Australian Computer Society

Professional Standards Board

The ICT Profession Body of Knowledge

ICT Professionals Shaping Our Future

www.acs.org.au

October, 2008

An appropriate citation for this paper is:

Gregor, S., von Konsky, B.R., Hart, R., and Wilson, D. (2008). *The ICT Profession and the ICT Body of Knowledge (Vers. 5.0)*, Australian Computer Society, Sydney, Australia.

TABLE OF CONTENTS

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 Program (offered by the ACS to recognise ongoing professional development)
CPeP	Computer Professional Education Program (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	International IT Professional
IS	Information Systems
IT	Information Technology
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. INTRODUCTION

In January 2007, the Australian Computer Society (ACS) replaced both its Accreditation, Assessment & Appeals Board and Membership Standards Board with the Professional Standards (PS) Board.

An important responsibility for the Board is the ACS Core Body of Knowledge (CBOK). The current CBOK dates back to 1997 (Underwood, 1997) and, although it is widely used to accredit ICT programs in Australian universities, it is in need of updating. The Board was tasked with a review of the CBOK, beginning April 2007, with an outcome expected no later than December 2008. The scope of the review has widened along the way as it has become apparent that the CBOK must be considered within the wider framework of the ICT profession. It has also become apparent that we are considering Bodies of Knowledge (BOKs) for a number of different disciplinary fields of study within ICT, in addition to a true, common Core Body of Knowledge (CBOK).

In summary, the reasons for updating the current CBOK document are:

- ICT itself has changed since the last CBOK specification in 1997;
- The current CBOK does NOT have a focus on designing programs to match graduate careers and roles;
- The CBOK may not be seen as relevant by employers and industry;
- The CBOK only addresses undergraduate degree programs;
- The CBOK can be viewed as not having enough “bite”. It does not specify any ICT knowledge as mandatory components of an ICT program, although it does specify required professional skills (interpersonal communication, ethics/social implications/professional practice and project management/quality assurance).

Against this background, the aims of the CBOK review are to:

- Provide for a common understanding of the nature and boundaries of the ICT profession;
- Update the ACS Core Body of Knowledge (Underwood 1997);
- Provide a framework of *ICT Building Blocks* that indicates how the requisite skills/knowledge for an ICT professional can be shaped and developed through programs of study and personal development;
- Present the framework developed in a White Paper, which is accessible and useful to ALL involved stakeholders (October 2008); and
- Provide a means of strengthening and promoting the profession.

The purpose of this Working Paper is to present the results of the review to date and to seek comment and feedback. Input on any aspect of the BOK review can be forwarded to members of the PS Board. Industry forums across Australia were held in June and July 2008 to seek further feedback.

Appendix A shows the membership of the PS Board and Appendix B shows the timeline of events in the CBOK revision process.

The scope of the document should be noted. At this point, the main focus in describing educational programs is on **undergraduate bachelor degrees** and the appropriate bodies of knowledge for these degrees. The paper does not address postgraduate programs or non-bachelor degree programs at this point.

Note that regular review and update of this document recommended.

2. BACKGROUND

2.1 CURRENT ENVIRONMENT

The ICT industry in Australia is currently facing some serious problems[1]:

- An apparent skills gap is perceived, with industry continues to find it difficult to find professionals to fill vacancies and some current professionals find it difficult to find jobs;
- Long term growth in the ICT job market is expected, but employment levels have been volatile (the DEEWR ICT job vacancy index has risen by 250 per cent in five years);
- Student demand for tertiary-level ICT study programs has declined by about two-thirds between 2001 and 2007. The most marked decrease was in the first years after the dot-com bust in the early 2000s; and
- Students and those who influence them have poor perceptions of ICT careers.

Some systemic problems have been observed as well, which may in part be due to the relative newness of the ICT profession. Some of these problems have become more evident as the CBOK review has progressed. What has been observed is:

- There is a lack of a common understanding of the ICT profession. Amongst the general public, there is low recognition regarding what constitutes the ICT profession. There are even very fragmented views amongst the different parts of the profession;
- Different groups of stakeholders tend to look only from their own point of view and not the viewpoint of the ICT profession as a whole. For example, some employers want to just look at ‘what type of graduates they want’ and hand over the problem to universities to produce ‘work ready’ graduates; and
- Some program designers focus on using curricula that matches their traditional disciplinary field, rather than looking at whether their programs lead to graduates who possess the skills and knowledge required for professional practice.

2.2 A COMMON VISION

The review team has an underlying perspective on the problems facing ICT that has evolved through the meetings of the PS Board and in workshops with stakeholders.

We believe it is time for a common vision shared by all ICT stakeholders, including industry, government, educators, academic disciplinary bodies, the community, students and professional standards bodies (see Figure 1). All stakeholders should take ownership of the definition and future direction of the profession.

Program designers in educational institutions should determine what is required of professionals in the workforce. Industry should be involved in program design through advisory committees, guest lectures and involvement with student projects and work-integrated learning.

We should encourage communication and collaboration between ICT and other disciplines in our universities. There may be more overlap amongst them than often thought. ICT professionals usually need knowledge ACROSS traditional disciplines. There is more value for the ICT profession as a whole in seeking synergy amongst the traditional ICT disciplines in our universities rather than emphasising differences.

[1] Data obtained from the ICT Workforce and Labour Market Research project of the Industry Leadership Group formed in response to the findings of the Skills Foresighting Group in 2005.

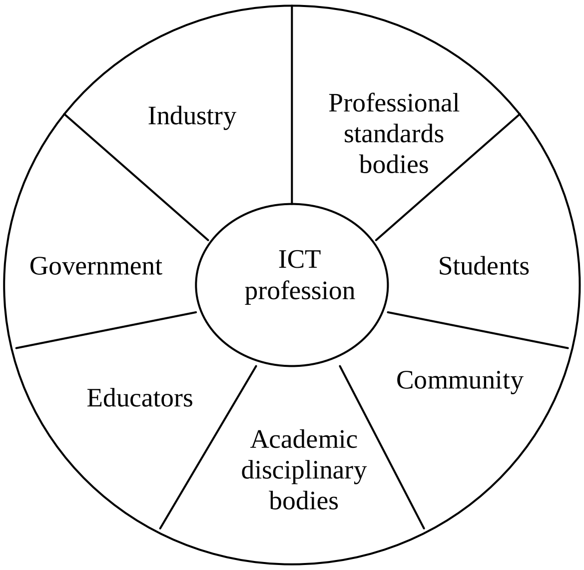


Figure 1: Stakeholders and the ICT profession

2.3 Philosophy for the Design of Programs of Study

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

Program design is the process by which educators in an academic institution develop a 'program of study' that leads to the award of a qualification such as a bachelor's degree. The program of study will include individual "units" of study, otherwise known as "subjects" or "courses". As an example, a three-year bachelor's degree in Australian universities commonly has 24 units of study (eight units per year). A curriculum-driven approach means that the program designers base their program 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 program designers consider what roles their graduates will undertake after graduation and design programs 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 programs are designed to address short-lived market trends or skills gaps. Nor do we advocate abandoning the study of fundamental knowledge. Rather, program 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.

In Australia, data is incomplete as to the paths most students follow after graduation. However, Appendix C points to some data sources that can be consulted on employment trends.

2.4 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 meeting the needs of many stakeholders, including diversity of industry sectors, 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 programs of study should take. The rapid change in the profession means that tight program prescription could constrain the development of programs of study in new fields: e.g., multimedia and games. Educators should be free to design innovative programs 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 programs of study is recommended, so that program designers consider the roles that graduates will occupy upon graduation (as explained in Section 2.3);
- The **context** of the ICT industry and education in Australia should be recognised. ICT has made significant contributions to productivity in Australia because industry 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 Australian context;
- ICT can be considered a **practical science**[2] and practical work, such as project work, is required at some point in programs of study in order to fully develop learning of applied skills and knowledge;
- **Flexibility** is required in thinking about the industry and programs of study because of the ongoing and rapid **change** in an industry and the disciplines that are based around ICT; and
- **Regular updating** of this document will be needed because of ongoing change in ICT and will require continuing discussion among the many stakeholders.

[2] See Strasser (1985)

3. 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.

3.1 DEFINITION OF A PROFESSIONAL

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

A view compatible with the ACS charter is 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.

Note that work on defining what it means to be an ICT professional is proceeding separately in other initiatives outlined below.

3.2 STRENGTHENING THE ICT PROFESSION

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

The ***International Professional Practice Partnership*** (IP3) from the ***International Federation of Information Processing*** (IFIP) accredits schemes for the certification of professional status of member societies. Under the IP3, ACS members would have global recognition as ICT professionals. The program is managed by a taskforce that includes the British Computer Society, the ACS, the Canadian Information Processing Society (CIPS) and IEEE (CS).

The ACS ***Computer Professional Program*** (CP) is accredited under IP3. ICT degree graduates can attain CP status after 18 months work experience and the ACS CPeP OR 5 years of relevant experience (two years at SFIA level 5). An internationally recognised ICT certification offers greater recognition of ICT disciplines and increases the global status of ICT professionals. A recognised body of knowledge is an essential component required for professional certification.

Several bodies are proposing an accord for the trans-national recognition of accredited educational programs in computing and ICT-related disciplines. In November 2007, the ***Seoul Accord*** was agreed by representatives from Australia, Britain, Canada, Japan, Korea and the US (ABET) as a process for establishing such an agreement. The Seoul Accord established a draft set of graduate attributes expected of students entering the ICT profession. The ACS CBOK will need to map to the finalised Seoul Accord graduate attributes and the ACS accreditation process will need to be revisited with a view to full membership of the accord.

3.3 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. A solution will 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	Development	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 Provision - Infrastructure	Organisational roles that provide and support the networked infrastructure underpinning technology building and implementation.
Service Management	Service Provision – Operation, User Support	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 resource management.
	Strategy and Planning	Strategic roles implementing organisational strategy by aligning business and ICT strategic planning.

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

Recent attempts to define the skills of ICT professionals include:

- **The Skills Framework for the Information Age (SFIA)** gives a comprehensive and sophisticated picture of the ICT profession (SFIA, 2005). This framework was produced by the SFIA Foundation, a not-for-profit body comprising a number of UK-based organisations, including the British Computer Society. SFIA is being used by the IP3 as a framework against which to accredit the professional programs of member societies and is described in greater detail in Section 3.4 of this document.
- **Technologists in the Public Interest (TIPI)** is an ICT naming and competency framework from Queensland that was produced in 2006 with ACS sponsorship. This framework distinguished technologist specialisations in Business, Information, Marketing, Media, Security, Software and Systems.
- **The Queensland Government** offered a categorisation of ICT careers, which is somewhat similar to the first column of Table 1 (Grant, 2006).

Despite a lack of agreement on the best framework to describe graduate skills, ICT program designers in universities must be aware of the range of roles their graduates could fulfil and design programs accordingly. SFIA commends itself for primary use because of the link with the international IP3 accreditation.

3.4 THE SKILLS FRAMEWORK FOR AN INFORMATION AGE

Organisations employing ICT professionals can use the SFIA to write position descriptions, manage risk and improve the ICT function (SFIA, 2005, p.4). It has also been used to identify skills attained by graduates of an academic program (von Konsky, *et al.,* 2008).

The 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 2005 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, 2005)

Category	Sub-category	Skill	Code
Strategy and Planning	Information strategy	Information Management	IRMG
	Advice and guidance	Consultancy	CNSL
		Technical Specialisation	TECH
	Business/IS strategy and planning	Research	RCSH
		Innovation	INOV
		Business Process Improvement	BPRE
		Business Risk Management	BRUM
		Information Security	SCTY
		Information Assurance	INAS
	Technical strategy and planning	Remainder of table not completed. Refer to SFIA (2005, pp. 3-4).	
Development	Systems development		
	Human factors		
	Installation and integration		
Business change	Business change management		
	Relationship management		
Service provision	Infrastructure		
	Operation		
	User support		
Procurement and management support	Supply management		
	Quality		
	Resource management		
Ancillary skills	Education and training		
	Sales and marketing		

Table 3: SFIA Levels of Autonomy and Responsibility Axis (SFIA, 2005)

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

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

> *Conducts security risk 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 BS7799).* (SFIA, 2005)

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

The current IP3 working 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 program would be ready to assume Level 4 responsibilities in their area of specialisation.

3.5 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 program.

For the purposes of this paper, 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 forms 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 programs from supplied specifications in accordance with agreed standard*s. (SFIA, 2005)

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 program 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.

Table 4: Indicative criteria for ACS professional pathways

Grade	SFIA Level	Criteria
Computer Specialist (CS)	SFIA Level 7: set strategy, inspire, mobilise SFIA Level 6: instantiate, influence	Not yet defined, but likely to include CP status, plus an advanced specialist ICT body of knowledge and/or a qualification at the postgraduate level.
Computer Professional (CP)	SFIA Level 5: ensure, advise	Be eligible for CP status. Normal pathway is graduate of an accredited degree program plus experience at SFIA level 5 or completion of CPeP
Computer Technologist (CT)	SFIA Level 3: Apply	Be eligible for CT status. Normal pathway is completion of an accredited ICT diploma plus experience at SFIA level 3

3.6 ACS Professional Pathways

The ACS is currently working towards developing more comprehensive professional pathways for ICT practitioners. It is proposed that three levels of certification of ICT practitioners be introduced – the computer technologist, computer professional and computer specialist. The levels are described in Table 4.

This document only addresses the educational requirements for those courses preparing graduates for entry to the professional level.

4. DESIGNING ICT UNDERGRADUATE PROGRAMS

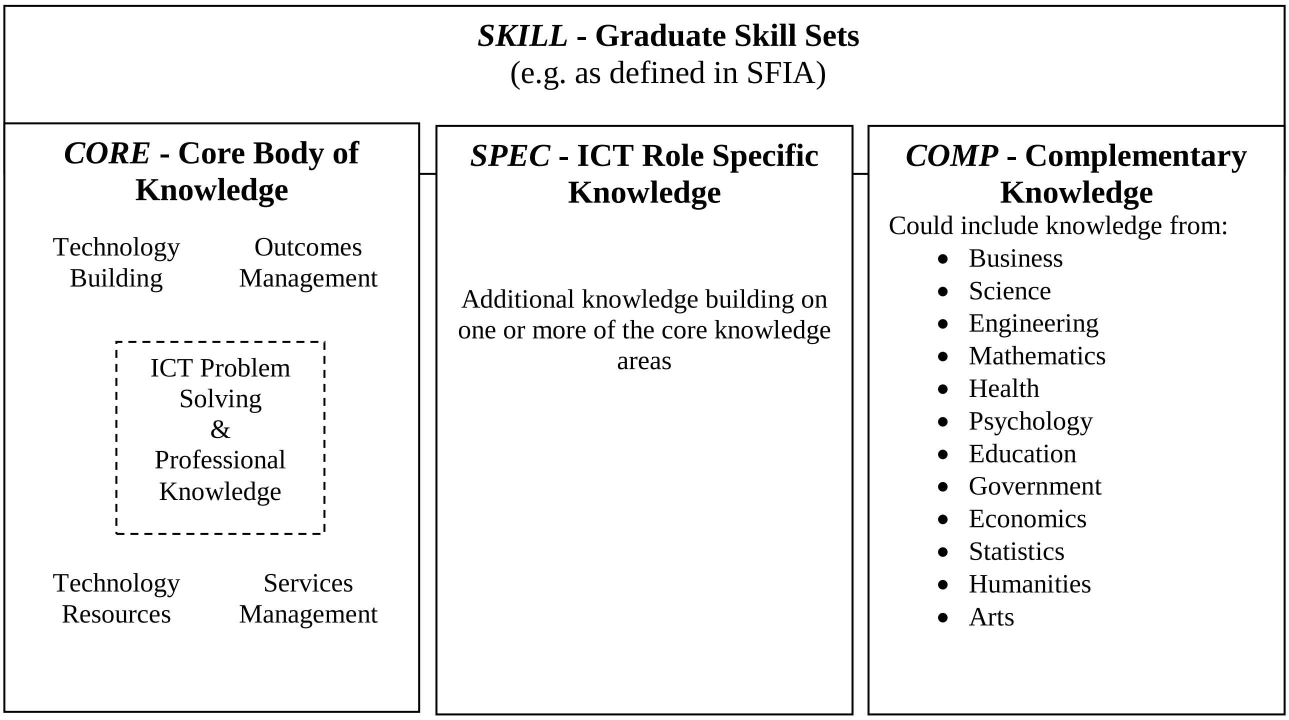
4.1 Overview

It is proposed that course designers define degree programs 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 program building blocks that lead to the development of these skills. The common framework could be used to design new ICT programs and as the basis for future accreditation assessments after the ACS formally adopts the new Body of Knowledge specifications.

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

- ***SKILL* Block:** the technical and professional skills, developed during a given program of study, that qualify graduates to undertake one or more ICT roles.
- ***CORE* Block:** the Core Body of Knowledge (CBOK) shared by all ICT programs, encompassing (i) ICT problem solving; (ii) Professional knowledge; (iii) Technology building; (iv) Technology resources; (v) Services management; and (vi) Outcomes management.
- ***SPEC* Block:** knowledge that is specific to a particular degree program or ICT discipline, and that is necessary to undertake the intended ICT role(s). In some programs predefined curriculum may assist in defining the components of this block.
- ***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 Program Design



4.2 A STRUCTURED APPROACH TO PROGRAM DESIGN

A goal of the proposed framework is to facilitate the design of degree programs that produce graduates with the skills necessary for given roles as ICT professionals. The level of autonomy and responsibility at which the skill is practised should also be established. Fundamentally, these skills require the application of underlying knowledge that is both broad and deep, and must include both technical and professional knowledge areas.

When designing a course, it is necessary to do the following:

- **Identify potential ICT roles that could be undertaken by graduates of a given program of study.** These roles might be generic, such that all graduates from a particular degree program would be qualified to undertake a range of gradate roles within a given ICT discipline. However, a program may to choose to place more emphasis on certain roles within that discipline. This might be because an institution has recognised expertise in a given area or because there are regional employment opportunities for graduates with a particular focus.
- **Identify the skills required by professionals in a given ICT career role.** Identify the type of tasks that a professional working in given ICT career role(s) would normally be capable of performing. These may be the type of tasks that are normally required to work in industry, or they may be the type of tasks more frequently associated with a research focussed career path.
- **Identify the level of autonomy and responsibility developed.** It should be possible to demonstrate that graduates of a program operate at reasonable levels of autonomy and responsibility as defined by SFIA.
- **Identify the ICT Role-Specific Knowledge required to practise the skills.** Where possible, internationally recognised curricula and bodies of knowledge developed elsewhere should be used to assist in identifying Role-Specific Knowledge. For ICT areas that lack a formal curricula or body of knowledge, supporting knowledge should be identified using other appropriate sources in consultation with the program's Industry Advisory Board. It should be possible to demonstrate that students acquire knowledge to a suitable depth and breadth.
- **Identify Complementary Knowledge that supports the skill set or that broadens student employability.** As software-based products or services are usually offered in conjunction with a business, it is reasonable that many ICT career roles require knowledge of business functions and processes. Additionally, employment prospects might be enhanced from regionally significant complementary disciplines. For example, knowledge of avionics might be useful in regions where aerospace organisations are prevalent.
- **Design a course structure that incorporates ICT Role Specific Knowledge with the Core Body of Knowledge and other Complementary Knowledge as part of a holistic program of study.** For example, a course structure should scaffold advanced knowledge on top of programming fundamentals and project management topics from the ICT Knowledge Area of the CBOK.
- **Collect artefacts to demonstrate that skills have been developed by students to an appropriate level.** This generally requires that a representative sample of student work be collected to demonstrate that skills have been developed to an appropriate level. Samples will be made available to accreditation panels for inspection. Artefacts produced by students in conjunction with a capstone project are a good source of material for demonstrating the skills attained by students.

5. BUILDING BLOCKS FOR ICT PROGRAMS OF STUDY

5.1 *SKILL* BLOCK: GRADUATE SKILLS

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

The SFIA has been adopted by the IFIP IP3 program as the framework by which the professional programs of member societies will be judged. Consequently, the ACS Professional Standards Board recommends that academic institutions consider modelling graduate skills on those from the SFIA. In those cases where an institution chooses not to base graduate skills on the SFIA, it will be necessary to demonstrate that the skill set used is equivalent to a similar set defined using the 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 Design (DBDS) skill as (SFIA, 2005):

> *"The specification, design, and maintenance of structure for information storage and access to support business information needs."*

Some programs 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".

5.2 *CORE* BLOCK: CORE BODY OF KNOWLEDGE

A principal aim of identifying the Core Body of Knowledge was to identify fundamental knowledge common across all ICT programs 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 were identified by the Professional Standards Board through workshops and an analysis of the content overlap 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 D 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 basic coverage in some topics 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 are 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
- We recognise that the **terminology** will vary across different areas in ICT. We are attempting 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 E).

KNOWLEDGE AREA: ICT PROBLEM SOLVING (PS)

This area 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 specific ICT discipline, 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 practical disciplines (eg, 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*.

The 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 Area identified developed by mapping commonalities across the different disciplinary curriculum specifications (CC 2005) (see Appendix D). Assistance was also provided by Richard Lucas of the Centre for Applied Philosophy and Public Ethics (CAPPE). Appendix E 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; and
- 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); and
- 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: privacy and civil liberties, environmental and sustainability issues, 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)

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)

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 programs, efficiency and effectiveness analysis.

The principles, concepts and practices of successful software development 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 and their work practices. 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 (programs).

KNOWLEDGE AREA: SERVICES MANAGEMENT (SM)

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)

Includes:

- ICT Governance
- ICT Project management
- Change management
- Security policy.

Governance and organisational issues

Topics covered should include:

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

IT project management.

This area involves an understanding of the factors required to successfully manage ICT 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.

5.3 *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, Computer Science and Computer Engineering. 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 program 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 program that leads to roles such as a Business Analyst (Information Systems) may include an advanced treatment of database systems for application in a business context. This would typically be at a more advanced level than that of the simple data storage and retrieval requirements 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 program 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 program.

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 program 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 program 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 program 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 Role Specific Knowledge (SPEC) or CORE Block; and
- use assessments that demonstrate cognition at the Application Level (Level 3) or higher in Bloom's Taxonomy.

Bloom's Taxonomy provides a means of categorising the cognitive level to which knowledge is used. It consists of six levels. These are: (1) Knowledge; (2) Comprehension; (3) Application; (4) Analysis; (5) Evaluation; and (6) Synthesis. These are further described in Table 5.

Table 5: Bloom's Taxonomy

Bloom's Level	Bloom's Category	Description
1	Knowledge	Facts and figures can be recalled.
2	Comprehension	Information is understood well enough to explain it to others.
3	Application	Knowledge can be applied to new problems.
4	Analysis	Compare and contrast alternatives by decomposing a problem and understanding relationships.
5	Synthesis	Devise new approaches or understanding by reassembling and reconstructing existing knowledge and information.
6	Evaluation	Make judgements and recommendations based on an evaluation of available data and information.

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.

5.4 *COMP* BLOCK: COMPLEMENTARY KNOWLEDGE

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

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.

6. NEXT STEPS

This paper draws together material from PS Board meetings, documents and comments provided by individual members of the Board, meetings with various stakeholder groups and input from a series of industry workshops.

A number of points requires further discussion:

1. Course structures should be consistent with revised accreditation requirements. The revision of the accreditation requirements remains to be done.

   If a revised accreditation scheme is to be generally consistent with current requirements, then the Role Specific Knowledge (*SPEC* Block) and the *CORE* Block would constitute at least one third of the course. Of these, one third would be at an advanced level. In a three-year Australian program, this study would typically constitute at least eight of 24 subjects, with three of those subjects at an advanced level.

   A phasing-in process for new accreditation requirements is expected.

2. A significant capstone project is regarded as mandatory. The purpose and nature of the project requires further discussion. It is expected that this project should enable students to demonstrate both the technical and the professional skills that have been attained, and to further enhance those skills.
3. Exemplars/prototypes for the disciplinary-specific BOKs.
4. SPEC blocks have yet to be developed.
5. The CAPPE/ACS survey may give some ideas for improving teaching ethics and professional practice (Lucas and Weckert 2008). The ACS should examine whether additional support could be provided to assist Australian universities in this regard.
6. Consultation with industry, government and the wider profession.

REFERENCES

ACS (2008). ACS Membership Guidelines, March.

Bloom, B.S. (1984). *Taxonomy of educational objectives*. Boston, MA: Pearson Education.

[CC2005] *Computing Curricula 2005: The Overview Report covering Undergraduate Degree Programs in Computer Engineering, Computer Science, Information Systems, Information Technology, Software Engineering.* ACM, AIS, IEEE-CS. URL: http://www.acm.org/education/curricula.html

[CS2001] Computing Curricula 2001 Computer Science. The Joint Task Force on Computing Curricula, IEEE Computer Society, Association for Computing Machinery. URL: http://www.acm.org/education/curricula.html

Dahlbom, B. and Mathiassen, L. (1997). The future of our profession. *Communications of the ACM*, 40, 6, 80-89.

Grant, P. (2006) Presentation at Skills Summit, Brisbane.

[IS2002] *IS2002 Model Curriculum and Guidelines for Undergraduate Degree Programs in Information Systems*, ACM, AIS, AITP. URL: http://www.aisnet.org or http://info.acm.org/education/

[IT2005] *Computing Curricula Information Technology Volume*. URL: http://www.acm.org/education/curricula.html

Kramer, J. (2007). Is abstraction the key to computing? *Communications of the ACM*, 50, 4, 37-42.

Lucas, R. and Weckert, J. (2008). *Ethics and Regulation in the ICT Industry.* ARC Linkage Project LP 0560659, Canberra.

Professions Australia (2007). URL: http://www.professions.com.au/

[SE2004] *Guide to the Software Engineering 2004 Curriculum Guidelines for Undergraduate Degree Programs in Software Engineering.* The Joint Task Force on Computing Curricula, IEEE Computer Society, Association for Computing Machinery. URL: http://www.acm.org/education/curricula.html

SFIA (2005) Skills Framework for the Information Age Foundation, 3.0, SFIA Foundation, United Kingdom. URL: http://www.sfia.org.uk/

[SWEBOK] Guide to the Software Engineering Body of Knowledge (SWEBOK (r) (2004) Abran, A, Moore, JW, Bourque, P, Dupuis, R, and Tripp, LL, eds., IEEE Computer Society, Los Alamitos, California, URL: http://www.swebok.org/pdfformat.html

Strasser, S. (1985). *Understanding and Explanation*. Pittsburgh: Duquesne University Press.

TIPI. Technologists in the Public Interest (2006). Accelerating development of the Information and Communication Technology Industry and Profession (Vols 1 and 2). Australian Computer Society.

Topi, H et al. (2007) Revising the IS model curriculum: Rethinking the approach and process, Communications of the AIS, 20, 728-740. See also http://blogsand wikis.bentley.edu/iscurriculum

Turner, A.J. (1991). Computing curricula 1991. *Communications of the ACM*, 34, 6, 69-84.

Underwood, A. (1997). The Core Body of Knowledge for Information Technology Professionals, Australian Computer Society. http://www.acs.org.au/national/pospaper/bokpt1.htm

Von Konsky, B.R., Hay, D., and Hart, R. (2008): Skill set visualisation for software engineering job positions at varying levels of autonomy and responsibility, *19th Australian Conference on Software Engineering* (ASWEC 20008), Industry Experience Report, Perth, 26-28 March, 2008.

Wilson, D. and Avison, D. (2007). Double jeopardy: The crises in Information Systems, an Australian perspective, *18^{th} Australasian Conference on Information Systems*, Toowoomba, 5-7 Dec.

Appendix A

Professional Standards Board Membership

Members of the ACS PS Board include:

- Professor Shirley Gregor, Australian National University (Director, PS Board)
- Professor Doug Grant, Swinburne University (Deputy Director, PS Board) (Representative from Software Engineering)
- Dr Brian von Konsky (Associate Director, PS Board) (Representative of Computer Science and Software Engineering Education Research Community)
- Kumar Parakala, National President, ACS (ex officio member)
- Bob Hart, Manager, General Manager: Professional Standards, Accreditation and Certification, ACS (ex officio member)
- Chris Avram, Monash University (Chair: ACS Disciplinary Committee)
- Derek Goh, Executive General Manager, IT & Facilities Management, Challenger Financial Services (Nominee of CIO Executive Council)
- Professor Michael Johnson, Macquarie University (Representative from Computer Science Heads)
- Dr Paul O'Brien, University of Queensland (ACS Queensland Branch Executive)
- Dennis Street (ACS Victoria Branch Executive)
- Dr David Lindley, Academic Principal: ACSEducation
- Professor David Wilson, University of Technology, Sydney (Representative from Australian Council of Professors and Heads of Information Systems (ACPHIS))
- Penny Collings, Adjunct Associate Professor, University of Canberra
- Wayne Knack, Director Innovations, Brisbane North Institute of TAFE
- Michel Duneman, Director Corporate Services, City of Port Augusta (Representative of local government and regional areas)
- Steve Jacob, Sun Australia (Representing industry)
- Peter Dale, Australian Government Information Office (Representing federal government agencies)

Appendix B
Timeline of BOK Revision

Date	Completed Activities
2007	
April	First PS Board meeting, process begun
26 May	First discussion paper presented to ACS Council (V1.0)
21 June	Version 2.0 of discussion paper placed on ACS web site for public comment. Input encouraged through mailing lists.
	Further develop Working Paper
25 Sept	Presentation to ACPHIS, Adelaide (S. Gregor)
3-4 October	Second PS Board meeting
	Further develop Working Paper
15 Oct	Distribute update of Working Paper to PS Board, seek feedback
22 Nov	Report on progress to ACS Council
	Further develop Working Paper
Dec	Workshop at ACIS, Toowoomba (D. Wilson and S. Gregor)
2008	
18 Jan	Version 3.0 of Working Paper released.
23 Jan	Workshop with CORE, Wollongong, ACSW (S. Gregor & B. Von Konsky)
8 Feb	Presentation at ICT Deans Meeting (D. Wilson & S. Gregor)
5 March	Third PS Board meeting
2 June	Version 4.0 of Working Paper released.
June-July	Industry workshops in Brisbane, Canberra, Sydney, Melbourne and Perth (S.Gregor, B. Von Konsky, D. Wilson).
July	Presentation at NACCQ, NZ (B. Von Konsky)
12 August	Fourth PS Board Meeting
October	Version 5.0 of Working Paper.
	Anticipated Activities
	Presented to ACS Management Committee.
Nov	Presentation at ACS Congress

Appendix C
Demand for ICT professionals

The Australian Government collects some information on the ICT industry. Until recently, statistics were collected against the Australian Standard Classification of Occupations (ASCO 2nd edn), which did not give very useful classifications since most ICT professionals were lumped into one category. However, a newer classification system, the Australian and New Zealand Standard Classification of Occupations (ANZCO), is now being used, which gives a finer-grained breakdown, with "SUB-MAJOR GROUP 26 ICT PROFESSIONALS" described at:

http://www.abs.gov.au/ausstats/abs@.nsf/Product+Lookup/A3D7E89E4F30A825CA2571E2008354A4?opendocument

The SkillsInfo website, an initiative of the Department of Education, Employment and Workplace Relations (DEEWR), gives information about the ICT labour market and skills-in-demand. See http://www.skillsinfo.gov.au/skills/SkillsIssues/ICTSkills/

A range of information can be found on the DEEWR site, such as a report by Multimedia Victoria, 2007. This report shows that during 2005-2006, the largest areas of ICT job placements across Australia were:

- Analysts/programmer/software developer and engineer (21%)
- Support, QA or test engineer (approx 19%)
- Help desk/support technician/web administrator (approx 17%)
- Business analyst/consultant/systems analyst (approx 13%
- Network engineer/admin/analyst (approx 8%)
- ICT manager/CIO/project manager (approx 8%)
- Database/systems administrators/security specialists (approx 6%).

A further service is SkillsMatch offered by the Information Technology Contract and Recruitment Association (ITCRA), and developed in partnership with the Australian Government. See http://www.itcra.com/index.asp?menuid=070&artid=289

One needs to be a member to get full access to data. However, a report for the quarter April to June 2007 showed**:**

> *"the average salary of total ICT placements was $107,014. Among occupations where salaries were specified, the highest averages were for multimedia specialists ($146,900), project managers ($146,338) and business development managers ($143,200). The top 10 ICT skills in demand during the quarter were: Windows-related (161); project-related (140); help desk (92); MS-related (90); business analysts (84); SQL-related (84); testing-related (82); Java (50); C-related (49); and web management (46).*

The above may be of some interest, but it also demonstrates some of the confusion in reporting statistics for job demand when various terms are mixed together.

The question of what roles most graduates fill has been addressed elsewhere. For example, in Computing Curricula 2005 (CC2005, p. 31) there is reference to the "ongoing discussion regarding the relationship between what *computer science programs teach* and what *most graduates of computer science actually do* in their careers". CC2005 identifies four career paths:

1. Designing and implementing software;
2. Devising new ways to use computers;
3. Developing effective ways to solve computing problems; and

4. Planning and managing organisational technology infrastructure.

The CC2005 authors believe that paths 2 and 3 are what many computer science academics wish to see their students choose, although an extremely small minority of students actually choose them. The CC2005 authors believe that career paths 1 (being overtaken by Software Engineering) and career path 4 (being overtaken by Information Technology) draw the overwhelming majority of graduates.

Appendix D

Mapping of International Curriculum to ACS CBOK

The ACS Professional Standards Board identified the CBOK Knowledge Areas during workshops and through an analysis of the knowledge overlap 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).

To some extent, identifying the overlap in international curriculum documents was a difficult task. The principal difficulty was the use of different terminology to denote the same or similar concepts by the various ICT disciplines.

Although an attempt has been made in this document to use neutral language to describe CBOK knowledge areas, some may find the headings or nomenclature to be confusing or inconsistent with respect to that used by a specific discipline. Appendix E and F give cross-references between CBOK Knowledge Areas and 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 D-1 and D-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 after 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 grouped as shown for the purposes of CBOK.

Table D-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
Computer 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 Info Systems Org		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 D-2: Overlap ICT-related Topics and Relationship to BOK (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 Role Specific Knowledge
OM	Outcomes Management
PK	Professional Knowledge

Appendix E

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	N/A
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

Core Body of Knowledge September 2007 version is available at
http://www.acs.org.au/index.cfm?action=show&conID=cbok