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6: The ACS and ITP NZ Degree Accreditation Body of Knowledge

ITP New Zealand Degree Accreditation

The ITP Degree Accreditation documentation has been derived with permission from the Degree Accreditation process of the Australian Computer Society (ACS).

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LIST OF ACRONYMS

ABET	Accreditation Board for Engineering and Technology (USA)
ABS	Australian Bureau of Statistics
ACM	Association of Computing Machinery
ACPHIS	Australian Council of Professors and Heads of Information Systems
ACS	Australian Computer Society
AAIS	Australasian Association of Information Systems
AIIA	Australian Information Industry Association
AQF	Australian Qualifications Framework
BOK	Body of Knowledge
CAPPE	Centre for Applied Philosophy and Public Ethics
CBOK	Core Body of Knowledge
CIPS	Canadian Information Processing Society
CORE	Computing Research and Education Association of Australasia
CPP	Computer Professional Programme (offered by the ACS to recognise ongoing professional development)
CPeP	Computer Professional Education Programme (offered by the ACS)
CE	Computer Engineering
CS	Computer Science
DEEWR	Department of Education, Employment and Workplace Relation
EQF	European Qualifications Framework
IEEE	Institute of Electrical and Electronics Engineers
IP3	International Professional Practice Partnership
IITP	IT Professionals New Zealand Inc (the legal name of ITP NZ)
IS	Information Systems
IT	Information Technology
ITP NZ	IT Professionals New Zealand
ICT	Information and Communications Technology
IFIP	International Federation of Information Processing
PS	Professional Standards
PCP	Practicing Computer Professional
SE	Software Engineering
SFIA	Skills Framework for the Information Age

1. BACKGROUND

This document is part of a series of seven documents that make up the ITP Degree Accreditation Document Set. These include:

1. Administrative Guidelines
2. Application Guidelines
3. Guidelines for Submission
4. Seoul Accord Graduate Attributes
5. Submission Forms
6. **The ACS and ITP NZ Degree Accreditation Body of Knowledge** *(this document)*
7. The ITP Professional Knowledge Curriculum

This document outlines the ACS Core Body of Knowledge with minor modifications to ensure relevance in New Zealand. Rather than reinventing the wheel, the IT Professionals NZ utilises the ACS CBoK for the purposes of a Degree Accreditation Body of Knowledge.

The CBOK presented is a framework of information and communications technology areas of study to inform:

- the design of programmes of study and their subsequent accreditation;
- knowledge requirements for professional certification and
- supporting programmes of professional development.

1.1 Philosophy for the Design of Programmes of Study

This document adopts an approach to educational programme design that focuses on the development of professionals rather than taking a strict bottom-up "curriculum-driven" approach.

Programme design is the process by which educators in an academic institution develop a 'programme of study' that leads to the award of a qualification such as a bachelor's degree. The programme of study will include individual "units" of study, otherwise known as "papers" or "courses". As an example, a three-year bachelor's degree in Australian and New Zealand institutions commonly has 24 units of study (eight units per year), but there are many models. A curriculum-driven approach means that the programme designers base their programme on curricula that have been developed elsewhere, for example, by the Computer Science discipline in the United States (see CS 2001). Such curricula specify very precisely what material is to be covered in individual units of study and in some cases also suggest how many hours of study should be devoted to specific topics. These curricula are useful but can lag behind developments in a field such as ICT where change is rapid and ongoing.

The recommended approach is that programme designers consider what roles their graduates will undertake after graduation and design programmes accordingly. This approach means considering "blended" degrees that encompass study across the boundaries of traditional disciplines. It should be clear that we are not advocating an extreme position where programmes are designed to address short-lived market trends or skills gaps. Nor do we advocate abandoning the study of fundamental knowledge. Rather, programme designers should adopt a balanced approach and focus on the roles that graduates are likely to undertake as well as carefully considering what underlying knowledge is needed.

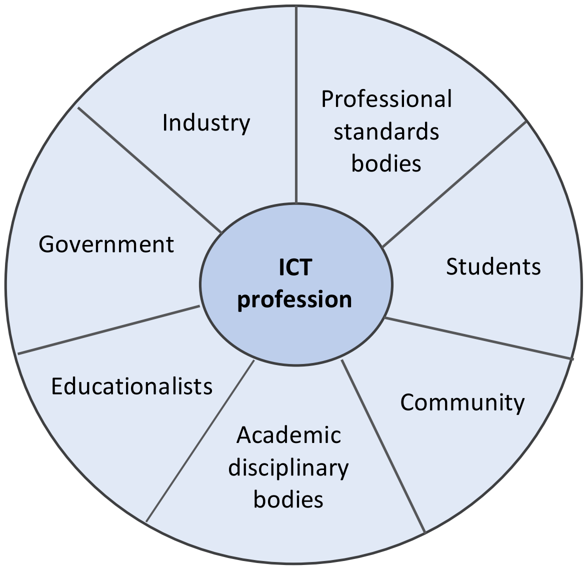

Figure 1: Stakeholders and the ICT profession

1.2 Underlying principles

Some guiding principles have evolved over the course of the BOK revision process and underlie the general thrust of this document:

- **A common core** of knowledge areas can be defined for the ICT profession as a whole, despite the large number of roles that an ICT professional could fill. This common core shows the areas of knowledge about which all professionals should have at least some basic knowledge. Having this core knowledge means that ICT professionals working in teams in organisations will have some understanding of the role of their fellow professionals. Defining the core knowledge will also assist in explaining to the outside world what it is that distinguishes the ICT profession.

- **Balance** is aimed at, in meeting the needs of many stakeholders, including different industry sectors and educationalists in different fields and between addressing long-term and short-term perspectives on professional development. All perspectives are important and the views of one group of stakeholders are not taken as more important than those of any other group.

- **Minimal prescription** is aimed at in specifying what form programmes of study should take. The rapid change in the profession means that tight programme prescription could constrain the development of programmes of study in new fields: e.g., multimedia and games. Educationalists should be free to design innovative programmes to suit perceived needs, as long as the rationale for the design is clear and the degree is still aimed at developing ICT professionals.

- A **top-down**, rather than a bottom-up, approach to the design of programmes of study is recommended, so that programmes consider the roles that graduates will occupy upon graduation when designing programmes (as explained in Section 2.3).

- The **context** of the ICT industry and education in New Zealand should be recognised. ICT has made significant contributions to productivity in New Zealand because industry here has been able to make effective and transformational use of ICT, rather than having a large ICT manufacturing industry as in some other countries. Recommendations for education and professional development in other countries may not necessarily translate directly to the New Zealand context.

- ICT is a **practical science** (Strasser, 1985) and practical work, as in project work or industry placements, is required at some point in programmes of study so that learning of applied skills and knowledge can be fully developed.

- **Flexibility** is required in thinking about the industry and programmes of study because of the ongoing and rapid **change** in an industry and the disciplines that are based around ICT.

- **Regular updating** of this document will be needed, because of ongoing change in ICT, and will require continuing discussion among the many stakeholders.

2. THE ICT PROFESSION

Various regional and international initiatives assist in defining the skills associated with the ICT profession and with the global recognition of the profession.

2.1 Definition of a Professional

Professions Australia's definition of a professional is useful in both the Australian and New Zealand context, and stresses both the possession "of special knowledge and skills in a widely recognised body of learning derived from research, education and training at a high level" as well as the possession of a Code of Ethics (Professions Australia, 2007).

This is consistent with the view that a professional is one who:

- Possesses an underlying core body of specialised, in-depth, knowledge;
- Adheres to a code of ethics;
- Possesses the capacity for independent action, operating with a high level of responsibility and autonomy; and
- Engages in continuing professional development, enhancing relevant technical and professional skills.

2.2 Strengthening the ICT profession

A number of initiatives are underway to strengthen the ICT profession.

The ***International Professional Practice Partnership*** (IP3) from the ***International Federation of Information Processing*** (IFIP) accredits schemes for certification of professional status of member societies and works to increase the prevalence and visibility of the global ICT Profession (see http://www.ipthree.org).

In November 2007, the ***Seoul Accord***, was agreed to by representatives from Australia, Britain, Canada, Japan, Korea and the US (ABET) as a process for establishing an accord for the trans-national recognition of accredited educational programmes in computing and ICT-related disciplines. Since then, Hong Kong and Taiwan have joined and others such as New Zealand (through ITP) have joined as Provisional Signatories.

The Seoul Accord has established a set of graduate attributes expected of students entering the ICT profession.

2.3 Defining the ICT Profession

Describing ICT careers and the skills required of ICT professionals is necessary to communicate the nature of the profession to others and also to make sense of its diversity in the context of rapid change. Finding a common nomenclature and method of categorisation is a major challenge facing the discipline. A solution would make an enormous difference in evolving the profession and establishing a common view among all stakeholders. Table 1 shows a mapping between categorisation of knowledge areas in the CBOK and the SFIA categories.

Table 1: Examples of ICT Roles Categorisation

CBOK categories	SFIA Category	Description
Technology Building	Solution Development and Implementation	Specialised programming and engineering roles involved in building systems from the ground up. This stream accounted for a majority of ICT jobs in the 1980s and 1990s.
Technology Resources	Service Management – Strategy, Design	Organisational roles that provide and support the networked infrastructure underpinning technology building and implementation.
Service Management	Service Management – Transition, Operation	Roles concerned with the ongoing operation of ICT in an organisational context and the structuring of the interactions of ICT technical personnel with business customers and users.
Outcomes management	Business Change	Business technology roles that are critical in managing and implementing change across organisations. ICT roles integrated into business units attempting to leverage competitive advantage from packaged software implementations.
	Procurement and Management Support	Includes supply management, quality management, quality assurance and conformance.
	Strategy and Architecture	Strategic roles implementing organisational strategy by aligning business and ICT strategic planning.

Note: Draws on Grant (2006) and Wilson and Avison (2007).

2.4 Skills Framework for the Information Age

Organisations employing ICT professionals can use SFIA to write position descriptions, manage risk and improve the ICT function (SFIA, 2011). It has also been used to identify skills attained by graduates of an academic programme (von Konsky, et al., 2008).

SFIA is constructed as a two-dimensional matrix. One axis gives SFIA skills grouped by categories and subcategories. The second axis gives the different levels of responsibility and accountability at which ICT practitioners can exercise each skill. Table 2 shows in part the skills axis of the SFIA (See SFIA 2011 for the full definition). The second axis is defined using the seven levels listed in Table 3. At Level 1, the skill is practised under close supervision. At Level 7, the skill is practised in a leadership capacity in which the ICT professional leads, manages or influences others.

Table 2: SFIA Skills Axis (SFIA, 2011)

Category	Sub-category	Skill	Code
Strategy and architecture	Information strategy	IT governance	GOVN
		Information management	IRMG
		Information systems co-ordination	ISCO
		Information security	SCTY
		Information assurance	INAS
		Information analysis	INAN
		Information content publishing	ICPM
	Advice and guidance	Consultancy	CNSL
		Technical specialism	TECH
	Business strategy and planning	Research	RCSH
		Innovation	INOV
		Business process improvement	BPRE
		Enterprise and business architecture development	STPL
		Business risk management	BURM
		Sustainability strategy	SUST
	Technical strategy and planning	Remainder of table not completed. Refer to SFIA (2011, pp. 5-6).	
Business change	Business change implementation		
	Business change management		
	Relationship management		
	Skills management		
Solution development and implementation	Systems development		
	Human factors		
	Installation and integration		
Service management	Service strategy		
	Service design		
	Service transition		
	Service operation		
Procurement and management support	Supply management		
	Quality and conformance		
Client interface	Sales and marketing		
	Client support		

Table 3: SFIA Levels of Autonomy and Responsibility Axis (SFIA, 2011)

SFIA Level	Description of the Level of Autonomy and Responsibility
1	Follow
2	Assist
3	Apply
4	Enable
5	Ensure, advise
6	Initiate, influence
7	Set strategy, inspire, mobilise

As an example, the cell in the matrix for ***Information Security SCTY*** *(Category: Strategy and Architecture, Sub-Category: Information Strategy)* on the Skills Axis, *and Level 4 (Enable)* on the Responsibility Axis, contains the following definition of the competence required:

> *"Conducts security risk and vulnerability assessments for defined business applications or IT installations in defined areas, and provides advice and guidance on the application and operation of elementary physical, procedural and technical security controls (e.g. the key controls defined in ISO27001). Performs risk and vulnerability assessments, and business impact analysis for medium size information systems. Investigates suspected attacks and manages security incidents."* (SFIA, 2011)

Levels are also defined generically, described in terms of autonomy, influence, complexity and business skills.

The IP3 definition of the ICT profession expects that a professional would be operating at levels equivalent to SFIA Level 5 in their area of responsibility.

It might be expected that a graduate from a degree programme would be ready to assume Level 3 or 4 responsibilities in their area of specialisation, especially after a level of experience.

2.5 Knowledge Supporting SFIA Skills

The SFIA defines ICT ***skills***, but does not list underlying ***knowledge*** areas, which may be ICT discipline or domain dependant. These knowledge areas include methodologies, technologies, programming paradigms or specific ICT tools, libraries or languages that may be specific to a given ICT discipline, position description or academic study programme.

For the purposes of the CBoK, skill and knowledge are defined as follows:

> **Skill:** the application of knowledge and know-how to complete tasks and design ICT solutions.
>
> **Knowledge:** the body of facts, principles, theories and practices that form the basis for a given discipline.

For example, the SFIA lists the ***Programming/Software Development (PROG)*** skill as follows:

> *"The design, creation, testing and documenting of new and amended programmes from supplied specifications in accordance with agreed standards*." (SFIA, 2011)

Graduates from a multimedia and computer games course would demonstrate attainment of the PROG skill by writing computer applications that require underlying knowledge of graphics languages like OpenGL, utilising principles from trigonometry and linear algebra.

A more traditional computer science programme with an emphasis on artificial intelligence might instantiate this skill by requiring knowledge of machine learning algorithms in order to build and test applications that mimic human intelligence and learning.

It is important to recognise that the ability to use machine learning algorithms and graphics languages are not considered skills in the context of the nomenclature used in this paper. Instead, they form part of the underlying body of knowledge required by professionals working in a specific ICT discipline or domain.

Taken together, skills and discipline-specific knowledge prepare graduates for particular career roles, equipped to work as professionals within a given domain or focus area. However, it is assumed that the skills are generic in the sense that they are transferable to different domains if the necessary underlying domain knowledge can be acquired through self-study, on the job training or professional development.

3. DESIGNING ICT UNDERGRADUATE PROGRAMMES

3.1 Overview

It is proposed that course designers define degree programmes using a common framework and nomenclature across the many disciplines that comprise ICT. This framework depends on identifying ICT professional skill sets and designing the programme building blocks that lead to the development of these skills.

Key components common to the proposed framework, as shown in Figure 2, are:

- ***SKILL* Block:** The technical and professional skills developed during a given programme of study that qualify graduates to undertake one or more ICT roles;
- ***CORE* Block:** The Core Body of Knowledge (CBOK) shared by all ICT programmes, encompassing (i) ICT problem solving; (ii) Professional knowledge; (iii) Technology building; (iv) Technology Resources; (v) Services management; and (vi) Outcomes realization.
- ***SPEC* Block:** Knowledge that is specific to a particular degree programme or ICT discipline, and that is necessary to undertake the intended ICT roles(s);
- ***COMP* Block:** Complementary knowledge that broadens a student's education, enhances employability and prepares graduates for ICT careers in the global economy, and to be of service to society and the local community.

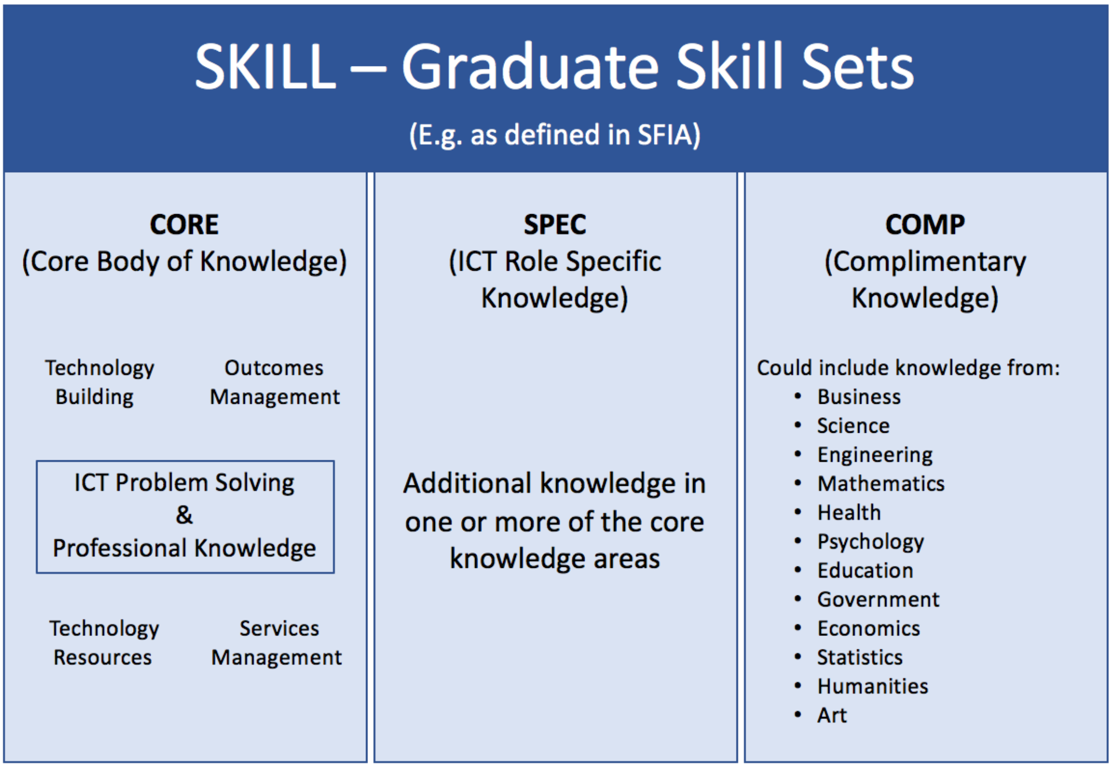

Figure 2: Framework for ICT Programme Design

4. BUILDING BLOCKS FOR ICT PROGRAMMES OF STUDY

4.1 SKILL Block: Graduate Skills

The skills developed by the academic programme should be identified, including the level of autonomy and responsibility at which each skill is practised by graduates.

SFIA has been adopted by the IFIP IP3 programme as the framework by which the professional programmes of member societies will be judged. Thus, ACS and ITP recommend that academic institutions consider modelling graduate skills on those from SFIA. In those cases where an institution chooses not to base graduate skills on SFIA, it will be necessary to demonstrate that the skill set used is equivalent to a similar set defined using SFIA.

In some cases, the SFIA terminology might introduce problematic nomenclature for a given discipline area. Within reason, it would be appropriate to modify skill definitions accordingly.

For example, the SFIA defines the ***Database/Repository Design (DBDS)*** skill as:

> *"The specification, design and maintenance of mechanisms for storage and access to both structured and unstructured information, in support of business information needs."* (SFIA, 2011)

Some programmes may find the word "business" to be problematic in this skill definition. In such cases, it would be reasonable to omit the word business or to substitute an alternative word like "organisation".

4.2 CORE Block: Core Body of Knowledge

A principal aim of identifying the Core Body of Knowledge is to identify fundamental knowledge common across all ICT programmes of study. This common knowledge is shown in the *CORE* Block of Figure 2 and represents the knowledge that is shared by **all** ICT Professionals, regardless of their specific ICT discipline or domain. This building block has six sub-components.

- ICT Problem Solving (PS)
- Professional Knowledge (PK)
- Technology Building (TB)
- Technology Resources (TR)
- Services Management (SM)
- Outcomes Management (OM).

Core knowledge areas overlap content in international curriculum documents for Information Systems, Computer Science, Software Engineering, Information Technology and Computer Engineering (IS2002, CS 2001, SE 2004, IT 2005, CE2004). See Appendix A for a more in-depth treatment of the methodology and data used in this analysis.

It should be noted that:

- The core knowledge areas are a **minimal core**. They contain only those areas on which there is broad consensus that some knowledge of the material is **essential** for anyone who is an ICT professional. In some roles, ICT professionals would require only a basic knowledge of some of the areas that are not central to their role (that is, they may have had only the equivalent of about six hours of study in some areas, and they would be expected only to know the topic well enough that they could explain it to others, i.e. at Bloom's Level 2).
- The core is **not a complete specification** of the knowledge needed by an ICT professional. Because the core is defined as minimal, it does not contain sufficient knowledge for any specific ICT professional. Each ICT professional role would have additional knowledge needed for its particular requirements. For example, in some of the knowledge areas, the professional would be able to operate at a very high level, being able to design solutions to problems and to make judgments about alternative courses of action.
- The core knowledge areas may be less likely to change than other more specialised knowledge, however, it will still be necessary to **review and update** the core knowledge areas on a regular basis
- The **terminology** will vary across different areas in ICT. This document intends to find common terminology that is relatively acceptable across the different areas so we have some underlying understanding from which to work. The descriptions below use indicative wording to describe the topics in each area. However, for definitions of the topic area as understood in different ICT disciplines, the appropriate curriculum should be consulted (see Appendix B).

KNOWLEDGE AREA: ICT PROBLEM SOLVING (PS)

This requires knowledge of how to use modelling methods and processes to understand problems, handle abstraction and design solutions.

This knowledge area is somewhat different in type from the other knowledge areas, as it is seen as an underlying base for all of them. The ability to handle both **abstraction** and **design** solutions has been recognised as a fundamental requirement in computing disciplines over a long period (Dahlbom and Mathiassen, 1997; Kramer, 2007; Turner, 1991).

The methods and tools that are used for handling abstraction could vary a great deal with the branch of ICT, from circuit diagrams to data modelling tools to business process modelling.

It is important to recognise this area because it captures some of the creativity and innovation that is required of computing professionals, and the excitement that is present in their jobs. Recognising this component also assists in identifying what is unique about ICT and what differentiates it from other disciplines. In no other discipline is there such an emphasis on developing artefacts (e.g., computer and information systems) which are so abstract and complex and where modelling tools and methods are so essential. The systems that ICT professionals deal with cannot be seen or handled in the same simple and direct manner as products of other applied disciplines (e.g., buildings, bridges, chairs, drugs). Consequently, highly developed problem solving skills and the need for methods to handle abstraction and modelling are absolutely vital.

KNOWLEDGE AREA: PROFESSIONAL KNOWLEDGE (PK)

This area includes:

- Ethics
- Professionalism
- Teamwork concepts and issues
- Interpersonal communication
- Societal issues/Legal issues/Privacy
- History and status of discipline

The issue of “Professionalism” is important and wide-ranging. Other bodies have provided in-depth treatment of the issue and this document should be read against that background. For example, CC2001 has a chapter on “Professional Practice” (Ch 10, pp. 55-61), which is useful. The IP3 Taskforce is currently focusing on the issue in the context of professional certification. The previous ACS CBOK (Underwood 1997) specified the requirements for *Ethics/Social Implications/Professional Practice* and *Interpersonal Communications*.

SFIA in its Levels of Autonomy and Responsibility Axis mentions degrees of autonomy, influence and complexity, and “Business Skills” including knowledge of standards, problem solving, communication, planning and scheduling, quality, health and safety, acquiring new knowledge, and appreciation of industry activities and organisational contexts.

It is understood that Professional Knowledge topics will need to be addressed at multiple levels in different stages of professional development. The very nature of professional work means that some knowledge and skills are best developed through experience and that understanding of complex issues such as ethics grows with maturity. Thus, the goals for developing professional knowledge/skills will be different at entry-level (graduate) than at full professional level (a certification program).

The topics for the Professional Knowledge Areas were developed by mapping commonalities across the different disciplinary curriculum specifications (CC 2005) (see Appendix A). Appendix B gives relevant references for each Knowledge Area in the curriculum documents for each discipline area.

Ethics

Topics covered should include:

- Fundamental ethical notions (virtues, duty, responsibility, harm, benefit, rights, respect and consequences);
- Basic ethics theories;
- Integrity systems (including, the ACS Code of Ethics, the ACS Code of Conduct, ethics committees and whistle blowing);
- Methods of ethical analysis
    - Methods of ethical reflection’
    - Methods and procedures of ethical repair and recovery;
- ICT specific ethical issues (professional – e.g. compromising quality and conflict of interest, and societal – e.g. phishing and privacy).

Professionalism

Topics covered should include:

- Basic concepts of professionalism (expertise, certification, competence, autonomy, excellence, reflection, responsibility and accountability);
- ICT specific professionalism issues.

Teamwork concepts and issues

Topics covered should include: collaboration, group dynamics, leadership styles, conflict resolution, team development and groupware.

Communication

Topics covered should include: oral and written presentations, technical report writing, writing user documentation and the development of effective interpersonal skills.

Societal issues

Topics covered should include: history of computing and the ICT discipline, privacy and civil liberties, computer crime, intellectual property and legal issues.

History and status of discipline

Professionals should have some knowledge of where and when their discipline began and how it has evolved, in addition to understanding of ongoing issues in the discipline.

KNOWLEDGE AREA: TECHNOLOGY RESOURCES (TR)

This area includes:

- Hardware and software fundamentals
- Data and information management
- Networking.

Hardware and software fundamentals

An understanding of the basic components of computer systems is required, including:

- Computer architecture and organisation - *Form, function and internal organisation of the integrated components of digital computers (including processors, registers, memory, and input/output devices)* (CC 2001, p. 52);
- Systems software – *Operating systems functions and types, operating system modules, processes, process management, memory and file system management* (IS 2002, p. 27).

Data and information management

An understanding is required of how data is captured, represented, organised and retrieved from computer files and databases. Topics include:

- Data modelling and abstraction
- Physical file storage techniques
- Database Management Systems (DBMS)
- Information assurance and security in a shared environment.

Networking

This area requires an understanding of data communications and networking fundamentals. Topics include:

- Network concepts and protocols (e.g., Web standards and technologies)
- Network security
- Wireless and mobile computing
- Distributed systems.

KNOWLEDGE AREA: TECHNOLOGY BUILDING (TB)

This area includes:

- Programming
- Human-computer interaction
- Systems development
- Systems acquisition.

Programming

This involves an understanding of the fundamental constructs of a programming language, the behaviour of simple programmes, efficiency and effectiveness analysis.

The principles, concepts and practices of successful software development (software engineering) should be understood, including program/software testing.

Given the applied nature of software development, it is expected that the requisite knowledge of programming fundamentals would be best developed by engaging students in software developments tasks (programming). However, the range of programming languages and tools that could be used to develop this knowledge is wide.

Human-computer interaction

This area requires an understanding of the importance of the user in developing ICT applications and systems, and involves developing a mindset that recognises the importance of users, their work practices and organisational contexts. Topics covered could include user-centred design methodologies, interaction design, ergonomics, accessibility standards and cognitive psychology.

System development and acquisition

An understanding is required of how to develop or acquire software (information) systems that satisfy the requirements of users and customers. All phases of the lifecycle of an information system should be understood including: requirement analysis (systems analysis) and specification, design, construction, testing and operation and maintenance. There should also be knowledge of methodologies and processes for developing systems.

Terminology for this area varies from 'systems development' in Information Systems to 'software engineering' in Software Engineering and Computer Science, to 'systems acquisition and integration' in Information Technology.

The feature that distinguishes this area from 'programming' is that systems development/software engineering knowledge is applied to larger software systems, where no one person has complete knowledge of the whole system. Of course, many of the principles involved in developing larger software systems also apply to smaller pieces of software (programmes).

KNOWLEDGE AREA: SERVICES MANAGEMENT (SM)

This area includes:

- Service management
- Security management.

ICT Service management deals with the ongoing operation of ICT in an organisational context and includes frameworks for structuring the interactions of ICT technical personnel with business customers and users. The area is concerned with the "back office" or operational concerns of the organisation and could be referred to as "operations architecture" or "operations management".

Many frameworks exist to guide ICT service management, e.g., The Information Technology Infrastructure Library (ITIL) and Control Objectives for Information and Related Technology (CobiT).

KNOWLEDGE AREA: OUTCOMES MANAGEMENT (OM)

This area includes:

- IT governance
- IT project management
- Change management
- Security policy.

Governance and organisational issues

Topics covered should include:

- Fundamental governance principles (e.g. structures to encourage moral behaviour within organisations and corporations, and moral behaviour by organisations and corporations);
- ICT specific governance issues, including ICT management;
- Organisational context, including business processes, organisational culture and change management.

IT project management

This area involves an understanding of the factors required to successfully manage systems development projects. Topics include: team management, estimation techniques, cost/benefit analysis, risk analysis, risk management, project scheduling, quality assurance, software configuration management, project management tools, reporting and presentation techniques.

Change management

Change management is a structured approach to transitioning people and organisations from a current state to a desired future state. In project management, change management refers to a project management process where changes to a project are formally introduced and approved.

Security policy

Topics covered should include:

- *Computer system security*: CPU, Peripherals, OS. This includes data security.
- *Physical security*: The premises occupied by the ICT personnel and equipment.
- *Operational security*: Environment control, power equipment, operation activities.
- *Procedural security*: By IT, vendor, management personnel, as well as ordinary users.
- *Communications security*: Communications equipment, personnel, transmission paths, and adjacent areas.

4.3 SPEC Block: Role Specific Knowledge

The CBOK defines the Core Body of Knowledge shared by all ICT professionals, whereas the Role Specific Knowledge prepares students for career roles in a particular ICT discipline or focus area. Examples of ICT disciplines include, but are not limited to: Software Engineering, Information Systems, and Communications Technology. Examples of focus areas include, but are not limited to: Enterprise Architecture, E-commerce, Computational Science, Simulation and Visualisation.

Role-specific knowledge developed by a degree programme should:

- Build on the foundational knowledge identified in the *CORE* Block as appropriate;
- Share a common focus, providing breadth of treatment within an identified ICT discipline or focus area, and not be a mere collection of unrelated ICT subjects;
- Consist of an appropriate number of subjects and levels as specified in accreditation requirements to be defined later; and
- Facilitate the development of intended skills.

Role-specific knowledge will include advanced knowledge that builds on basic knowledge defined in the CBOK. For example, a Business Analyst (Information Systems) programme may include an advanced treatment of database systems for application in a business context. This would typically be at an advanced level that is beyond that of the simple data storage and retrieval requirement defined in the CBOK.

In many cases, discipline knowledge will be developed that is not directly identified in the CBOK. For example, knowledge of computer graphics is not required by all ICT professionals, but is likely to be important to those working in computational science or simulation and visualisation.

Demonstrating a Common Focus and Breadth of Treatment

Knowledge developed in a degree programme should constitute that required for a well-defined ICT discipline or focus area. There should be an appropriate breadth of treatment.

Where possible, a recognised body of knowledge for a given discipline should be used to demonstrate the common focus and breadth of treatment for a given programme.

For example:

- A joint taskforce (ACM/AIS/IEEE-CS) has given an overview of Computing Curricula (CC 2005), which points to more detailed curricula for a range of computing disciplines. These include Computer Science (CC 2001), Computer Engineering (CE 2004), Information Systems (IS 2002), Information Technology (IT 2008) and Software Engineering (SE 2004).
- Updates for Information Systems can be found in Topi et al. (2007).
- Additionally, the Software Engineering Body of Knowledge (SWEBOK, 2004) has been compiled by the IEEE Computer Society. It defines 10 software engineering knowledge areas that are further decomposed into 251 topics. It excludes knowledge from related areas such as computer science. However, it is reasonable to assume that some of these excluded topics are included in the CBOK. An appendix uses Bloom's Taxonomy to identify the expected level of knowledge cognition attained after four years of professional practice following graduation from an undergraduate programme in software engineering.

In those cases where there is no recognised Body of Knowledge for a given discipline or focus area, a custom body of knowledge can be developed. However, doing so is necessarily more complicated and must be justified in supporting accreditation documentation. Developing the custom body of knowledge must be done in strict consultation with an Industry Advisory Panel whose members represent the focus area, and who are potential employers of programme graduates. It is essential to demonstrate that the custom body of knowledge facilitates the holistic development of intended skills and career roles. This should not merely be a list of subjects. For example, in a degree programme with a computer games focus, it is likely that graduates would have a knowledge of physics. However, it would not be sufficient to list "knowledge of physics" without decomposing this to "dynamics". It would also be necessary to demonstrate the relationship of this to other knowledge areas such as computer graphics. Together, knowledge of dynamics and computer graphics support the skill that enables one to design, implement and test computer games that simulate realistic motion using Computer Graphics Imagery (CGI).

Demonstrating Depth of Treatment

Accreditation requirements will specify the number of ICT subjects that are required at an advanced level. To demonstrate that a subject is advanced, the subject must:

- Require pre-requisite knowledge from at least one other subject, the content of which is contained within the *SPEC* or *CORE* Block; and
- Use assessments that demonstrate cognition at the Application Level (Level 3) or higher in Bloom's Taxonomy; however, they should also require elements of analysis, evaluation and synthesis (Levels 4, 5 and 6) of the taxonomy.

Revised Bloom's Taxonomy provides a means of categorising the cognitive level to which knowledge is used. It consists of six levels. These are: (1) Remembering; (2) Understanding; (3) Applying; (4) Analysing; (5) Evaluating; and (6) Creating.

These are further described in the table on the following page:

Table 5: Revised Bloom's Taxonomy

Level	Bloom's Category	Description
1	Remembering	Recognizing or recalling knowledge from memory. Remembering is when memory is used to produce definitions, facts, or lists, or recite or retrieve material.
2	Understanding	Constructing meaning from different types of functions be they written or graphic messages activities like interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining.
3	Applying	Carrying out or using a procedure through executing, or implementing. Applying related and refers to situations where learned material is used through products like models, presentations, interviews or simulations.
4	Analysing	Breaking material or concepts into parts, determining how the parts relate or interrelate to one another or to an overall structure or purpose. Mental actions included in this function are differentiating, organizing, and attributing, as well as being able to distinguish between the components or parts. When one is analyzing he/she can illustrate this mental function by creating spreadsheets, surveys, charts, or diagrams, or graphic representations.
5	Evaluating	Making judgments based on criteria and standards through checking and critiquing. Critiques, recommendations, and reports are some of the products that can be created to demonstrate the processes of evaluation. In the newer taxonomy evaluation comes before creating as it is often a necessary part of the precursory behaviour before creating something.
6	Creating	Putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning, or producing. Creating requires users to put parts together in a new way or synthesize parts into something new and different a new form or product. This process is the most difficult mental function in the new taxonomy.

Note that the third-year level alone is not sufficient to identify an advanced subject and, in contrast, some subjects taught early often require advanced levels of cognition.

Under normal circumstances, a final-year Capstone project would meet the criteria for an advanced subject.

4.4 COMP Block: Complementary Knowledge

Complementary Knowledge from outside the ICT area that supports the skill set should be included in the programme.

Complementary Knowledge should be defined to:

- Support the Graduate Skill Set (*SKILL* Block);
- Enhance the employability of graduates, particularly with respect to subjects that are significant for regional employability;
- Broaden the education of students;
- Prepare students who will practise as ICT professionals in industries like science and the environment, mining and resources, banking and aerospace, public administration and education; and,
- Include subjects from related areas that are pre-requisites for ICT subjects, such as subjects from business, management, mathematics or computer engineering.

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APPENDIX A: Mapping of International Curriculum to CBOK

The CBOK Knowledge Areas overlap knowledge identified in international curriculum documents from the disciplines of Information Systems, Computer Science, Software Engineering, Information Technology and Computer Engineering (IS2002, CS 2001, SE 2004, IT 2005, CE2004).

Although an attempt has been made in this document to use neutral language to describe CBOK Knowledge Areas, some may find the headings or terminology to be confusing or inconsistent with respect to that used by a specific discipline. See Appendix B to cross-reference CBOK Knowledge Areas with the corresponding sections from the international curriculum for a specific discipline.

The initial overlap analysis was undertaken by considering each curriculum document and manually identifying knowledge areas common to each. Only those areas that were specified as mandatory in the curriculum documents of each discipline were included in the analysis.

Subsequently, a second analysis was undertaken using the data and conventions of the Computing Curricula 2005 Overview Report (CC 2005) to verify the initial analysis. Results are shown in Figure A-1 and A-2.

In these tables, numbers represent the emphasis of individual topics for each discipline on a six-point scale from 0 (not part of the discipline) to 5 (strong emphasis) (CC 2005 p.23). If a topic had a non-zero weighting for each discipline, it was considered to be core to all disciplines and included in CBOK. The minimum weighting is also shown. The CBOK Knowledge Area to which each topic contributes is also indicated.

A brief description of each topic can be found in the glossary of the Computing Curricula Overview Report (CC 2005).

A final revision to the CBOK areas occurred after industry workshops. The feedback from these workshops resulted more in a different way of presenting the core areas, and categorising and naming of them, rather than a radical revision.

NOTES:

Although ***Knowledge Area PS: Problem solving using modelling and abstraction*** was not identified in the overlap analysis, this Knowledge Area was added to CBOK following discussions during Professional Standards Board meetings and workshops.

Some topics listed in the tables might be classified under different headings or interpreted differently by the various disciplines, but have been groups as shown for the purposes of CBOK.

Table A-1: Overlap in Computing Curricula and Relationship to CBOK (CC 2005).

Topic	CBOK	CE	CS	IS	IT	SE	Status	Min
Information Management (DB) Theory	TR	1	2	1	1	2	CORE	1
Information Management (DB) Practice	TR	1	1	4	3	1	CORE	1
Human-Computer Interaction	TB	2	2	2	4	3	CORE	2
Operating Systems Configuration and Use	TR	2	2	2	3	2	CORE	2
Computer Architecture and Organisation	TR	5	2	1	1	2	CORE	1
Operating Systems Principles & Design	TR	2	3	1	1	3	CORE	1
Distributed Systems	TR	3	1	2	1	2	CORE	1
Net Centric Principles and Design	TR	1	2	1	3	2	CORE	1
Net Centric Use and Configuration	TR	1	2	2	4	2	CORE	1
Security: Issues and Principles	TR/OM	2	1	2	1	1	CORE	1
Security: Implementation and Management	TR/OM	1	1	1	3	1	CORE	1
Systems Administration	SM	1	1	1	3	1	CORE	1
Legal / Professional / Ethics / Society	PK	2	2	2	2	2	CORE	2
Programming Fundamentals	TB	4	4	2	2	5	CORE	2
Algorithms and Complexity	TB	2	4	1	1	3	CORE	1
Analysis of Technical Requirements	TB	2	2	2	3	3	CORE	2
Software Design	TB	2	3	1	1	5	CORE	1
Software Modelling and Analysis	TB	1	2	3	1	4	CORE	1
Software Verification and Validation	TB	1	1	1	1	4	CORE	1
Software Evolution (Maintenance)	TB	1	1	1	1	2	CORE	1
Software Process	TB	1	1	1	1	2	CORE	1
Software Quality	TB	1	1	1	1	2	CORE	1
Systems Integration	TB	1	1	1	4	1	CORE	1
Integrative Programming		0	1	2	3	1		0
Platform Technologies		0	0	1	2	0		0
Theory of Programming Languages		1	3	0	0	2		0
Graphics and Visualisation		1	1	1	0	1		0
Intelligent Systems (AI)		1	2	1	0	0		0
Scientific Computing (Numerical Methods)		0	0	0	0	0		0
Information Systems Development		0	0	5	1	2		0
Analysis of Business Requirements		0	0	5	1	1		0
E-business		0	0	4	1	0		0
Engineering Foundations for SW		1	1	1	0	2		0
Engineering Economics for SW		1	0	1	0	2		0
Comp Systems Engineering		5	1	0	0	2		0
Digital Logic		5	2	1	1	0		0
Embedded Systems		2	0	0	0	0		0
Management of Information Systems Organisations		0	0	3	0	0		0
Digital Media Development		0	0	1	2	0		0
Technical Support		0	0	1	5	0		0

KEY	DESCRIPTION
PS	Problem Solving using Modelling & Abstraction
PK	Professional Knowledge
TR	Technology Resources
TB	Technology Building
SM	Services Management
OM	Outcomes Management

Table A-2: Overlap non-ICT Topics and Relationship to CBOK (CC, 2005).

Topic	CBOK	CE	CS	IS	IT	SE	Status	Min
Mathematical Foundations	SPEC	4	4	2	2	5	CORE	2
Risk Management (Project, Safety Risk)	OM	2	1	2	1	4	CORE	1
Project Management	OM	2	1	3	2	5	CORE	1
Interpersonal communication	PK	3	1	3	3	4	CORE	1
Organisational Theory		0	0	1	1	0		0
Decision Theory		0	0	3	0	0		0
Organisational Behaviour		0	0	3	1	0		0
Organisational Change Management		0	0	2	1	0		0
General Systems Theory		0	0	2	1	0		0
Business Models		0	0	4	0	0		0
Functional Business Areas		0	0	4	0	0		0
Evaluation of Business Performance		0	0	4	0	0		0
Circuits and systems		5	0	0	0	0		0
Electronics		5	0	0	0	0		0
Digital Signal Processing		3	0	0	0	2		0
VSLI Design		2	0	0	0	1		0
HW Testing and Fault Tolerance		3	0	0	0	0		0

KEY	DESCRIPTION
SPEC	ICT Roles Specific Knowledge
OM	Outcomes Management
PK	Professional Knowledge

APPENDIX B: CROSS-REFERENCING OF CORE ICT KNOWLEDGE CONCEPTS

Table B-1: Cross-referencing of Core ICT Knowledge Concepts

Knowledge Area		Curriculum Reference				
		IS2002	**CS 2001**	**SE 2004**	**IT 2005**	**CE 2004**
OM	IT Project Management	IS2002.10	SE8	MGT	SIA4	CE-SPR4 CE-SWE8
OM	Governance & Organisational Issues	Organisational problem solving	SP	ITF2	SP7	CE-SPR4 CE-SPR8
PK	Ethics	Ethics & professionalism	SP	PRF.pr	SP5, SP6	CE-SPR1 CE-SPR2 CE-SPR3 CE-SPR9
PK	Professionalism	Ethics & professionalism	SP	PRF.pr	SP8	CE-SPR3
PK	Teamwork Concepts and Issues	Teamwork & leadership	-	PRF.psy	SP4	CE-SWE8
PK	Communication	Communication	-	PFR.com	SP1	-
PK	Societal Issues		SP	ITF3	SP2, SP3, SP9	CE-SPR1 CE-SPR5 CE-SPR6 CE-SPR7
PS	Problem Solving	-	-	-	-	-
TB	Programming Fundamentals	IS2002.5	PL	CMP.cf.9	PF	CE-PRF0 CE-PRF1 CE-PRF3 CE-ALG0 CE-ALG1
TB	Human-Computer Interaction	-	HC	DES.hci VAV.hct	HCI	CE-HCI0 CE-HCI1 CE-HCI2 CE-HCI6
TB	System Building and Acquisition	IS2002.7 IS2002.8 IS2002.9	SE	MAA, DES, VAV, EVL, PRO, QUA	SIA1, SIA2, SIA3, SIA5	CE-SWE0 CE-SWE1 CE-SWE2 CE-SWE3 CE-SWE4
TR	Hardware and Software Fundamentals	IS2002.4	AR OS	CMP.cf.5	PT	CE-CAO0 CE-CAO1 CE-CAO2 CE-OPS0 CE-OPS4
TR	Data and Information Management	IS2002.5	IM	CMP.cf.11	IM	CE-DBS0 CE-DBS1 CE-DBS2
TR	Networking	IS2002.6	NC	CMP.cf.12 NET		CE-NWK0 CE-NWK2 CE-NWK4