, intellectual environment, morale, professional attitudes and the quality of staff and students.

For programmes which are being planned by a university, the HKIE will arrange consultation visits by experts as appropriate in each case. On such visits, the experts shall only comment and advise on the proposed programmes and shall not commit the HKIE to granting accreditation to a programme.

It should be noted that the accreditation visits are only a part of the accreditation exercises. There is considerable preparation prior to a visit and many post visit activities.

A visit will normally take one and a half days and shall include:

- meetings of the team with the appropriate senior university staff;
- meetings with the programme leader and other academic staff;
- meetings with the students, graduates and support staff;
- meetings with stakeholders (e.g. employers, members of advisory board, alumni);
- visit to the departmental facilities, including lecture theatres, laboratories, library and computing facilities;
- review of examination papers, laboratory instructions and reports, project reports and other materials demonstrating student performance and programme outcomes;
- private meetings of the team; and
- an exit meeting with the Dean and senior staff to convey the team's initial observations.

1.10 Accreditation Reports

Based on a consensus of opinion, ascertained at the end of a visit, the team chairman, with the assistance of the HKIE secretariat, shall draft a formal report based on the observations of the team, and assess whether the programme conforms to the HKIE Accreditation Criteria.

The following procedures have been adopted by the Accreditation Committee for Computer Science Programmes in dealing with the Accreditation Report.

(i) The visiting team chairman will draft the report with the assistance of members of the team and the HKIE staff.
(ii) The draft report will be sent to the visiting team members for comments.
(iii) The comments made by the members of the visiting team will be considered by the chairman.
(iv) The modified draft report will then become the final report.
(v) The final report will be sent to the Dean and relevant Head(s) of Department(s)

for comments on the factual accuracy of the report and for providing responses to the report.

(vi) The comments made by the Dean and Head(s) will be sent to the visiting team chairman and the assessor.

(vii) The final report, and the comments made by the Dean and Head(s) will be submitted to the Accreditation Committee for Computer Science Programmes at the decision meeting.

The HKIE maintains strict confidentiality regarding accreditation matters. It is for the university to decide how information related to this accreditation should be released and may inform the HKIE accordingly.

1.11 Accreditation Decisions

In advance of the accreditation visit, the Accreditation Committee for Computer Science Programmes will appoint one of its members, who can join the visit as an observer, to act as an assessor. The assessor will study all the documentation and, in consultation with the visiting team chairman, make recommendations to the Committee for an accreditation decision. The Chairman of the Committee will initiate the discussion on the programme(s) under consideration.

The accreditation report and university responses, and all other relevant information and correspondence are passed to the Committee for a decision.

The representatives of the university concerned, usually the Dean and/or Head of Department may attend that part of the Committee meeting devoted to the presentation of the report. Members of the visiting team may also be present.

At the meeting, the visiting team chairman will present the report and representatives of the university may put forward further information and answer questions of fact. The Committee will then conduct a private meeting from which the university representatives are excused. The assessor will present recommendations. The Committee may then make decisions on the programme(s) (section 1.6 refers).

The Secretary to the Committee will write to inform the university of the decision with a copy of the final report, in confidence, to the university Vice Chancellor/President/Director, copied to the relevant Dean and Head of Department.

1.12 Costs

Any university having its computer science programmes to be accredited by the HKIE shall pay an accreditation fee on each visit. The accreditation fee charged per visit is to be determined by the Accreditation Committee for Computer Science Programmes.

The direct costs of each accreditation exercise (travel, subsistence, accommodation) will

be paid by the university concerned.

1.13 Confidentiality

All documents and other information obtained by the Accreditation Committee for Computer Science Programmes during the course of an exercise are kept confidential.

1.14 Appeal Procedures

In the event of a decision by the Accreditation Committee for Computer Science Programmes to refuse or terminate accreditation of a degree programme, the university concerned has the right to appeal to the Accreditation Board to review the decision.

2. CRITERIA FOR THE ACCREDITATION OF COMPUTER SCIENCE DEGREE PROGRAMMES

2.1 Introduction

The HKIE acts as the accrediting authority to evaluate the standard and quality of computer science programmes. In doing so, it takes into account a number of factors about the programmes and the universities which offer them. The quality of a computer science programme depends on more than just the curriculum and syllabus. The quality of graduates is an important consideration in the evaluation of a computer science programme. The degree programme must define outcomes that they expect of their graduates consistent with their educational objectives and the needs of the discipline; and describe the processes that are used to measure and evaluate these outcomes. In addition, the calibre of the academic staff, the entry standards, staffing levels, teaching methods, facilities, funding and methods of assessment are just some of the factors which influence the quality of the educational experience and the outcomes.

The following describes broad criteria which will be used in assessing computer science programmes. In setting them out, the HKIE considers it important for universities to provide an environment which can accommodate innovative educational developments and for the strengths, qualities and ideals of universities.

2.2 Standards

The HKIE seeks to conform with internationally recognised standards in terms of accreditation processes and outcomes, in particular the Seoul Accord signatories.

2.3 Aims and Objectives

In its submission for accreditation of a computer science programme(s), a university should be able to express the aims, objectives and ethos of the programme(s) both in relation to the appropriate standards of degree level education and the requirements of the profession. The university should demonstrate how its programme(s) meets the aims and objectives, and how they can respond to future developments.

The HKIE appreciates that computer science programmes are dynamic entities, which must evolve with technology and the changing needs of the profession and society. Consequently, the HKIE expects a university to be able to articulate such developments in terms of how the structure and rationale of its programmes can respond to change. Based on generally accepted norms, computer science programmes must demonstrate that their graduates have the following attributes:

(a) An ability to apply knowledge of computing and mathematics appropriate to the programme outcomes and to the discipline
(b) An ability to apply knowledge of a computing specialisation, and domain knowledge

appropriate for the computing specialisation to the abstraction and conceptualisation of computing models

(c) An ability to analyse a problem, and identify and define the computing requirements appropriate to its solution

(d) An ability to design, implement, and evaluate a computer-based system, process, component, or program to meet desired needs with appropriate consideration for public health and safety, social and environmental considerations

(e) An ability to function effectively on teams to accomplish a common goal

(f) An understanding of professional, ethical, legal, security and social issues and responsibilities

(g) An ability to communicate effectively with a range of audiences

(h) An ability to analyse the local and global impact of computing on individuals, organisations, and society

(i) Recognition of the need for and an ability to engage in continuing professional development

(j) An ability to use current techniques, skills, and tools necessary for computing practice with an understanding of the limitations.

The interpretation of the above graduate attributes should be consistent with the requirements of the Seoul Accord, including the range of problem solving and range of computing activities and a copy of the Seoul Accord Graduate Attributes is enclosed as Appendix in this Handbook.

2.4 Duration

The HKIE believes that computer science programmes should have a minimum duration of four years full-time equivalent, of which a one-year full time equivalent consists normally of about 26 weeks of classroom, laboratory, workshop and related activities. (Time allocated to assessment and practical training is excluded from these 26 weeks.)

The criteria set out here provide broad guidance for a four-year full-time equivalent programme. It is accepted that a longer programme than this will enable an academic institution to introduce subjects and activities which could contribute further to the education of a computer science undergraduate, but the onus is on the university to demonstrate that the programme contains at least the equivalent of the four years which meets the HKIE's requirements. When technology based delivery of content is used, the university must demonstrate the equivalence of this method with traditional delivery methods.

2.5 Part-time Degree Programme

If a part-time degree programme is offered, or if a student undertakes a programme on a part-time basis, all requirements of an accredited programme must be met.

2.6 Syllabus and Curriculum

Computer science programmes fall within the domain of information science and computer technology, and is defined as:-

Definition

Computer Science is a discipline which applies appropriate scientific principles and technological advances to the design and utilization of computing techniques and computer systems to solve practical problems. The scope includes fundamentals of computation (such as algorithms and data structures), computer components (such as processors, networks and operating systems) and applications (such as software, database and data communication systems). It also involves specification, design, development, construction, testing, maintenance, and quality assurance of computing techniques and systems. In addition, Computer Science addresses issues which are pertinent to computing techniques and computer systems, such as safety, cost effectiveness, efficiency, reliability, user-friendliness, legal issues and ethics.

The HKIE accepts that over the whole range of the computing disciplines, it is not possible to state precisely the essential characteristics and content of courses and programmes. However, the Institution expects the curricula to prepare students in a broad range of computer science and engineering subjects, mathematics and sciences, and complementary electives, appropriate to the degree discipline. The Institution considers that these would normally include:

(a) three-fourths year of mathematics and sciences;
(b) one and a half years of computer science and engineering subjects; and
(c) complementary electives that support the professional nature of the curriculum.

A description of each is given below to provide guidance, but is not considered to be all-inclusive. The programme must ensure that its curriculum is consistent with the prescribed outcomes and objectives. The presence of each of the above elements in the curriculum is not sufficient evidence that the graduates have the outcomes that the programme desires.

The description below is provided in the context of computer science discipline. In future, the HKIE may undertake accreditation of other computing disciplines than computer science, and separate set of criteria guide will be published.

2.6.1 Mathematics and Sciences

The mathematics content of computer science degrees should underpin the scientific subjects and should emphasise concepts, principles and their applications to problem solving. It is accepted that these can be delivered as separate topics. However, the accrediting authority believes that it is also desirable for mathematics to be delivered within the context of its applications to computing techniques and computer systems and be within the scientific subjects of the programme.

Sample subjects include, but not limited to the following:-

Underpinning Mathematics

· Discrete Mathematics
· Probability and Statistics
· Logic

The sciences content of computer degrees should develop an understanding of the scientific method and provide students with an opportunity to experience this mode of inquiry in courses for computer science and engineering subjects and may include, but not limited to the following subjects:

· Chemistry
· Physics
· Biology

2.6.2 Computer Science and Engineering Subjects

A computer science programme should include subjects which require:-

(i) the students to obtain a high level of proficiency and a practical knowledge of the science and technology of computing such as design of algorithms and fundamentals of computation;

(ii) the application of scientific, engineering and mathematical principles to the analysis and solutions of problems;

(iii) an emphasis in design and synthesis which should be taught in the context of design philosophy and technology as well as financial, quality, and security implications.

Projects

Projects are an important means of helping students to develop a professional approach to the use of computer systems and computing techniques to solve practical problems. For this reason, the use of projects as a vehicle for the integration of subject areas is strongly recommended throughout the programme. Normally, the final year of the computer science programme should include an intellectually challenging project which is individually assessed. The project should pull together the many strands of the programme, particularly addressing design, synthesis, application, and creativity. The assessment of the project should have a significant weighting in the degree classification.

Sample subjects include, but not limited to the following :-

Fundamentals of Computation

- Algorithm design and analysis
- Data structures
- Complexity and computability

Computer Systems

- Computer organization and architecture
- Communications and networking
- Distributed and parallel systems

Data and Knowledge Bases

- Representation, modelling and processing of data
- Database management
- Information retrieval

Software Systems and Software Engineering

- Programming languages, compilation, and operating systems
- Program design and development
- Software design and specification methods
- Group design and implementation

2.6.3 Complementary Electives

Studies which provide an appreciation of those wider issues which enable Information engineers to practise professionally in society should be fully integrated within the programme. Such studies may include management, economics, law, history, finance or a foreign language. Furthermore, the following elements should be included in the curriculum.

(a) Training through work experience

The benefits of practical experience obtained during a computer science programme are recognised and students are encouraged to aggregate significant, relevant training or employment. This will normally be obtained during summer and winter vacations, and universities should encourage this activity.

(b) Communications

It is essential for students of computer science programmes to have good communication skills. Computer science programmes should contain instruction in the art and practice of communication in spoken and written English as well as presentation.

(c) The role of computer and IT professionals

Students are expected to be familiar with the role of professionals in practice and their responsibilities towards the profession, colleagues, employees, clients and the public, particularly with reference to the impact of technology on society. Furthermore, they should be made aware of the role of professional institutions and matters of professional practice such as professional qualification and registration.

2.7 Academic Staff

An important factor in determining the standard of a computer science programme is the quality and commitment of the teaching staff. The programme must demonstrate that they have academic staff consistent with the delivery of the educational objectives and outcomes desired. The qualifications and number of staff is a necessary, but not sufficient criteria in establishing the appropriateness of the teaching cadre.

2.8 Resources

A computer science programme relies on an adequate provision of support staff, administration, laboratories, information services, computer facilities, finance and other resources as follows:

2.8.1 Support Staff

There should be sufficient qualified technicians and workshop staff to ensure the smooth and safe management of laboratories, maintenance of equipment and general support.

Administrative and secretarial staff should be sufficient to support the academic staff.

2.8.2 Accommodation and Equipment

There must be adequate provision of lecture rooms, laboratories, workshops and private study areas to support the programme of lectures, tutorials and laboratory sessions. Laboratories should be well equipped with adequate and modern equipment and should provide a safe working environment for the students.

2.8.3 Computer Facilities

Computer facilities should be consistent with the aims of the programme. Students should have easy and adequate access to such facilities.

2.8.4 Information Services

The university should provide adequate resources for information services which include conventional and digital up-to-date methods and facilities, for example, books, journals,

tapes, films, disks and databases.

Conventional and digital library facilities should provide a range and variety of technical and non-technical books, and a comprehensive range of journals covering all information system science and technology disciplines. The inter-library loan system should be available to all students, together with abstract and literature search facilities for project work. Students should have easy and adequate access to these facilities.

2.8.5 Financial Resources

There should be adequate financial resources to ensure the smooth operation of the department, the provision and maintenance of laboratories, computers, libraries and other support facilities as well as for the development of staff, programmes, courses, and the upgrading of equipment.

2.9 Assessment

Assessment of student performance should demonstrate the effectiveness of the learning process in achieving the programme outcomes.

The HKIE believes that there should be an effective internal quality assurance system which is essential to maintain the academic standards of programmes. In addition, there should be an independent quality assurance system such as an external examiner system or equivalent.

2.10 Entry Levels

The HKIE does not prescribe minimum qualifications for entry to computer science degree programmes, but it does expect that the selection criteria are consistent with the majority of students being able to complete the programme at the expected standard.

The programme must demonstrate that the selection procedures in place are consistent with the selection criteria and the expected outcomes.

2.11 Development

The HKIE believes it is incumbent on an academic institution to be sensitive to the requirements of society and the profession, and consequently, to develop programmes to respond to local and international requirements and to provide opportunities for staff to be able to develop their skills so that they can deliver programmes meeting local and international professional and academic standards. In order to do this, the HKIE believes that universities have a responsibility to liaise with the profession and industry in relation to computer science degree programmes and their development.

2.12 Programme Amendments

It is expected that from time to time there will be evolutionary changes to a programme within the period of its accreditation. Any modifications to a programme should maintain the spirit of the programme as accredited and may include such changes as:

- a change in the title of the programme;
- a change in the length of the programme;
- the addition of options and/or streams;
- the deletion of some subjects;
- a significant change in the provision of resources for the programme.

The university should inform the HKIE of the above and other major curriculum or operational changes. The Accreditation Committee for Computer Science Programmes may then consider any subsequent actions, including initiation of a visit or request of a written report.

3. ACCREDITATION SUBMISSIONS

When preparing a submission for professional accreditation, the university is advised to consider the criteria in section 2 carefully, and to consult the HKIE as appropriate.

3.1 Provisional or Full Accreditation

The information requested in the following sections relates to both provisional and full accreditation submissions.

For the provisional accreditation of developing programmes, the process should normally commence at least six months before the first cohort of intakes has reached the half way stage of the programme, at which time a university should provide the preliminary details (section 3.2).

For the full accreditation of existing programmes, a university should submit the preliminary details no later than six months before the expiry of the current approval.

For the full accreditation of developing programmes, the exercises may commence at a date, mutually acceptable to the HKIE and the university, after the first cohort of graduates has emerged. The preliminary details should be submitted no later than six months before the visit.

In both cases, the full information requested (section 3.3) should be submitted at least six weeks before the date of any visit. If, as a result of considering the submission, further information is required, the chairman of the HKIE Accreditation Committee for Computer Science Programmes in consultation with the chairman of the visiting team and the university may arrange to defer the timing of any visit or, in exceptional circumstances, the cancellation of the exercises.

3.2 Preliminary Details

A university seeking accreditation of a programme(s) is required to submit the following preliminary details:

1. title of the Faculty or Department;

2. names, qualifications and date of appointments of Dean and Heads of Department;

3. title of the programme;

4. name of programme leader;

5. accreditation sought (provisional or full);

6. brief resume(s), 100 words maximum, about the programme(s) submitted;

7. provisional dates for the visit.

Upon receiving the preliminary details, the HKIE will contact the university seeking further information and/or providing further directions related to the submission.

3.3 Full Information

Submission of full information for accreditation should be made by completing the questionnaire contained in the HKIE standard submission format. Softcopies of the questionnaire are available from the HKIE upon request. Copies of the completed questionnaire are to be provided at least six weeks before the date of a visit. The questionnaire is set out as follows:

Part 1: General information related to the university/institution
Part 2: General information related to the department
Part 3: Information related to the computer science programme – general
Part 4: Information related to the computer science programme – criteria specific

3.4 Information to be Available During the Visit

The following materials and representative samples of student work that reveal the spectrum of educational outcomes are to be made available during the accreditation visit:

1. Evidence of process used to identify educational objectives.

2. Evidence of process used to identify programme outcomes.

3. Evidence regarding students' achievement of the intended learning outcomes at various stages of the programme. This may include students' work, e.g. examination papers, marked examination scripts, examples of final year projects, laboratory reports, external evaluation, etc.

4. Evidence of process used to improve the educational system of the programme including changes that have been made and/or proposed.

APPENDIX

NOMENCLATURE

Academic Accreditation
Any evaluation or assessment to determine whether the academic standards of an institution of higher education are comparable with internationally recognised standards. It includes course validation, course revalidation, institutional review and institutional accreditation.

Professional Accreditation
The evaluation and comparison of the academic standards of a degree or sub-degree and consideration of the appropriateness of the education component of that degree or sub-degree for professional practice.

The Accreditation Panel
Those Members of the Institution who are appointed to carry out professional accreditation visits on behalf of the HKIE.

The Accreditation Exercise
The complete professional accreditation process.

The Accreditation Visit
A visit to an academic institution as an integral part of the professional accreditation exercise.

The Visiting Team
Members of the Accreditation Panel selected to carry out a specific accreditation exercise.

Programme
Refers to the complete curriculum of a degree, comprising courses/modules/credit units, assignments, workshops, projects and supported by other resources which may include staff resources, laboratory facilities, computer facilities, information services, financial resources and so on.

Course
Refers to a specific taught part of a degree programme (course is sometimes used to describe a whole degree programme, where that programme has a fixed curriculum). Courses are sometimes referred to as subjects, modules or credit units.

Section D - Graduate Attributes

D.1 Introduction

The role of professionals who innovate, design, implement and maintain computers, computing systems, and computing applications has become essential to both the economic development of, and the provision of services to, society. Typical computing activities require several roles that are named and recognized in different ways in many jurisdictions.[1] These roles, with a degree of overlap among them, are defined by their respective distinctive competencies.

The development of a computing professional is a continuous learning process. The first stage may be the attainment of an *accredited educational qualification*, the graduate stage. The second stage, following a period of training and experience, may lead to *professional registration, licensure*, or some other professional recognition, depending on the country or jurisdiction. In addition, computing professionals are expected to engage in life-long learning in order to maintain and enhance competency throughout their working lives.

Because of the universally essential nature of computer applications and the mobility of professionals across jurisdictional boundaries due to globalization, there is a real need to identify academic programs that adequately prepare graduates for entry into a computing profession based on generally recognized knowledge and abilities across country and other jurisdictional boundaries. Toward this end, the Seoul Accord is established as a mechanism for recognizing the equivalence of accredited educational qualifications in the development of computing professionals. The Seoul Accord provides for mutual recognition of graduates of accredited programs[2] among the Signatories of the Accord. This Accord is based on the principle of equivalence of educational preparation for entry to a computing profession, rather than on exact correspondence of content and outcomes of accredited programs. This document, Seoul Accord Graduate Attributes (SAGA), presents the Accord Signatories' consensus on the generally-accepted attributes of graduates for programs included in the Accord.

Section 2 of this document provides background, scope, limitations, and the contextual interpretation for the graduate attributes (presented in Section 5). Section 3 provides a number of definitions that form a common basis for understanding the general applicability of the attributes. General range statements are presented in Section 4, and the graduate attributes themselves are provided in Section 5.

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[1] The term *computing* is used in this document as a discipline in a broad sense, and it includes many other general terms such as *informatics*, *computing and IT-related*, and *information and communication technology* that may be used elsewhere. It is recognized that different terminology is used in different countries, and that specific titles or designations may have differing legal empowerment or restrictions within individual jurisdictions.

[2] The term *program* is used in this document to indicate the academic qualification that prepares a graduate for entry into a computing profession. Other terms for the same thing, such as *course*, may be used in some educational systems.

D.2 Background for the Graduate Attributes

D.2.1 Purpose of Graduate Attributes

The *graduate attributes* are intended to define the scope and standards for programs that are recognized by the Seoul Accord, as well as to assist Accord Signatories and Provisional members in developing outcomes-based accreditation criteria for use in their respective jurisdictions. Also, the graduate attributes guide bodies that are currently developing their accreditation systems with a goal of seeking to become Signatories of the Accord.

Graduate attributes form a set of individually-assessable outcomes that are indicative of a graduate's potential competency. The graduate attributes are exemplars of the attributes expected of a graduate from an accredited program. Each attribute is a succinct statement of an expected capability, qualified, if necessary, by a range indication appropriate to the type of program. The attributes identify the characteristics of graduates of all computing programs that fall within the scope of the Seoul Accord. A Signatory may identify additional attributes that differentiate specific programs accredited by the Signatory.

D.2.2 Limitation of Graduate Attributes

Each Signatory defines the criteria against which computing educational programs are evaluated for accreditation. The Accord is based on the principle of *Substantially Equivalent qualification*. That is, programs are not expected to have identical outcomes or content, but rather are expected to produce graduates who are prepared to enter professional careers in computing. The graduate attributes provide a point of reference for accreditation bodies to describe the outcomes of a Substantially Equivalent qualification. The graduate attributes do not represent "international standards" for accreditation.

D.2.3 Scope and Organization of Graduate Attributes

In defining the attributes, it is useful to distinguish among various types of post-secondary educational preparation. In conformance with corresponding terminologies employed by the International Educational Accords [3], the graduate attributes contrast the differences among the educational preparation for what will be called the *computing professional*, the *computing technologist*, and the *computing technician*. Each of these categories is unique in the range of problem solving skills and professional competency, and the categories are generally typified by successively less formal educational requirements. For each attribute name, characteristics or abilities relative to the attribute that should be obtained through formal education or training are listed for each of the roles of computing professional, computing technologist, and computing technician. The scope of the Seoul Accord encompasses only those academic programs that are accredited by Accord Signatories as preparing graduates for roles as computing professionals.

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[3] The International Educational Accords are comprised of the Washington Accord, Sydney Accord, and Dublin Accord (see http://www.washingtonaccord.org/)

Each of the attribute statements is formulated for the professional, technologist, and technician using a common stem, with varying additions appropriate to each educational track. For example, for the **Knowledge for Solving Computing Problems** attribute:

Common Stem: Apply knowledge of computing fundamentals, knowledge of a computing specialization, and mathematics, science, and domain knowledge appropriate for the computing specialization ...

Computing Professional Range: ... to the abstraction and conceptualization of computing models from defined problems and requirements.
Computing Technologist Range: ... to defined and applied computing procedures, processes, systems, or methodologies.
Computing Technician Range: ... to a wide variety of practical procedures and practices.

The resulting statements are shown below for this example:

... for **Seoul Accord (Computing Professional)** graduate	... **for Computing Technologist** graduate	... for **Computing Technician** graduate
Apply knowledge of computing fundamentals, knowledge of a computing specialization, and mathematics, science, and domain knowledge appropriate for the computing specialization to the abstraction and conceptualization of computing models from defined problems and requirements.	Apply knowledge of computing fundamentals, knowledge of a computing specialization, and mathematics, science, and domain knowledge appropriate for the computing specialization to defined and applied computing procedures, processes, systems, or methodologies.	Apply knowledge of computing fundamentals, knowledge of a computing specialization, and mathematics, science, and domain knowledge appropriate for the computing specialization to a wide variety of practical procedures and practices.

The range qualifier in several attribute statements uses the notions of complex computing problems, broadly-defined computing problems, and well-defined computing problems or the notions of complex activities, broadly-defined activities, and well-defined activities. These designators for different levels of problem complexity and professional activity are defined in Section 4, and the full set of graduate attribute definitions is given in Section 5.

D.2.4 Contextual Interpretation

The graduate attributes are stated generically and are applicable to all computing disciplines. In interpreting the statements within a disciplinary context, each individual statement may be amplified and given particular emphasis, but in doing so its substance must not be altered and its individual elements must not be ignored.

D.3 Definitions Associated with the Graduate Attributes

The **practice area** of a computing professional, computing technologist, or computing technician is defined both by the area of computing knowledge and skills, and by the nature of the activities performed.

A **computing problem** in any domain is one that can be solved by the application of computing knowledge, skills, and generic competencies.

Solution means an effective proposal for resolving a problem, taking into account all relevant technical, legal, social, cultural, economic, and environmental issues and respecting the need for sustainability.

D.4 Common Range and Contextual Definitions Associated with the Graduate Attributes

D.4.1 Range of Problem Solving

	Characteristic	A **Complex Computing Problem** is a computing problem having some or all of the following characteristics:	A **Broadly-defined Computing Problem** is a computing problem having some or all of the following characteristics:	A **Well-defined Computing Problem** is a computing problem having some or all of the following characteristics:
1	Range of conflicting requirements	Involves wide-ranging or conflicting technical, computing, and other issues	Involves a variety of factors, which may impose conflicting constraints	Involves several issues, but with few of these exerting conflicting constraints
2	Depth of analysis required	Has no obvious solution, and requires conceptual thinking and innovative analysis to formulate suitable abstract models	Can be solved by application of well-proven analysis techniques	Can be solved in standardised ways
3	Depth of knowledge required	A solution requires the use of in-depth computing or domain knowledge and an analytical approach that is based on well-founded principles	A solution requires knowledge of principles, and applied procedures or methodologies	Can be resolved using limited theoretical knowledge, but normally requires substantial practical knowledge
4	Familiarity of issues	Involves infrequently-encountered issues	Belongs to families of familiar problems, which are solved in well-accepted ways; context may be unfamiliar	Is frequently encountered and thus familiar to most practitioners in the field; context may be unfamiliar
5	Level of problem	Is outside problems encompassed by standards and standard practice for professional computing	May be partially outside those encompassed by standards or standard practice	Is encompassed by standards and/or documented procedures of practice
6	Extent of stakeholder involvement and level of conflicting requirements	Involves diverse groups of stakeholders with widely varying needs	Involves several groups of stakeholders with differing and occasionally conflicting needs	Involves a limited range of stakeholders with differing needs

7	Consequences	Has significant consequences in a range of contexts	Has consequences that are important locally, but may extend to a broader context	Has consequences that are important locally, and usually are not far-reaching
8	Interdependence	Is a high-level problem possibly including many component parts or sub-problems	Is part of, or systems within, a complex computing problem	Is a discrete component of a computing system
9	Requirement identification	Identification of a requirement or the cause of a problem is ill defined or unknown	Identification of a requirement or the cause of a problem is possible from a set of known options	A requirement or the cause of a problem can be determined by well-established ways

D.4.2 Range of Computing Activities

	Characteristic	A **Complex Computing Activity** is a computing activity or project that has some or all of the following characteristics:	A **Broadly-defined Computing Activity** is a computing activity or projects that has some or all of the following characteristics:	A **Well-defined Computing Activity** is a computing activity or project that has some or all of the following characteristics:
1	Range of resources (people, money, equipment, materials, information, and technologies)	Involves the use of diverse resources	Involves a variety of resources	Involves a limited range of resources
2	Level of interactions	Requires resolution of significant problems arising from interactions among wide-ranging or conflicting technical, computing, contextual, or other issues	Requires resolution of occasional interactions among technical, computing, contextual, and other issues, of which few are conflicting	Requires resolution of interactions between limited technical and computing issues, with little or no impact from broader issues
3	Innovation	Involves creative use of knowledge of computing or domain principles in novel ways	Involves the use of new resources, techniques, or computing processes in innovative ways	Involves the use of existing resources techniques, or computing processes in new ways
4	Consequences to society and the environment	Has significant consequences in a range of contexts	Has consequences that are most important locally, but may extend more widely	Has consequences that are locally important and not far-reaching
5	Familiarity	Can extend beyond previous experiences by applying principles-based approaches	Requires a knowledge of normal operating procedures and processes	Requires a knowledge of practical procedures and practices for widely applied operations and processes

D.5 Graduate Attributes

The following table provides profiles of graduates of three types of postsecondary educational computing programs. See Section 4 for definitions of *complex*, *broadly-defined*, and *well-defined*

computing problems and activities. Note that the Seoul Accord applies only to the Computing Professional graduate, and that the columns for Computing Technologist and Computing Technician are included for comparative and clarification purposes only.

		Differentiating Characteristic	... for Seoul Accord (Computing Professional) Graduate	... for Computing Technologist Graduate	... for Computing Technician Graduate
1	**Academic Education**	Educational depth and breadth	Completion of an accredited program of study designed to prepare graduates as computing professionals	Completion of a program of study typically of shorter duration than for professional preparation	Completion of a program of study typically of shorter duration than for technologist preparation
2	**Knowledge for Solving Computing Problems**	Breadth and depth of education and type of knowledge, both theoretical and practical	Apply knowledge of computing fundamentals, knowledge of a computing specialization, and mathematics, science, and domain knowledge appropriate for the computing specialization to the abstraction and conceptualization of computing models from defined problems and requirements	Apply knowledge of computing fundamentals, knowledge of a computing specialization, and mathematics, science, and domain knowledge appropriate for the computing specialization to defined and applied computing procedures, processes, systems, or methodologies	Apply knowledge of computing fundamentals, knowledge of a computing specialization, and mathematics, science, and domain knowledge appropriate for the computing specialization to a wide variety of practical procedures and practices
3	**Problem Analysis**	Complexity of analysis	Identify and solve *complex* computing problems reaching substantiated conclusions using fundamental principles of mathematics, computing sciences, and relevant domain disciplines	Identify, formulate, research literature, and solve *broadly-defined* computing problems reaching substantiated conclusions using analytical tools appropriate to the discipline or area of specialization	Identify and solve *well-defined* computing problems reaching substantiated conclusions using codified methods of analysis specific to the field of activity

4	**Design/ Development of Solutions**	Breadth and uniqueness of computing problems, i.e., the extent to which problems are original and to which solutions have previously been identified or codified	Design and evaluate solutions for *complex* computing problems, and design and evaluate systems, components, or processes that meet specified needs	Design solutions for *broadly-defined* computing technology problems, and contribute to the design of systems, components, or processes to meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations	Design solutions for *well-defined* computing problems, and assist with the design of systems, components, or processes to meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations
5	**Modern Tool Usage**	Level and appropriateness of the tool to the type of activities performed	Create, select, or adapt and then apply appropriate techniques, resources, and modern computing tools to *complex* computing activities, with an understanding of the limitations	Select and apply appropriate techniques, resources, and modern computing tools to *broadly-defined* computing activities, with an understanding of the limitations	Apply appropriate techniques, resources, and modern computing tools to *well-defined* computing activities, with an awareness of the limitations
6	**Individual and Team Work**	Role in, and diversity of, the team	Function effectively as an individual and as a member or leader of a team in multi-disciplinary settings	Function effectively as an individual and as a member or leader in diverse technical teams	Function effectively as an individual and as a member in diverse technical teams
7	**Communication**	Level of communication according to type of activities performed	Communicate effectively with the computing community about *complex* computing activities by being able to comprehend and write effective reports, design documentation, make effective presentations, and give and understand clear instructions	Communicate effectively with the computing community and with society at large about *broadly-defined* computing activities by being able to comprehend and write effective reports, design documentation, make effective presentations, and give and understand clear instructions	Communicate effectively with the computing community and with society at large about *well-defined* computing activities by being able to comprehend the work of others, document one's own work, and give and understand clear instructions

8	**Computing Professionalism and Society**	No differentiation in this characteristic except level of practice	Understand and assess societal, health, safety, legal, and cultural issues within local and global contexts, and the consequential responsibilities relevant to professional computing practice	Understand and assess societal, health, safety, legal, and cultural issues within local and global contexts, and the consequential responsibilities relevant to computing technologist practice	Understand and assess societal, health, safety, legal, and cultural issues within local and global contexts, and the consequential responsibilities relevant to computing technician practice
9	**Ethics**	No differentiation in this characteristic except level of practice	Understand and commit to professional ethics, responsibilities, and norms of professional computing practice	Understand and commit to professional ethics, responsibilities, and norms of computing technologist practice	Understand and commit to professional ethics, responsibilities, and norms of computing technician practice
10	**Life-long Learning**	No differentiation in this characteristic except level of practice	Recognize the need, and have the ability, to engage in independent learning for continual development as a computing professional	Recognize the need, and have the ability, to engage in independent learning for continual development as a computing technologist	Recognize the need, and have the ability, to engage in independent learning for continual development as a computing technician

D.6 Conclusion

Judgments on the standards of academic qualifications are often subjective. Only in the formal accreditation process is evidence judged against defined criteria. These criteria have become increasingly aligned through international accords, driven by globalisation of computing practice and the accompanying mobility of computing graduates and professionals. The Graduate Attributes listed here comprise a definition by the Seoul Accord of a set of outcomes that typify potential competency and performance on the part of graduates of computing programs within the scope of the Accord. The Graduate Attributes will undoubtedly be refined as the computing discipline and the criteria of the Accord Signatories evolve.

D.7 Acknowledgement

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