Information Systems and Technology Accreditation Council *(ISTAC)*

Accreditation Criteria

- **Applied Degree**
- **Diploma**
- **Certificate**

As of January 1, 2021

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Abstract

These guidelines are written to aid faculty and administrators involved in the accreditation of Information and Communications Technology (ICT) programs within public and private not-for-profit universities, colleges and institutes of technology. These guidelines are administered by the Information Systems and Technology Accreditation Council *(ISTAC)* and apply to programs leading to certificates, diplomas and applied degrees and are typically one to four years of duration. Specific criteria are applicable depending upon the duration and intent of the programs undergoing accreditation.

A separate set of criteria are applicable to the accreditation of university degree programs in computer science, software engineering and related inter-disciplinary degree programs under the Computer Science Accreditation Council (CSAC). For further information related to which Accreditation Council and Criteria would be appropriate for a specific program or set of programs, please contact the Canadian Information Processing Society (CIPS) Accreditation Secretariat.

The following sections specify the objectives of accreditation, the various steps in the process, and the essential and desirable qualities of accreditable programs. Questions and suggestions for improvements may be sent directly to the CIPS Accreditation Secretariat (accreditation@cips.ca).

1. Introduction

The Information Systems and Technology Accreditation Council is an autonomous body established by the Canadian Information Processing Society.

The Council has as its objectives:

1. To formulate and maintain high educational standards for universities, colleges and institutes of technology offering information and communications technology (ICT) programs, and to assist those institutions in planning and carrying out educational programs.
2. To promote and advance all phases of ICT education with the aim of promoting public welfare through the development of better educated computer practitioners and professionals.
3. To foster a cooperative approach to ICT education among industry, government, and educators both nationally and globally to meet the changing needs of society.

The purpose of accreditation is to recognize programs whose graduates will have received an outstanding undergraduate education in ICT – an education informed by state-of-the-art professional practice, sound underpinnings of information and computer technologies, and the needs and applications of industry. Accreditation can also be an important component in an Institution's quality monitoring and improvement program.

ISTAC accredits programs primarily in Canada but welcomes institutions from outside Canada wishing to undergo accreditation based on ISTAC criteria and standards.

ISTAC accreditation criteria incorporates principles of *outcomes-based* accreditation. This contrasts with an emphasis on educational *inputs*, such as number of courses taught, and lists of topics in the curriculum. The emphasis of these criteria is instead towards *outcomes*, i.e., *identifying and setting sound educational objectives and measuring the extent to which these objectives have been met*. These objectives and outcomes can be expressed at course or program levels.

More specifically, outcomes-based accreditation requires the setting of clear program *objectives* (i.e. the intended purpose of the program) and program *outcomes* which describe what students should know and be capable of doing upon graduation from the program. Program outcomes can also be expressed as *graduate attributes*, defined as 'a set of individually-assessable outcomes that are indicative of a graduate's potential competency' [SA citation]. Institutions will typically set their own specific program objectives, outcomes and graduate attributes but ISTAC-ccredited programs are expected to substantially meet one of three ranges of graduate attributes as defined by the Seoul Accord which has established a set of internationally recognized expectations for students graduating from various types of ICT programs.

ISTAC accreditation is designed primarily for applied degree, diploma and certificate programs as offered through universities, colleges, institutes of technology and other institutes of higher learning. Specific ISTAC criteria are provided corresponding to the three levels or ranges of graduate attributes as set by the Seoul Accord[1]*. As such, ISTAC accreditation is intended to be applied to a wide range of program types and durations, providing institutions with the flexibility to design ICT program outcomes and graduate attributes to meet the needs of their institutional mandates, students and target industries.

[1] "The eight signatories of the Seoul Accord have joined together for the primary purpose of contributing to the improvement of computing education worldwide through the mutual recognition of accredited academic computing programs that prepare graduates for professional practice. By establishing desired attributes for graduates of computing programs that prepare graduates for professional practice..."

URL: http://www.seoulaccord.org/about.php

2. Method of Evaluation

Programs submitted for accreditation will be evaluated on the basis of data submitted by the institution in the form of a self-study report and other supporting documentation, together with the report of an on-site visit by a qualified team representing the Council.

The self-study report should follow a structured outline to be described in Sections 5 though 11, and involves answering a series of questions and completion of tables. During the process of creating the report, the institution should demonstrate to itself and to the Council that it can meet the accreditation criteria or, if not, it should demonstrate that it is aware of the shortcomings and has a concrete plan to rectify them. In particular, the report should demonstrate how all aspects of the program, including students, faculty, resources and curriculum together enable the achievement of a set of defined program objectives, discussed in Section 4. The self-study report will be used as primary input for the analysis of the program by the on-site visiting team.

The purpose of the site visit is three-fold:

First, the site visit should assess factors beyond those described in the questionnaire. The overall educational environment, the morale and calibre of the staff and the student body, and the approach taken to the work performed are examples of intangible qualitative factors that are not always apparent in a written statement.

Second, the visiting team can observe firsthand the strengths, unique characteristics and areas of potential improvements related to the program.

Third, the team will assess and validate the material in the self-study including:

1. Organization structure and administration of the institution.
2. Education programs offered, and credentials conferred by the institution overall.
3. The basis of and requirements for admission of students both in general and to the program(s) undergoing accreditation.
4. Number of students enrolled in the educational programs undergoing accreditation.
5. Teaching staff and teaching loads.
6. Commitment to and support for professional development, industry involvement and research.
7. Resources:
    a. financial: total budget, non-salary portion of budget and salary scales,
    b. physical: classrooms, laboratories, equipment and offices,
    c. support staff: administrative, clerical, laboratory, research and technical,
    d. reference materials: electronic resources and/or digital libraries,
    e. additional facilities, where they exist and are relevant (e.g., entrepreneurship labs, maker spaces, innovation labs)
8. Curricular content of the program(s).
9. Program delivery and outcomes, including sampling of transcripts, examinations, projects, assignments, etc.
10. Innovative and special features of the program.
11. Institutional policies and supports.

3. Glossary

For the purpose of ISTAC accreditation, the following definitions apply.

Graduate Attributes: A high level 'set of individually-assessable outcomes that are indicative of a graduate's potential competency' [https://www.seoulaccord.org/document.php?id=79]. The Graduate Attributes used by ISTAC are those established by the Seoul Accord (www.seoulaccord.org).

Three ranges of attributes are defined:

Computing Professional

Computing Technologist

Computing Technician

Degree program*: A program typically 4 years in duration leading to a baccalaureate degree. The expected graduate attributes will be in the **Computing Professional** range.

Diploma Program*: A program typically 2 or 3 years in duration leading to a Diploma, Diploma of Technology or similar credential. The expected graduate attributes will be in the **Computing Technologist** range.

Certificate Program*: A program typically 1 year in duration leading to a Certificate. The expected graduate attributes will be in the **Computing Technician** range.

Objective: Planned goals or intent of a program or educational unit (e.g. course). Generally expressed from the perspective of the teacher or faculty. Occasionally the term is used interchangeably with Outcome.

Outcome: Measurable evidence that an objective has been met. Also refers to the expectations of the students' achievements or accomplishments after the educational activity. Generally expressed from the learners' perspective. Occasionally used interchangeably with Objective.

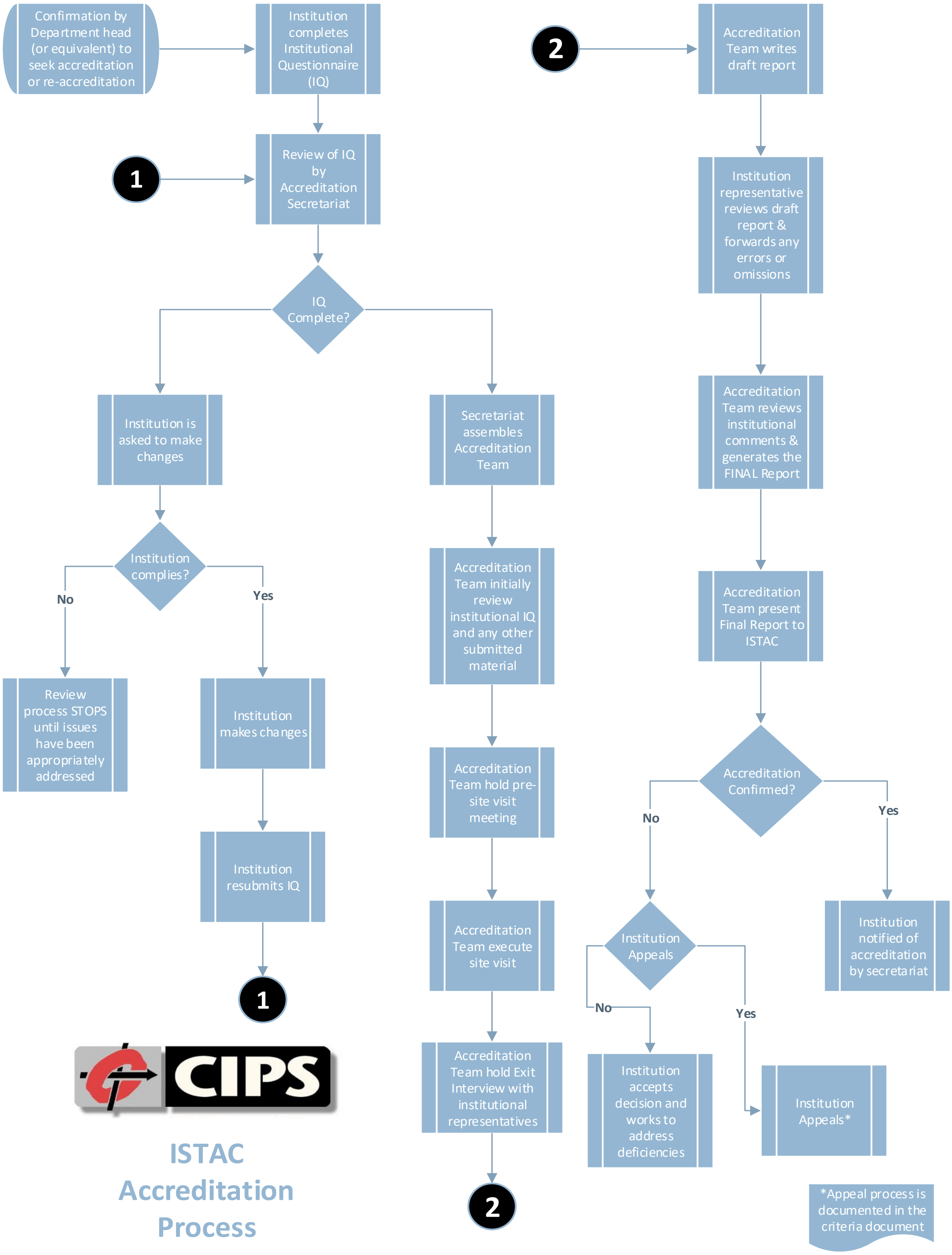
Quality Indicator: Qualitative or quantitative data used to help assess whether an objective has been met.

Rubric: A document describing how an exam, assignment or other student activity should be evaluated, specifically mapping to the learning objectives that should be assessed.

* These typically refer to an initial credential in the ICT area. The expected graduate attributes for programs which require advanced prerequisites, especially in the ICT field, may differ depending upon the nature of the program. E.g., the expected graduate attribute for a one-year certificate program where the prerequisite is a degree or diploma in an ICT area might be in the Computing Technologist or Computing Professional range. For further information which graduate attribute range might be appropriate for a specific program, please contact the CIPS Accreditation

Secretariat.

4. Accreditation Process



5. Objectives and Outcomes

Each program must have a set of program objectives and graduate attributes describing what students should know and be capable of doing following graduation.

Institutions and individual programs have flexibility in setting their own program objectives, outcomes and graduate attributes but they must also substantially meet the appropriate graduate attribute range set by the Seoul Accord. Institutions may: adopt these verbatim; add to them; or reword some of them to meet local conditions or conform to internal requirements. In some situations, a documented mapping of the institution's program objectives to the Seoul Accord attributes may be required to demonstrate that the appropriate attribute range has been achieved.

5.1 The ISTAC Graduate Attributes

Table in Appendix A provides profiles of graduates of three types of postsecondary educational computing programs, as defined for the Seoul Accord.

5.2 Quality Indicators and Outcomes

Evidence should be provided that the graduate attributes defined for each program have been fulfilled. In other words, there must be evidence that what students actually know and are capable of doing following graduation correspond with the defined program-level objectives. This is achieved by *quality indicators*. These are qualitative and quantitative data gathered by the institution.

The Accreditation will review quality indicators in each of the following areas/sections: Faculty, Students, Curriculum, and Resources. Suggestions for quality indicators are provided in each corresponding section. The self-study and accreditation process largely involve studying and verifying the quality indicators to ensure that the outcomes correspond to the defined objectives.

5.3 Quality Improvement/Enhancement Process

Evidence should be provided that the department has a quality enhancement process to improve the programs under accreditation through regular review and upgrade of program objectives and graduate attributes.

5. Faculty

The capability of any program to provide high-quality education or training is ultimately dependent upon the background and dedication of the faculty members. A competent and dedicated faculty can provide a good program despite deficiencies in other areas such as physical resource availability. However, excellent resources and facilities cannot compensate for insufficient or poor-quality staff. It is therefore important that a school seeking accreditation for a program has allocated the resources necessary to provide sufficient numbers of high-quality faculty and is committed to maintaining the allocations necessary for the continuation of high-quality program delivery.

The heart of any educational program is the faculty. A CIPS-accredited program will possess a strong, competent faculty with the necessary size and capabilities to deliver the program, establish the appropriate rapport with students and maintain overall program quality. Educational institutions seeking ISTAC accreditation must demonstrate the allocation of enough resources necessary to maintain this critical mass of quality faculty.

Factors related to faculty size include the enrolment, objectives of the program(s) being accredited, subject areas required by the curriculum, assigned teaching loads, funded (or applied) research, industry involvement, extension and continuing education activities, and participation in professional and technical societies.

To function effectively as teachers, faculty members require enough time to acquire new knowledge and skills, pursue industrial interaction, explore instructional innovation, as well as consult and engage in other professional development activities. Teaching loads should reflect these requirements.

Sabbatical leave opportunities, professional development funds and other resources are important in the faculty context.

Suitable quality indicators regarding faculty for the self-study and accreditation report include:

- The proportion of full-time faculty to part-time and sessional
- The teaching load (number of courses and preps taught per year)
- Faculty recruitment and hiring policies
- Gender distribution of faculty
- Job satisfaction of faculty as expressed in interviews or surveys
- Distribution of faculty expertise and experience over areas required by the program
- Knowledge and skills of faculty in areas corresponding to the Graduate attributes, including areas related to ethics and professionalism

Faculty members should be aware of the technical skills and business knowledge found in the local communities to be served by the program as well as those common to the business community in general. Factors to be considered in this assessment include academic background, pedagogical credentials and work experience [*Defined as professional level experience including working in nontrivial, complex project planning, analysis, development and implementation areas, including all phases of the system development cycle.*], and the related business experience of the instructional and administrative staff. There should be a broad range of knowledge and experience enough to provide expertise in all areas of the program's curriculum.

It is the expectation of accredited programs that all faculty possess formal qualifications in Computer Science, IS, IT, Computer Engineering, Software Engineering or a closely related discipline. The faculty profile should also reflect a balance of credential levels, including undergraduate and graduate degrees. ISTAC National Guidelines and Expectations for Faculty Teaching IT related courses are:

1. Faculty members have academic credentials and work experience equivalent to or better than the credential and work experience expectations of the students upon graduation.
2. IT faculty members, including lab assistants, hold a diploma or degree in Computing or closely related field,
3. A significant percentage (typically 30% or more) hold graduate degrees in Computing or a related field,
4. IT faculty members have at least 2 years of full-time IT related industry experience (other than teaching),
5. A significant percentage (typically 50% or more) have a minimum of 5 years of senior full-time IT related experience,
6. Alternative considerations:
    a. Faculty who possess their CIPS I.S.P. or ITCP designation.
    b. Mature faculty who do not have formal credentials but learned "on-the-job" and usually have a significant number (10 or more) of years of full-time IT related industry experience.
    c. Mature faculty who do not have formal credentials, but who do have an appropriate combination of vendor specific credentials and significant (typically 5 years or more) of senior full-time IT related experience.

To evaluate the quality of the faculty, the visiting team will examine the data presenting the quality indicators in the self-study report, as well as the CVs of the faculty members and any collective agreement. It will also meet with groups of faculty members. The team will gather further insights from discussions and interviews with staff, students and administrators.

In addition to faculty teaching directly into the program, the visiting team may also interview faculty from other specialty areas related to the program such as mathematics, business, communications, etc.

6. Facilities and Resources

All the disciplines in an accredited program must have buildings, offices, laboratories, equipment, support staff, and fiscal resources that are appropriate for the characteristics of the program that is being undertaken. The accreditation team will review and tour these facilities as part of the on-site visit.

For a program to be accredited there must be evidence of an ongoing commitment by the school to maintain and modernize the physical and support aspects of the instructional environment. The physical environment should be adequate to provide for learning. Classrooms and laboratories should be clean, well ventilated, and adequate to house the students and hardware. Staff should have enough space in their offices or meeting rooms for student consultation. The availability of computer resources for scheduled laboratory class hours and open labs for after-hours access is essential to a program in computer studies. The computer hardware facilities should be representative of the environment where students will be employed upon graduation. These computational facilities should be readily available to the students for the completion of out-of-class assignments. The number of units available in the open labs should allow for reasonable student access during the normal operating hours of the day.

Software provided and used within the program should be representative of commonly encountered business software in use in the community and should provide for the full spectrum of applications. There should be generalized business application software as well as technical software available to the students. Consideration should be given to the acquisition of software which embodies tutorial and help facilities as an integral part of its package. Reliable and fast response to hardware and software problems is a requirement to ensure that an optimum number of units are always available to the students and staff. There should be provision for a maintenance plan, and technical support staff to assist students and staff with software and hardware problems, and with the setup of student exercises.

There must be adequate access to electronic and other reference resources, such as the ACM and IEEE and other ICT digital libraries. The collections must be maintained and refreshed to remain current, and there must be a breadth of materials included. Electronic networking enough to provide students and faculty access to external resources is also important.

Suitable quality indicators for the self-assessment and accreditation report include the following, all assessed relative to the student population

- Budget for resources,
- Computers and software in labs,
- Numbers and levels of expertise of technical and support staff,
- Satisfaction of students and faculty with the resources available,
- Sufficiency of the resources to teach the courses discussed in the Curriculum section, and to meet the Program Objectives

To evaluate the quality of resources, the visiting team will inspect them while touring the facilities, and will interview students, staff and faculty. The team will also study budgets and policies in place for ensuring the resources are maintained and replaced as they become obsolete.

Access to technical information and documentation must be readily available. Alternative types of delivery should be available for use in order to enrich the program delivery. The program must have adequate administrative support and services that are consistent with the faculty size and student population. These services should handle clerical duties for the instructional staff. Services for students should also be provided, perhaps for a fee, for duplicating, typing, etc.

7. Administration, Planning and Internal Process

A capable administration must be in place that understands the special needs of a technical program. Formally documented policies and procedures should be in place and well communicated to faculty, students and other stakeholders as appropriate. Planning (long and short term, operational and strategic) must take place at all levels, and a monitoring and feedback process must be present.

There should be a budget provision and a plan for updating equipment and software on a regular basis. Procedures for the disposal of obsolete equipment should also be in place. Planning for equipment should be consistent with student enrolment and other uses of the facilities such as continuing education classes and special courses and seminars. A documented process must be in place to assure continuity and sustainability of ongoing program quality and currency.

The process for ongoing curriculum renewal must include the gathering of data from a variety of sources to inform the curriculum renewal process; including feedback from graduates and industry.

8. Students

A CIPS-accredited program is typically characterized by its enthusiastic students. Student selection and retention standards will be appropriate to the program. Well-established protocols will be in place for students transferring from other institutions, programs, or branch campuses.

A student advisory system for both academic and personal support is an important component in any educational program. The advisory system should embrace course selection, graduation advice and resolution of problems of a personal nature. Career guidance and employment support both pre- and post graduation is a valuable resource.

Faculty members and career counsellors will be familiar with professionalism issues, ethical codes of conduct and related matters within the ICT industry. Exposure to specific professional standards and ethical expectations in the IT industry (e.g. CIPS Ethics Code) is expected.

Suitable quality indicators regarding students for the self-study and accreditation report include:

- Feedback from employers, assessed through questionnaires or surveys that ask employers the extent to which students they hire possess the graduate attributes defined for the program,
- Jobs offered for co-op and internship programs, and the proportion of students who find satisfactory employment following graduation,
- Prizes and scholarships awarded, especially external ones,
- Student's satisfaction with their program and progress as assessed through questionnaires and interviews,
- Attrition rates.
- Admission rates,
- Graduation rates

To assess the quality of students, the visiting team will interview groups of students and alumni, study transcripts and samples of student work, as well as analyse the data presented in the self-study report. Where possible, the team will also speak to employers, such as members of the department's program advisory board.

9. Industry Support

An important feature in the success of an information systems program is the interaction between the school and the local business community. A good interaction means support from industry and advice for the instructional staff. This interaction can take many forms, but the most common are:

- An advisory committee made up from a cross-section of local business representatives; such a committee can keep the school aware of current trends in hardware, software, and skill requirements, as well as to inform the local community of the current activities of the academic world.
- Visits to local businesses where the faculty and/or students are provided with exposure to real life situations not only from the information systems point of view but also involving the various functional areas of business such as marketing, manufacturing, finance, etc.
- Guest lecturers from a variety of business and industry backgrounds can also be used to provide faculty and students with a valuable insight into the realities of the working world,
- Co-op and work-term projects which facilitate student involvement in a program-related activity in a real business setting are highly desirable. Such activities are not only beneficial to the students, but also to all groups involved. Industry representatives can assess the skill-level of potential employees and to acquire a better knowledge of the skills embodied in the graduates.

Through this interaction the faculty members become more conscious of the requirements of industry and the various areas in which their graduates will become employed. Finally, the school could receive access to hardware and software resources which would not otherwise be available to its students and faculty.

10. Curriculum

The curriculum must serve the needs of the students, employers and the community. Accredited programs should allow all these stakeholders the opportunity to provide an influence on the curriculum and to ensure that graduates are qualified for information systems related employment. It should foster the development of graduates with a diverse set of skills to meet immediate and long-term needs. It is particularly important that graduates be prepared for 'life-long learning' to maintain currency in this rapidly changing and evolving field.

This section refers to units of instruction comprising the curriculum for a program. It is recognized that institutions can design their instructional units in differing ways (traditional courses, learning modules, self-paced units, etc.). For the purpose of this section, typically an instructional unit consists of a course outline or contract, learning objectives, teaching materials (notes, textbooks, etc.) and teaching/learning activities (labs, lectures, assignments, etc.) and evaluations (tests, quizzes, exams)*.

The learning objectives of the instructional unit will contribute meaningfully to the objectives of the program and its graduate attributes. The Accreditation Team will review the curriculum to ensure that this is the case - both as a plan (i.e. the mapping of instructional unit level objectives to the appropriate graduate attributes) and in its execution (i.e. the actual outcomes of the course to the attributes in terms of the capability of the student).

While local industry or community needs will impact the content of the program, accredited programs also address preparing graduates to work as IT professionals nationally and even globally.

It is expected that the school will have several quality control mechanisms in place which will be used on an on-going basis to:

- conduct environmental scans related to both local and national industry trends,
- review program objectives and align to industry needs and trends,
- evaluate the appropriateness of course content,
- evaluate the appropriateness of grading and assessment procedures, and
- monitor the quality of faculty and teaching

** For convenience, the term course is often used in this section to refer to instructional units given that most post-secondary institutions use this terminology.*

10.1 Evidence that Graduate Attributes Have Been Met (Quality Indicators)

Central to outcomes-based self-study and accreditation is demonstrating that the appropriate range of Graduate Attributes have been met for the program undergoing accreditation. For each of the remaining subsections (Sections 10.2 to 108) measurable evidence (quality indicators) should be provided that each student has fulfilled each of the graduate attributes. Such evidence can include mappings from course-level objectives to graduate attributes, rubrics for assignments and tests indicating which graduate attributes are being assessed, and other quality indicators.

Learning objectives and outcomes should be presented for core courses in ICT topics, as well as topics in other related disciplines where appropriate. Expressed from the learners' perspective, learning outcomes should map to the appropriate graduate attributes and describe what students will have achieved by the end of each course. Each outcome will be typically expressed in sentences with an active verb. Verbs implying performance capabilities, such as ‘calculate’, ‘design’, ‘evaluate’, ‘apply’, ‘solve’, ‘create’, ‘build’, ‘determine’, ‘develop’, ‘assess’, ‘use’, ‘lead’ and ‘present’ are preferable to verbs implying more passive learning, such as ‘know’ and ‘understand’, although the latter would be appropriate for some types of knowledge.

In the same manner that the program-level objectives, outcomes and graduate attributes should be approved and reviewed through an appropriate quality review process, the learning objectives and outcomes at the instructional unit level should be approved by the department and reviewed periodically. Part of this review will be to ensure that the learning objectives, outcomes and graduate attributes remain in alignment. Evidence should be presented that the objectives are being accomplished within each instructional unit. The use of *rubrics* or similar documentation for learning activities is recommended. Rubrics describe what is to be expected of students in each learning activity and should indicate which learning outcomes students would be demonstrating by successfully completing the activity.

The visiting team will review samples of student work including examinations, tests, projects and assignments to this end. In addition, the team will cross-reference information gathered from interviews with faculty, students and others.

Taken together, the outcomes of the instructional unit taken regardless of the path a student chooses for graduation, should satisfy the graduate attributes. To demonstrate this, the self-study report contains a table for each required instructional unit, course (or course group) mapping how the unit contributes to each graduate attribute.

10.2 Technical Curriculum - Overall Distribution of Courses

For each range of graduate attributes, it is expected that an accredited program will have the necessary duration and deliver the required instructional unit or course to fulfill the attribute requirements. Furthermore, the program must ensure that *all* students must meet the graduate attributes to be eligible for the credential. This can be especially important where students are permitted electives or alternate courses for graduation.

The next two subsections describe the distribution of instructional units or courses that would generally be expected for different types of programs to fulfill the graduate attributes of the three ranges. The intent here is NOT to prescribe specific courses or topics but to illustrate how typical courses can map to the corresponding range of graduate attributes in terms of duration, breadth and depth. Institutions may design their programs to meet the graduate attribute requirements in other ways. The priority is to demonstrate that the proper range of graduate attributes has been met for the program undergoing accreditation.

10.2.1 Typical Instructional Durations to Fulfill Graduate Attributes

10.2.1a: Computing Professional

A. 70% of instructional activity in computer science, information systems, or information technology (Graduate Attributes 1a through 1e).

B. 10% in mathematics or statistics (Graduate Attributes 1f and 1g), and

C. 20% courses in topics *other than* ICT or mathematics/statistics (Graduate Attributes 7 thru 9).

10.2.1b: Computing Technologist

A. 70% of instructional activity in computer science, software engineering or computer engineering (Graduate Attributes 1a through 1e).

B. 10% in mathematics or statistics (Graduate Attributes 1f and 1g), and

C. 20% courses in topics *other than* ICT or mathematics/statistics (Graduate Attributes 7 thru 9).

10.2.1c: Computing Technician

A. 70% of instructional activity in computer science, software engineering or computer engineering (Graduate Attributes 1a through 1e).

B. 10% in mathematics or statistics (Graduate Attributes 1f and 1g), and

C. 20% courses in topics *other than* ICT or mathematics/statistics (Graduate Attributes 7 thru 9).

10.3 Breadth and Depth of Knowledge in ICT Topics to fulfill Graduate Attributes Requirements

10.3.1 Key Areas of ICT - Breadth of Knowledge [Graduate Attribute 2]

The following five topics listed below are illustrative of a range of topics that an accredited program would be expected to provide to fulfill the required graduate attribute range in terms of breadth of knowledge. Again, institutions may design their programs to fulfill the graduate attribute requirements in different ways.

10.3.1a Computing Professional

Graduate Attribute 1a: Software engineering, including requirements specification, software design and software architecture, software development, software testing, software maintenance, and other topics related to software development life cycle (SDLC) and adaptive methodologies.

Graduate Attribute 1b: Algorithms and data structures, including data structures such as stacks, trees, lists, queues, etc..; abstract data types, database management, established solutions to classical problems (e.g., sorting and searching), and analysis of algorithms (e.g., parallel and other non-linear algorithms).

Graduate Attribute 1c: Systems software, including operating systems concepts, virtual memory management, management of distributed, parallel, and concurrent processes, transaction processing, logging, security, mobile, cloud, IoT, and computer networking.

Graduate Attribute 1d. Computer elements and architectures, including computer organization, digital device and communications technology, logical and physical hardware design.

Graduate Attribute 1e. Theoretical foundations of computing, including models of computation, fundamentals of program specification and verification.

10.3.1b Computing Technologist

Graduate Attribute 1a: Software engineering, including requirements specification, software design, software development, software testing, software maintenance, and other topics related to software development life cycle (SDLC) and adaptive methodologies

Graduate Attribute 1b: Algorithms and data structures, including data structures such as stacks, trees, lists, queues, database management, etc.

Graduate Attribute 1c: Systems software, including operating systems concepts, transaction processing, logging, security, mobile, cloud, IoT, and computer networking.

Graduate Attribute 1d. Computer elements and architectures, including computer organization, digital device and communications technology, logical and physical hardware design.

Graduate Attribute 1e. Theoretical foundations of computing, including models of computation, fundamentals of program specification.

10.3.1c Computing Technician

Graduate Attribute 1a: Software engineering, including software testing, software maintenance, and other topics related to software process.

Graduate Attribute 1b: Algorithms and data structures, including data structures such as stacks, trees, lists, queues, database management, etc.

Graduate Attribute 1c: Systems software, including operating systems concepts, transaction processing, security, mobile, cloud, IoT, and computer networking.

Graduate Attribute 1d. Computer elements and architectures, including computer organization, digital device and communications technology, physical hardware design.

Graduate Attribute 1e. Theoretical foundations of computing including fundamentals of program specification.

10.3.2 Key Areas of ICT Programs - Depth of Knowledge [Graduate

Attribute 3]

Each graduate attribute range has differing requirements for depth of knowledge and capabilities. The following is illustrative of the expectations of each attribute range for the five topic areas (Software Engineering, Algorithms and Data Structures, Systems Software, Computer Organization and Architecture, Theoretical Foundations).

Computing Professional

- Basic knowledge of each area at the level typically provided by a first course or instructional unit in the area.
- Advanced knowledge in at least two key areas typically from a second or third course or instructional unit in the area

Computing Technologist

- Basic knowledge of each area at the level typically provided by a first course, instructional unit or equivalent in the area.
- Advanced knowledge in at least one key area typically from a second or third course or instructional unit in the area.

Computing Technician

- Basic knowledge of 3 areas at the level typically provided by a first course, instructional unit or equivalent in the area.
- Advanced knowledge in at least one key area typically at an application level

10.3.3 Exposure to Multiple Programming Languages and Paradigms [Graduate Attribute 5]

Computing Professional

Students graduating from an accredited program should have proficiency in at least two programming languages and exposure to a variety of programming languages. Exposure to a variety of programming paradigms – procedural, object-oriented, logical or functional, sequential and concurrent – is also important.

Computing Technologist

Students graduating from an accredited program should have proficiency in at least one programming language and exposure to a variety of programming languages. Exposure to a variety of programming paradigms – procedural, object-oriented, logical or functional, sequential and concurrent – is also important.

Computing Technician

Students graduating from an accredited program should have exposure to coding in at least one programming language.

10.3.4 Significant Design/Project Experience [Graduate Attribute 4 and 6]

Computing Professional

Students graduating from an accredited program should have had the chance to develop a complete significant system, or make a major modification to an existing system, at some point in their studies, whether it be in course projects, a final 4th-year project, and an internship or in some other manner. This design experience should be open-ended and enable the student to integrate their knowledge from most, if not all, of the areas of ICT, as well as knowledge of mathematics, domain knowledge and, where appropriate, with consideration for economics, societal issues, safety, etc.

Computing Technologist

Students graduating from an accredited program should have had the chance to develop or modify a complete significant system, or make a major modification to an existing system, at some point in their studies, whether it be in course projects, a final project, and an internship or in some other manner. This design experience should be sufficient to enable the student to integrate their knowledge from most, if not all, of the areas of ICT, as well as knowledge of mathematics, domain knowledge and, where appropriate, with consideration for economics, societal issues, safety, etc.

Computing Technician

Students graduating from an accredited program should have had the chance to work on a project related to their program. This design experience should enable the student to integrate their knowledge from their program.

10.3.5 State-of-the-Art Tools and Practices [Graduate Attribute 4 and 5]

Accredited programs must prepare students to meet the computing challenges they will face after graduation, whether they embark on careers immediately or continue their education. Thus, as part of their education, students must be sufficiently well-grounded in state-of-the-art computing practices to meet the needs of their program. An accredited program should expose students to several computing configurations, including varied hardware, operating systems, and programming environments.

Computer Professional: An accredited program should expose students to several computing configurations, including varied hardware, operating systems, and programming environments.

Computer Technologist: An accredited program should expose students to several computing configurations, including varied hardware, operating systems, and programming environments.

Computer Technician: An accredited program should ensure students are aware of different computing configurations, including varied hardware, operating systems, and programming environments.

10.3.6 New Areas of Computing [Graduate Attribute 5 and 10]

Computer Science is a rapidly developing and growing subject. At the current time, these newer developments include such areas as mobile devices and networks, health and medical informatics, cyber security, bioinformatics, data mining, quantum computation, augmented and virtual reality, machine learning, artificial neural networks, robotics, and so forth. While it is not to be expected that an accredited program will include material in all of these areas, accredited programs should nonetheless demonstrate that they recognize the rapidly evolving nature of the subject, and should include some of the newer areas of the subject, particularly within the intermediate and advanced courses which they offer to their students.

Computing Professional: Accredited programs should demonstrate that they recognize the rapidly evolving nature of the subject and should include some of the newer areas of the subject, particularly within the intermediate and advanced courses which they offer to their students.

Computing Technologist: Accredited programs should expose students to the rapidly evolving nature of the subject and should include some of the newer areas of the subject, particularly within the intermediate and advanced courses which they offer to their students.

Computing Technician: Accredited programs should expose students to the rapidly evolving nature of the subject.

10.4 Mathematics [Graduate Attributes 1f and 1g]

10.4.1 Mathematics

Computing Professional: Students in accredited programs must have attained knowledge and skills in the following two areas: (i) discrete mathematics, and (ii) probability and statistics. Students are expected to receive a solid grounding in logic, Boolean algebra and graph theory.

Computing Technologist: Students in accredited programs should have attained knowledge and skills in the following two areas: (i) discrete mathematics, and (ii) probability and statistics. Students are expected to receive a solid grounding in logic, Boolean algebra.

Computing Technician: Students in accredited programs must have attained sufficient mathematics to meet their program objectives.

10.5 Breadth and Depth in Topics Outside Computing and Mathematics [Graduate Attribute 9]

Computing applications can be found in all human endeavours, so education in any discipline outside computer science has the potential to prepare students in a field of direct relevance to their future livelihood.

The diversity of backgrounds needed by various computing professionals necessitates flexibility within these accreditation requirements. Innovation in establishing institutional requirements or in promoting everyone's ability to reach personal goals is encouraged. Nevertheless, this section identifies topics that enhance a program's ability to meet the needs of ICT students. As before, the goal of breadth in exposure must be balanced by the goal of depth in understanding, which can best be achieved through the selection of complementary courses or equivalent learning experiences having a common focus.

Students should be encouraged to choose courses such that their programs include enough breadth in other domains, to be able to communicate with people working in those domains, to develop software for those domains, and to in general be well-rounded graduates. It is suggested that to meet this requirement, students be required to take:

Topics in physics and electrical engineering are basic to many aspects of computing, and knowledge in these areas are particularly encouraged. Challenges such as the endeavour to map the human genome underline the value of education in other fields of natural science as well, including chemistry, the earth sciences, and the life sciences, especially when integrated with computer studies.

A thorough grounding in business fundamentals is important to prepare students of computer science to contribute to Canadian industry in domains such as: eHealth, Public/Private sectors, Education, Manufacturing to name but a few. Relevant knowledge and skills in this area include particularly accounting, business organization, economics, and auditing, but also include marketing, personnel management, and production management.

Students graduating in computing must also exhibit skills in non-technical disciplines. Through knowledge and skills in humanities or social science, students will gain understanding of political theories and processes, knowledge of individual and group social interactions, appreciation of cultures and history, sensitivity to the literary and fine arts, and fluency in languages. Not only is this important background for future self-study, but several aspects have direct bearing on particular areas of computing: linguistics is central to natural language processing, cognitive science provides mechanisms to evaluate human-computer interaction, law can be applied to assessing liability of computer professionals, and ethics helps to evaluate social implications of computing.

It is also recognized that educational institutions will often impose specific breadth requirements on programs which must be accommodated.

Computing Professional

- Significant background in science, engineering (but not computer or software engineering), or business as evidenced by numerous courses or equivalent
- Good background in humanities or social science as evidenced by courses or equivalent

Computing Technologist

- Good background in science, engineering (but not computer or software engineering), or business as evidenced by numerous courses or equivalent

Computing Technologist

- Background in science, engineering (not computing or software engineering) or business as evidenced by a course or equivalent

10.6 Non-Trivial Problem Solving in Teams [Graduate Attributes 2, 4, 5 and 6]

A significant component of an accredited program is direct experience with non-trivial problem-solving. This component helps to develop students' creativity in solving open-ended problems through practice in formulating problem statements and specifications, considering alternative solutions, determining feasibility and cost, and communicating the results including detailed systems descriptions. Projects and courses that require teamwork are strongly encouraged. Students, individually and as members of teams, must be required to design and implement a system, program, process, or device to achieve stated objectives. Team-based learning does not imply face-to-face modalities for teamwork; in fact, it may be appropriate for teams to complete at least part of their work using electronically mediated and/or asynchronous means.

The problem solution should include the establishment of objectives and criteria, analysis, synthesis, documentation, implementation, testing, and evaluation. It is desirable that problems include a variety of realistic constraints such as economic factors, performance thresholds, ergonomics, compliance with standards, interoperability with other systems, and conformance to ethical, professional and legal restrictions.

Computing Professionals: Must complete a team project or equivalent.

Computing Technologist: Must complete a team project or equivalent.

Computing Technician: Must complete a team project or equivalent.

10.7 Written and Oral Communication Skills [Graduate Attribute 7 thru 9]

The expanding and demanding role of modern information systems dictates strong interpersonal and teamwork skills requirements of the IT practitioner. The ability of the graduate to communicate has a direct bearing on the quality of "on-the-job" performance. To facilitate the participation of the graduate in this environment, students are expected to develop the following proficiencies:

- oral presentation and the use of presentation tools: slide projectors, use of graphics, multi-media
- writing skills: letters, memos, business reports, electronic communications media
- use of productivity software
- interpersonal skills: listening skills, interviewing, analyzing problem situations, teamwork, leadership, organizational skills
- workplace and employment skills
- interpersonal, customer relations and user support skills
- time management skills
- face-to-face and electronic communications
- remaining current (technical and non-technical)
- training and knowledge transfer
- ethical and legal impact of information systems and emphasize on professionalism

The program should include curriculum components designed to encourage students to apply these proficiencies throughout their studies. These components may be delivered in courses specifically designed to teach certain of these skills and taught by specialists in the area (e.g., communication or technical writing courses taught by a Communication or English department) or be embedded as a formal component in other courses or learning activities throughout the program.

Computing Professionals: At least one course in communications, business writing or equivalent.

Computing Technologist: At least one course in communications, business writing or equivalent.

Computing Technician: One writing or communications component in the program.

10.8 Professionalism [Graduate Attribute 8 and 9]

Aspects of professionalism are to be emphasized throughout the curriculum. A specific course or courses in social implications of computing may be offered, but ethical and legal issues surrounding computing, including the social responsibility of programmers and computer users, must be emphasized in courses throughout the program so that students learn that these aspects are part of computing, not merely tangential disciplines. Topics can be covered in a dedicated course or embedded throughout.

Computing Professionals: At least one course or equivalent in professionalism and ethics.

Computing Technologist: At least one course or equivalent in professionalism and ethics.

Computing Technician: One professionalism and ethics component in the program.

11. Innovation and Research

Although research is not usually considered to be mandatory for a school to fulfill its mandate, such an involvement can be considered indicative of an ongoing commitment to innovation and excellence. This innovation could take the form of the devising of new pedagogical approaches, or the development of new course notes and manuals. Research work could be evidenced through the personal involvement of faculty members in the use of computers, or in their collaboration with local businesses, university or government research centres.

Appendix A

	Attributes	Differentiating Characteristic	… for 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.

	Attributes	Differentiating Characteristic	… for Computing Professional Graduate	… for Computing Technologist Graduate	… for Computing Technician Graduate
3	Problem Analysis	Complexity of analysis	Identify, formulate, research literature, 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 with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.	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, adapt and 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.

	Attributes	Differentiating Characteristic	… for Computing Professional Graduate	… for Computing Technologist Graduate	… for Computing Technician Graduate
6	Individual and Teamwork	Role in, and diversity of, the team	Function effectively as an individual and as a member or leader in diverse teams and 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 the type of activities performed.	Communicate effectively with the computing community and with society at large 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.

	Attributes	Differentiating Characteristic	… for Computing Professional Graduate	… for Computing Technologist Graduate	… for Computing Technician Graduate
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 can engage in independent learning for continual development as a computing professional.	Recognize the need and can engage in independent learning for continual development as a computing technologist.	Recognize the need and can engage in independent learning for continual development as a computing technician.