Learning and Teaching Academic Standards Project

ENGINEERING AND ICT

Learning and Teaching Academic Standards Statement
December 2010

AUSTRALIAN LEARNING & TEACHING COUNCIL

Promoting excellence in higher education

An initiative of the Australian Government Department of Education, Employment and Workplace Relations

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EXECUTIVE SUMMARY

The combined discipline of Engineering and ICT acknowledged from the outset the existing learning outcomes or competencies developed by their relevant professional bodies. Drawing upon these standards, the Engineering and ICT project team endeavoured to not only meld the two disciplines' outcomes into a single coherent set, but also to reconceptualise them in a way that offered a more holistic grasp of Engineering and ICT as practised in industry.

To support the Discipline Scholars, an advisory group was established to assist in the drafting of the threshold learning outcomes (TLOs). This group comprised members who held strategic responsibilities in the pertinent stakeholder organisations: Engineers Australia, the Australian Computer Society, the Australian Council of Engineering Deans and the Australian Council of Deans of Information and Communications Technology.

A national consultative strategy was adopted that would allow in-depth consultation within the academic and industry-based communities.
In March 2010, the Discipline Scholars invited senior academics, industry professionals, recent graduates and senior students to an event in Melbourne that became the first of many similar consultative sessions held in major regional centres. Open invitations to attend events were sent directly to engineering and ICT deans and associate deans (T&L). Professional societies extended invitations to their membership. During these events feedback was sought from attendees that provided insight and validation into the ongoing refinement of the TLOs.

The practical reconceptualisation of the disciplines' learning outcomes and the endorsement of the TLOs by five key professional bodies are the major achievements of this project. From the extensive list of professional competencies produced by Engineers Australia and the Australian Computer Society, the Discipline Scholars have developed a set of five overarching learning outcomes that is considered more useful and meaningful to all stakeholders. These outcomes also align with the outcomes specified by the International Engineering Alliance.

With an integrated set of TLOs, academics are in a better position to interrogate the design of an aligned curriculum that addresses the breadth and depth of learning outcomes from year one. Members of accrediting bodies will be able to seek, review and identify learning outcomes across

five broad areas. Furthermore, students can be offered a conceptually easier grasp of the five key areas they need to develop during their undergraduate experiences.

The Discipline Scholars gratefully acknowledge the generous contributions given by people from stakeholder communities, who have travelled, gathered, contributed and challenged the ideas and directions put forward during the life of this project.

Project Leaders

Discipline Scholars: Professor Ian Cameron and Associate Professor Roger Hadgraft
Project Officer: Dr Sue Wright

1. Learning and Teaching Academic Standards Project Background

The Australian Government is developing a new Higher Education Quality and Regulatory Framework which includes the establishment of the Tertiary Education Quality and Standards Agency (TEQSA). TEQSA will be a national body for regulation and quality assurance of tertiary education against agreed standards. In developing the standards, the Australian Government is committed to the active involvement of the academic community.

The Australian Government has commissioned the ALTC to manage aspects of the Learning and Teaching Academic Standards (LTAS) component of the framework. The approach was designed to ensure that discipline communities would define and take responsibility for implementing academic standards within the academic traditions of collegiality, peer review, pre-eminence of disciplines and academic autonomy.

In 2010, both directly through a specific contract and indirectly through base funding of the Australian Learning and Teaching Council, the Australian Government funded a one-year demonstration project to define minimum discipline-based learning outcomes as part of the development of Learning and Teaching Academic Standards.

The project took as its starting point the award level descriptors defined in the Australian Qualifications Framework (AQF). Threshold learning outcomes (TLOs) were defined in terms of minimum discipline knowledge, discipline-specific skills and professional capabilities including attitudes and professional values that are expected of a graduate from a specified level of program in a specified discipline area.

The process took account of and involved the participation of professional bodies, accreditation bodies, employers and graduates as well as academic institutions, teachers and senior students. These representatives of the discipline communities were encouraged to take responsibility for the project and the outcomes within broad common parameters. Some disciplines extended the brief to begin consideration of the implications of implementing standards at institutional level.

1.1 Discipline areas encompassed in the demonstration project

Broad discipline areas were defined according to Australian definitions of Field of Education from the Australian Standard Classification of Education. They correspond to the most common broad structural arrangements of faculties or aggregates of departments within Australian universities.

Eight broad discipline groups participated in 2010:

- architecture and building
- arts, social sciences and humanities
- business, management and economics
- creative and performing arts
- engineering and ICT
- health, medicine, and veterinary science
- law
- science.

Discipline Scholars were appointed to lead each discipline area. The key deliverable for each Discipline Scholar was the production of a document of minimum learning outcomes for a specified discipline at an agreed AQF level or levels. This booklet represents that outcome for this discipline.

2. Engineering and ICT in the Learning and Teaching Academic Standards Project

2.1 Scope

The Learning and Teaching Academic Standards Statement for Engineering and ICT addresses entry level programs into professional practice in Engineering and ICT. These programs are the focus of accreditation by Engineers Australia (EA) and the Australian Computer Society (ACS). Typically, entry to the professions is after a four-year degree in Engineering or a three-year degree in ICT.

This statement acknowledges the importance of curriculum diversity within individual institutions. The revised Learning and Teaching Academic TLOs for Engineering and ICT do not prescribe any particular pedagogical approach in terms of determining appropriate teaching and learning activities. Nevertheless, they clearly provide opportunity for national collaboration to make best practice teaching and learning resources available across the sector.

Similarly, this statement makes no prescription concerning assessment procedures and suitability of those procedures regarding academic standards. It does, however, provoke questions concerning the kind of evidence that would demonstrate achievement against each of the standards. Again, there is further opportunity for sharing of best practice assessment approaches across the sector as encouraged by the existing educational divisions of the technical societies. This statement may be effectively employed by accrediting bodies from Engineers Australia and the Australian Computer Society as it is complementary to their existing accreditation guidelines.

2.2 Rationale

Engineers Australia, in its 2010 revised (draft) *Stage 1 Competencies and Elements of Competency,* sets out 16 elements of competency as the key expected learning outcomes for a graduate engineer. These elements of competency are supported by 70 indicators of attainment. The Australian Computer Society offers their body of knowledge and the Australian Council of Professors and Heads of Information Systems (ACPHIS) presents a comprehensive list of learning outcomes. Each accreditation system (EA and ACS) categorises outcomes in terms of knowledge, skills and professional attributes.

The LTAS project offered the Engineering and ICT communities a timely opportunity to move away from thinking of learning outcomes as a list of discrete outcomes or aspirational statements. From the outset, the Discipline Scholars proposed that the threshold learning outcomes could better reflect the way engineers and ICT professionals approach, think and do their work. This change necessitated a different clustering of learning outcomes into five major domains of capability.

Professionals within Engineering and ICT practice focus on problem-solving and design, whereby artefacts and systems are conceived, created, modified, maintained and retired. Graduates must also be able to resolve complex socio-technical needs. Decision-making is informed by processes of abstraction, modelling, simulation and visualisation, underpinned by mathematics and sciences. Engineering and ICT practice involves the coordination of a range of disciplinary and interdisciplinary activities and the exercise of effective communication predominantly in team contexts. Finally, graduates must have capabilities for self-organisation, self-review, personal development and lifelong learning. Hence the five key capability areas include: design, systems, modelling, communication and self-management. These five areas will enable academics and students to quickly grasp the key outcomes of a degree program in their disciplines. This approach does not infer simplification in its pejorative sense. Rather, establishing the key domains was a way of enabling academics and students alike to seize the bold ideas that express the concepts, capabilities and practices vital to the Engineering and ICT professions.

The approach adopted fits well with professional accreditation bodies in Engineering and ICT. This does not impede progress towards more detailed TLOs that address discipline capabilities such as specific technical outcomes.

In Appendix 3 the TLOs are shown mapped against standards identified by national accrediting organisations as well as those from the International Engineering Alliance that provides international cross-accreditation for professional engineering degrees.

2.3 Consultation and development process

A wide-ranging consultation process was adopted in order to capture a breadth of informed perspectives. Representatives from professional organisations, academic communities, industry professionals and commercial stakeholders were engaged through a range of workshops and forums. Views and perspectives were also sought from senior undergraduate students and recent graduates.

There were five key phases involved consultation processes:

1. February–May 2010: An initial discipline stakeholder meeting, as part of the national LTAS project forum in February 2010, established the framework of the Discipline Scholars' activity and the generation of the initial learning outcome domains. This meeting also established advisory and reference groups for the Engineering and ICT discipline to help guide and advise the learning outcomes development. Further consultation with the advisory and reference groups helped focus on key issues around learning outcomes, such as alignment with existing professional accreditation guidelines.

2. June–August 2010: An intensive round of Australia-wide negotiations with major industry, professional and academic stakeholders in state capitals and several regional centres. This activity addressed issues that helped reshape and refocus the learning outcome domains and their elements. It also began a conversation around the potential evidence necessary to verify threshold learning outcomes.

3. September–October 2010: An Australia-wide online web-based survey to seek further input from stakeholders on the refined and extended threshold learning outcomes from Phase 2. This strategy also offered people unable to attend the workshops opportunity to comment. It sought input from both the advisory and reference groups.

4. October–November 2010: A final revision of the threshold learning outcomes though consultation with the Engineering and ICT Advisory Group.

5. Preparation and submission of the final Engineering and ICT Discipline statement to the ALTC (3 December 2010).

3. Learning and Teaching Academic Standards Statement for Engineering and ICT

3.1 Nature and extent of Engineering and ICT

The disciplines of Engineering and ICT are professional disciplines, accredited by and taking direction from their professional bodies, respectively Engineers Australia and the Australian Computer Society. It is from these organisations that conceptual and descriptive statements were sought about the nature and extent of each discipline. The following extracts are drawn from the accreditation documents for each professional society.

From Engineers Australia's *Stage One Competency Standards* (Engineers Australia, 2006), the role of the mature practising engineer is defined as:

> *Professional engineers are required to take responsibility for engineering projects and programs in the most far-reaching sense. This includes the reliable functioning of all materials and technologies used, their integration to form a complete and self-consistent system and all interactions between the technical system and the environment in which it functions. The latter includes understanding the requirements of clients and of society as a whole; working to optimise social, environmental and economic outcomes over the lifetime of the product or program; interacting effectively with the other disciplines, professions and people involved; and ensuring that the engineering contribution is properly integrated into the totality of the undertaking. Professional engineers are responsible for interpreting technological possibilities to society, business and government; and for ensuring as far as possible that policy decisions are properly informed by such possibilities and consequences, and that costs, risks and limitations are properly understood.*
>
> *Professional engineers are responsible for bringing knowledge to bear from multiple sources to develop solutions to complex problems and issues, for ensuring that technical and non-technical considerations are properly integrated, and for managing risk.*
>
> *The work of professional engineers is predominantly intellectual in nature. In the technical domain, they are primarily concerned with the advancement of technologies and with the development of new technologies and their applications through innovation, creativity and change. They may conduct research concerned with advancing the science of engineering and with developing new engineering principles and technologies. Alternatively, they may contribute to continual improvement in the practice of engineering, and in devising and updating the Codes and Standards that govern it.*
>
> *Professional engineers have a particular responsibility for ensuring that all aspects of a project are soundly based in theory and fundamental principle, and for understanding clearly how new developments relate to established practice and experience and to other disciplines with which they may interact. One hallmark of a professional is the capacity to break new ground in an informed and responsible way.*
>
> *Professional engineers may lead or manage teams appropriate to these activities, and may establish their own companies or move into senior management roles in engineering and related enterprises.*

For the ICT disciplines, the following statement has been adapted from *The Overview Report* [ACM, AIS & IEEE-CS] 30 September 2005 (Joint Task Force for Computing Curricula, 2005).

> *In a general way, we can define ICT (Information and Communications Technology) to mean any goal-oriented activity requiring, benefiting from, or creating computers and/or telecommunications*

technology. Thus, ICT includes designing and building hardware and software systems, stand-alone and networked, for a wide range of purposes; processing, structuring, and managing various kinds of information; doing scientific studies using computers; making computer systems behave intelligently; creating and using communications and entertainment media; finding and gathering information relevant to any particular purpose, and so on. The list is virtually endless, and the possibilities are vast. ICT also has other meanings that are more specific, based on the context in which the term is used. For example, an information systems specialist will view computing somewhat differently from a software engineer.

A student typically earns a bachelor's degree in one of the main computing disciplines (arguably computer engineering, telecommunications and network engineering, software engineering, computer science, information technology, information systems), often with a named specialisation, to prepare for entry into the ICT profession. Because ICT provides such a wide range of choices, it is impossible for anyone to become proficient at all of them. Hence, an individual who wishes to become an ICT professional requires some focus for his or her professional life. The different kinds of undergraduate degree programs in computing provide different foci and perspectives on the ICT discipline of computing.

3.2 Threshold Learning Outcomes for Engineering and ICT

The five threshold learning outcomes (TLOs) developed for Engineering and ICT degrees have been determined via an extensive consultation and feedback process that has engaged the broad discipline community across its professional, academic, regulatory and educational aspects.

Taken as a whole, the TLOs for Engineering and ICT degrees represent what a graduate is "expected to know, understand and be able to do as a result of learning" (AQF, 2010). While there has been an attempt to ensure minimal overlap across the TLOs, each is defined independently, even at the threshold level of achievement. It is expected that graduates will be able to demonstrate a broad and coherent assimilation of the identified TLOs across the various knowledge, skills and attitudinal domains.

For example, as part of a final year project, a student, in approaching a complex problem that requires the design of an artefact or system, will use the full range of outcomes. They will engage with the problem using systems thinking (TLO1). They will use a design or problem-solving process (TLO2) and complex analysis and modelling skills (TLO3). They will coordinate their work with others and communicate it effectively at various stages (TLO4). Throughout the process, students will be planning their work and self-monitoring to ensure that what is delivered matches the original requirements (TLO5).

The five TLOs are not equally weighted. The development of complex technical knowledge and skill is likely to continue to occupy the larger part of course hours. Nevertheless, it is essential that all graduates emerge with adequate proficiency in each of the five TLOs in an integrated fashion, as described in the preceding paragraph.

This project has been an opportunity to reconceptualise the key outcomes from Engineering and ICT programs. The intention was to capture the essence of professional practice. At the February National Forum for the LTAS project in Melbourne, the first three outcomes were identified:

- understand a problem in its context through systems thinking
- apply design and problem-solving processes, and
- use modelling and analysis tools.

Further reflection identified two further outcomes:

- coordination and communication that represents the team and project nature of the professions, and
- self-development and self-management.

These five outcome areas were then used to classify the capabilities or competencies specified by Engineers Australia, the Australian Computer Society and various national and international equivalents

(Appendix 2), with the intention of producing a short list of key intended outcomes. In this process, each major outcome has been broken into a small number of individual elements. The Discipline Scholars acknowledge the input of their advisory group in these discussions.

Threshold Learning Outcomes for Engineering and ICT

[Developed from stakeholder consultations (industry, academe, students) and draft standards of Engineers Australia and the Australian Computer Society.]

Outcome areas	Rationale	Graduates will have the knowledge and skills to:
Needs, context and systems	Graduates must be able to recognise, understand and interpret socio-technical, economic and sustainability needs within the context of Engineering and ICT challenges. Systems thinking enables graduates to represent the individual components, interactions, risks and functionality of a complex system within its environment.	Identify, interpret and analyse *stakeholder needs, establish priorities* and the *goals, constraints and uncertainties* of the system (social, cultural, legislative, environmental, business etc.), using *systems thinking*, while recognising *ethical implications* of professional practice.
Problem-solving and design	Engineering and ICT practice focuses on problem-solving and design, whereby artefacts are conceived, created, modified, maintained and retired (lifecycle assessment). Graduates must have capabilities to apply theory and norms of practice to efficient, effective and sustainable problem solution.	Apply *problem solving, design and decision-making methodologies* to develop components, systems and/or processes to meet specified requirements, including *innovative approaches* to synthesise alternative solutions, concepts and procedures, while demonstrating *information skills* and *research methods.*
Abstraction and modelling	Graduates must be able to model the structure and behaviour of real or virtual systems, components and processes. Decision-making is informed by these processes of abstraction, modelling, simulation and visualisation, underpinned by mathematics as well as basic and discipline sciences.	Apply *abstraction, mathematics and discipline fundamentals* to analysis, design and operation, using appropriate *computer software,* laboratory *equipment* and other *devices,* ensuring *model applicability, accuracy and limitations.*
Coordination and communication	Engineering and ICT practice involves the coordination of a range of disciplinary and interdisciplinary activities and the exercise of effective communication to arrive at problem and design solutions usually in team contexts.	*Communicate and coordinate* proficiently by listening, speaking, reading and writing English for professional practice, working as an *effective member* or *leader* of diverse teams, using basic tools and practices of formal *project management.*
Self-management	Graduates must have capabilities for self-organisation, self-review, personal development and lifelong learning.	Manage own time and processes effectively by *prioritising competing demands* to achieve *personal* and *team goals, with regular review* of personal *performance* as a primary means of *managing continuing professional development.*

4. Notes on the Threshold Learning Outcomes for Engineering and ICT

The workshop activities were designed not only to raise an awareness of the standards agenda but to also engage in dialogue with the people directly involved in the implementation or outcomes of academic standards. The Discipline Scholars asked attendees to provide feedback on what is expected of graduates' learning outcomes, where there are perceived gaps, and also recommendations for change.

The feedback strongly indicated that Engineering and ICT graduates are generally very well prepared in terms of technical skills. The gaps identified resonated with the fourth and fifth elements 'Coordination and communication' and 'Self-management'. Industry attendees asked for more developed communication skills and abilities to confidently engage with uncertainty or unfamiliarity. Comments and recommendations offered by academics, people from industry and recent graduates provided useful validation and a whetstone for continual sharpening of the learning outcomes.

Participants at workshops were also asked to offer threshold standards: *What would you consider to be acceptable and not acceptable evidentiary performance against each of the five learning outcomes?* A challenging aspect in terms of 'threshold' is in identifying a standard that would meet the approbation of all Engineering and ICT courses without being prescriptive. The feedback given varied considerably, suggesting that there is little common dialogue across institutions and industry regarding standards *per se.* What was very evident, however, was the importance of establishing clear standards. Also the feedback raised the need for ways of providing evidence against outcomes, such as teamwork, in ways that all stakeholders could accept with confidence.

Appendix 1: Terms of Reference and Membership of advisory panels

Discipline Scholars

Professor Ian Cameron	Ian Cameron is a Professor in the School of Chemical Engineering, The University of Queensland.
Associate Professor Roger Hadgraft	Roger Hadgraft is Director, Engineering Learning Unit, The University of Melbourne and is a past president of the Australasian Association for Engineering Education.

Advisory group

Membership of the advisory group was derived from leaders within the Engineering and ICT disciplines. In particular, it was considered imperative to also include key representatives of the professional accrediting bodies.

Terms of reference for the Engineering and ICT Advisory Group included:

- assisting the Discipline Scholars in developing the threshold learning outcomes that would be mutually agreeable to both Engineers Australia and the Australian Computer Society, and
- offering support and direction in conducting regional consultations and in the development of the final statement.

Professor Alan Bradley	Associate Director, Australian Engineering Accreditation Centre, Engineers Australia
Professor Doug Grant	Chair, Professional Standards Board, Australia Computer Society (ACS)
Professor Robin King	Executive Officer, Australian Council of Engineering Deans (ACED) Chair, Engineers Australia Accreditation Board
Dr Tony Koppi	Executive Officer, Australian Council of Deans of Information and Communications Technology (ACDICT)
Professor Mark Toleman	Chair, Australian Council of Professors and Heads of Information Systems (ACPHIS) Head, School of Information Systems, University of Southern Queensland

The Engineering and ICT Reference Group

During the February forum, discipline groups were asked to identify key stakeholders within their discipline community. The Engineering and ICT Disciplines made a conscious decision to include and continue consultation with the following: leading academics, industry professionals and senior students (undergraduate). As recent graduates were likely to offer acute insights into the discussion arising from their transition from university to industry, this group also became an important target cohort for consultation.

Terms of reference

The reference group was a wider body of stakeholders, intentionally structured to be representative of both sub-disciplines, gender and breadth of experience.

The purpose of the reference group was to bring together leaders from academic and professional organisations as well as recent graduates and senior students to discuss learning outcomes and to generate direction for forthcoming regional consultations.

Membership

The reference group was convened for their meeting on 16 March, 2010. The reference group members were:

Academics

Professor Martin Betts	Executive Dean, Faculty of Built Environment and Engineering, Queensland University of Technology, Brisbane; Member, ACED
Professor John Roddick	Dean, School of Computer Science, Engineering and Mathematics, Flinders University, South Australia; Member, ACDICT
A/Professor Judy Sheard	School of Computer Science and Software Engineering, Monash University, Victoria
Professor Caroline Crosthwaite	Associate Dean (T&L), Faculty of Engineering, Architecture and Information Technology, The University of Queensland, Brisbane
Dr Euan Lindsay	President, Australasian Association for Engineering Education (AAEE); Department of Mechanical Engineering, Curtin University, Western Australia
Professor David Dowling	Past-President AAEE; DYD Project Leader; former Associate Dean (T&L), University of Southern Queensland.

Industry representatives

Mr Clive Carter	Engineering Director, HATCH Associates, Queensland
Ms Leeanne Bond	Director, Breakthrough Energy Pty Ltd, Queensland
Mr Lloyd Williams-Wynn	General Manager, Engineering and Supply, Udhe Shedden (Australia) Pty Ltd, Melbourne
Mr Mark Palmer	Technical Director, Thales Australia, Melbourne.

Recent Graduates

Mr Rory Paltridge	Engineering graduate with ABB Australia Pty Ltd; Committee Member, Young Engineers Australia, Victoria
Mr Joel Nation	ICT graduate with PSARN International; Vice-Chair, Young IT Board, ACS
Ms Kari Marshall	ICT graduate with Infosys Australia, Melbourne.

Senior undergraduate students

Mr Scott Butler	Final year ICT, Swinburne University
Ms Sarah Chadderton	Final year ICT, RMIT University
Mr Andrew Rouse	Final year, Mechanical Engineering, The University of Melbourne
Ms Stephanie Field	Final year, Mechanical Engineering, The University of Melbourne.

International and professional accreditation comparison

The following table shows a comparison of the proposed threshold learning outcomes (TLOs) together with those from Engineers Australia, the Australian Computer Society, the Australian Council of Professors and Heads of Information Systems, and the International Engineering Alliance, which represents the signatories to the Washington Accord on graduate attributes for professional engineers.

Engineering and ICT threshold learning outcomes *Graduates will have the knowledge and skills to...*	**Engineers Australia 2010** Revised Stage 1 Competency Standards, November 2010 (Latest DRAFT under the ALTC grant: Curriculum Support Specification and Support for Engineering Education)
Needs, context and systems Identify, interpret and analyse *stakeholder needs, establish priorities* and the *goals, constraints and uncertainties* of the system (social, cultural, environmental, business etc.), using *systems thinking*, while recognising *ethical implications* of professional practice.	1.5 Identifies the interactions between engineering systems and people in the social, cultural, environmental, commercial, legal and political contexts in which they operate, including both the positive role of engineering in sustainable development and the potentially adverse impacts of engineering activity in the field of practice. 1.5 Is aware of the founding principles of human factors relevant to the engineering discipline. 1.5 Is aware of the fundamentals of business and enterprise management. 1.5 Identifies the structure, roles and capabilities of the engineering workforce. 1.5 Appreciates the issues associated with engineering in a global operating context. 1.6 Appreciates the basis and relevance of standards and codes of practice applicable to the engineering discipline. 1.6 Appreciates the principles of safety engineering, risk management and the health and safety responsibilities of the professional engineer, including legislative requirements applicable to the engineering discipline. 1.6 Appreciates the social, environmental and economic principles of sustainable engineering practice. 1.6 Appreciates the formal structures and methodologies of systems engineering as a holistic basis for managing complexity and sustainability in engineering practice. 2.3 Addresses broad contextual constraints such as social, cultural, environmental, commercial, legal political and human factors, as well as health, safety and sustainability imperatives as an integral part of the design process. 3.1 Demonstrates commitment to uphold the Engineers Australia Code of Ethics and established norms of professional conduct pertinent to the engineering discipline. 3.1 Understands the need for 'due diligence' in certification, compliance and risk management tasks. 3.1 Understands the accountabilities of the professional engineer and the engineering team for the safety of other people and for protection of the environment. 3.1 Is aware of the fundamental principles of intellectual property rights and protection.

Australian Computer Society (ACS)	Australian Council of Professors and Heads of Information Systems (ACPHIS)	International Engineering Alliance (IEA)
Societal issues: Topics covered should include: privacy and civil liberties, environmental and sustainability issues, computer crime, intellectual property and legal issues. Fundamental ethical notions: 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; and ICT-specific ethical issues (professional, eg compromising quality and conflict of interest, and societal, eg phishing and privacy). 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.	ICT professionals must have an understanding of how ICT is used and managed to gain benefits in organisational and societal contexts. Demonstrate the ability to effectively plan and organise activities in a range of contexts. Act responsibly and ethically as information technology professionals with due regard to the social, legal and environmental contexts of information technology practice, including awareness of professional codes of ethics, their role and limitations.	Engineer and society (6) Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice. Environment and sustainability (7) Understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development. Ethics (8) Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.

Engineering and ICT threshold learning outcomes *Graduates will have the knowledge and skills to...*	**Engineers Australia 2010** Revised Stage 1 Competency Standards, November 2010 (Latest DRAFT under the ALTC grant: Curriculum Support Specification and Support for Engineering Education)
Problem-solving and design Apply *problem-solving, design and decision-making methodologies* to develop components, systems and/or processes to meet specified requirements, including *creative approaches* to synthesise alternative solutions, concepts and procedures, while demonstrating *information skills* and *research methods.*	1.6 Applies systematic principles of engineering design relevant to the engineering discipline. 1.2 Develops and fluently applies investigatory, analysis, assessment, characterisation, prediction, evaluation, modelling, decision-making, measurement, evaluation, storage, referencing and communication tools and processes pertinent to the engineering discipline and related fields. 2.1 Identifies, discerns and characterises salient issues, determines and analyses causes and effects, justifies and applies appropriate simplifying assumptions, predicts performance and behaviour, synthesises solution strategies and develops substantiated conclusions. 2.3 Proficiently applies technical knowledge, open-ended problem solving skills, appropriate tools and resources to design components, elements, systems, plant, facilities and/or processes to satisfy user requirements. 2.3 Understands and applies the whole systems design cycle approach including steps such as: • determining client requirements and identifying the impact of relevant contextual factors, including business planning and costing targets • systematically addressing sustainability criteria • working within projected development, production and implementation constraints • eliciting, scoping and documenting the required outcomes of the design task and defining acceptance criteria • identifying assessing and managing technical, health and safety risks integral to the design process • writing engineering specifications, that fully satisfy the formal requirements • ensuring compliance with essential engineering standards and codes of practice • partitioning the design task into appropriate modular, functional elements that can be separately addressed and subsequently integrated through defined interfaces • identifying and analysing possible design approaches and justifying an optimal approach • developing and completing the design using appropriate engineering principles, tools, and processes • integrating functional elements to form a coherent design solution • quantifying the materials, components, equipment, facilities, engineering resources and operating arrangements needed for implementation of the solution • checking the design solution for each element and the integrated system against the engineering specifications • devising and documenting tests that will verify performance of the elements and the integrated realisation • prototyping/implementing the design solution and validating performance against specification • documenting, commissioning and reporting the design outcome.

Australian Computer Society (ACS)	Australian Council of Professors and Heads of Information Systems (ACPHIS)	International Engineering Alliance (IEA)
Each ICT professional role would have additional knowledge needed for its particular requirements. 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.	Specialised programming and engineering roles involved in building systems from the ground up. Demonstrate the ability to analyse a range of situations and contexts, utilising information effectively to make informed recommendations and draw coherent conclusions.	Engineering knowledge (1) Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialisation to the solution of complex engineering problems. Problem Analysis (2) Identify, formulate, research literature and analyse *complex* engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences. Design/Development of solutions (3) Design solutions for *complex* engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations. Investigation (4) Conduct investigations of *complex* problems using research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions.

Engineering and ICT threshold learning outcomes *Graduates will have the knowledge and skills to...*	**Engineers Australia 2010** Revised Stage 1 Competency Standards, November 2010 (Latest DRAFT under the ALTC grant: Curriculum Support Specification and Support for Engineering Education)
Problem-solving and design *continued…*	2.3 Is aware of the accountabilities of the professional engineer in relation to the 'design authority' role. 3.3 Applies creative approaches to identify and develop alternative solutions, concepts and procedures, and develop confidence to challenge engineering practices from technical and non-technical viewpoints and identifies new engineering opportunities. 3.3 Seeks out new developments in the engineering discipline and specialisations and applies fundamental knowledge and systematic processes to evaluate and report potential.
Abstraction and modelling Apply *abstraction, mathematics and discipline fundamentals* to analysis, design and operation, using appropriate *computer software,* laboratory *equipment* and other *devices,* ensuring *model applicability, accuracy and limitations.*	1.1 Engages with the engineering discipline at a phenomenological level, applying sciences and engineering fundamentals to systematic investigation, interpretation, analysis and innovative solution of complex problems and broader aspects of engineering application. 1.3 Proficiently applies advanced technical knowledge and skill to wide-ranging engineering application in at least one specialist practice area within the engineering discipline. 1.4 Identifies and critically appraises current developments, advanced technologies, emerging issues and interdisciplinary linkages in at least one specialist practice area within the engineering discipline. 1.4 Interprets and applies selected research literature to inform engineering application within at least one specialist area of the engineering discipline. 2.1 Ensures that all aspects of an engineering activity are soundly based on fundamental principles by diagnosing, and taking appropriate action with data, calculations, results, proposals, processes, practices, and documented information that may be ill-founded, illogical, erroneous, unreliable or unrealistic. 2.1 Competently addresses engineering problems involving uncertainty, ambiguity, imprecise information and wide-ranging and sometimes conflicting technical and non-technical factors. 2.1 Partitions problems, processes or systems into manageable elements for the purposes of analysis, modelling or design and then re-combining to form a whole, with the integrity and performance of the overall system as the paramount consideration. 2.1 Conceptualises alternative engineering approaches and evaluates potential outcomes against appropriate criteria to justify an optimal solution choice. 2.1 Applies relevant standards and codes of practice underpinning the engineering discipline and nominated specialisations. 2.1 Identifies, quantifies, mitigates and manages technical, health, environmental and safety risks associated with engineering application in the designated engineering discipline.

Australian Computer Society (ACS)	Australian Council of Professors and Heads of Information Systems (ACPHIS)	International Engineering Alliance (IEA)
In no other discipline is there such an emphasis on developing artefacts, eg 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. The methods and tools that are used for handling abstraction could vary a great deal with the specific ICT discipline. … 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.	Knowledge of how to use modelling methods and processes to understand problems, handle abstraction and design solutions. This area recognises the creativity and innovation that is required of IS professionals and the excitement that is present in their jobs. This area identifies what is unique about IS and what differentiates it from other disciplines. ICT professionals must have basic technical knowledge to underpin other professional activities, whether they are implementing or acquiring or managing IT, or whether they are engaging in higher-level specialised technical roles. Demonstrate critical, creative and analytical thinking and effective problem-solving, applying knowledge and skills in novel ways and demonstrating ability for high level synthesis and evaluation of experiences.	Modern tool usage (5) Create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to *complex* engineering activities, with an understanding of the limitations.

Engineering and ICT threshold learning outcomes *Graduates will have the knowledge and skills to...*	**Engineers Australia 2010** Revised Stage 1 Competency Standards, November 2010 (Latest DRAFT under the ALTC grant: Curriculum Support Specification and Support for Engineering Education)
Abstraction and modelling *continued...*	2.1 Interprets and applies legislative and statutory requirements applicable to the field of practice. 2.1 Investigates complex problems using research-based knowledge and research methods. 2.2 Proficiently identifies, selects and applies the materials, components, devices, systems, processes, resources, plant and equipment relevant to the engineering discipline. 2.2 Constructs from a qualitative description of a phenomenon, process, system, component or device a mathematical, physical or computational model based on fundamental scientific principles and justifiable simplifying assumptions. 2.2 Applies such models to analysis and design, understanding their applicability, accuracy and limitations. 2.2 Determines properties, performance, safe working limits, failure modes, and other inherent parameters of materials, components and systems relevant to the engineering discipline. 2.2 Applies a wide range of modern engineering tools for analysis, simulation, visualisation, synthesis and design, including assessing the accuracy and limitations of such tools, and validation of their results. 2.2 Applies formal systems engineering methods to address the planning and execution of complex, problem-solving and engineering projects. 2.2 Designs and conducts experiments, analyses and interprets result data and formulates reliable conclusions. 2.2 Perceives possible sources of error in models and experiments, and eliminates, minimises or compensates for them, and quantifies their significance to any conclusions drawn. 2.2 Safely applies laboratory, test and experimental procedures appropriate to the engineering discipline. 2.2 Understands the need for systematic management of the acquisition, commissioning, operation, upgrade, monitoring and maintenance of engineering plant, facilities, equipment and systems. 2.2 Understands the role of quality management systems, tools and processes within a culture of continuous improvement.

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Engineering and ICT threshold learning outcomes *Graduates will have the knowledge and skills to...*	**Engineers Australia 2010** Revised Stage 1 Competency Standards, November 2010 (Latest DRAFT under the ALTC grant: Curriculum Support Specification and Support for Engineering Education)
Coordination and communication *Communicate and coordinate* proficiently by listening, speaking, reading and writing English for professional practice, working as an *effective member* or *leader* of diverse teams, using basic tools and practices of formal *project management.*	3.6 Understands the fundamentals of team dynamics and leadership. 3.6 Functions as an effective member or leader of diverse engineering teams, including those with multi-level, multi-disciplinary and multi-cultural dimensions. 3.6 Recognises the value of alternative and diverse viewpoints, scholarly advice and the importance of professional networking. 3.6 Confidently pursues and discerns expert assistance and professional advice. 3.6 Takes initiative and fulfils the leadership role whilst respecting the agreed roles of others. 3.2 Is proficient in listening, speaking, reading and writing English, including: comprehending critically and fairly the viewpoints of others; expressing information effectively and succinctly, issuing instruction, engaging in discussion, presenting arguments and justification, debating and negotiation to/with technical and non-technical audiences and using textual, diagrammatic, pictorial and graphical media best suited to the context; representing an engineering position, or the engineering profession at large to the broader community; appreciating the impact of body language, personal behaviour and other non-verbal communication processes, as well as the fundamentals of human social behaviour and their cross-cultural differences. 3.2 Prepares high quality engineering documents such as progress and project reports, reports of investigations and feasibility studies, proposals, specifications, design records, drawings, technical descriptions and presentations pertinent to the engineering discipline. 3.4 Is proficient in locating and utilising information including accessing, systematically searching, analysing, evaluating and referencing relevant published works through the use of bibliographic databases and other resources. 3.4 Assesses the accuracy, reliability and authenticity of information. 3.4 Is aware of common document identification and control procedures. 1.6 Applies the fundamental principles of engineering project management as a basis for planning, organising and managing resources. 2.4 Contributes to and/or manages complex engineering project activity, as a member and/or as leader of the engineering team. 2.4 Seeks out the requirements, associated resources, and realistically assesses the scope, dimensions, scale of effort and indicative costs of a complex engineering project. 2.4 Accommodates relevant contextual issues into all phases of engineering project work, including the fundamentals of business planning and financial management. 2.4 Proficiently applies fundamental project management tools and processes to the planning and execution of project work, targeting the delivery of a significant outcome to a professional standard. 2.4 Is aware of the need to plan and quantify performance over the full life-cycle of a project, managing engineering performance within the overall implementation context. 2.4 Demonstrates commitment to sustainable engineering practices and the achievement of sustainable outcomes in all facets of engineering project work.

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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'. 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.	Demonstrates high-level communication and interpersonal skills. 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. Understand group dynamics and have the ability to work in collaborative environments as a productive member of a team, especially in relation to managing time and prioritising activities to achieve deadlines. Understand cross cultural issues and international perspectives and have a capacity for community engagement. Demonstrate competency in written and oral professional communication, and effectiveness in the formulation of reasoned arguments and clear explanations in writing and speaking.	Project management and team work (11) Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. Individual and team work (9) Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings. Communication (10) Communicate effectively on *complex* engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

Engineering and ICT threshold learning outcomes *Graduates will have the knowledge and skills to...*	**Engineers Australia 2010** Revised Stage 1 Competency Standards, November 2010 (Latest DRAFT under the ALTC grant: Curriculum Support Specification and Support for Engineering Education)
Self-management Manage own time and processes effectively by *prioritising competing demands* to achieve *personal* and *team goals*, with *regular review* of personal performance as a primary means of managing continuing professional development.	3.5 Earns the trust and confidence of colleagues through competent and timely completion of tasks. 3.5 Demonstrates commitment to critical self-review and performance evaluation against appropriate criteria as a primary means of tracking personal development needs and achievements. 3.5 Understands the importance of being a member of a professional and intellectual community, learning from its knowledge and standards, and contributing to their maintenance and advancement. 3.5 Demonstrates commitment to lifelong learning and professional development. 3.5 Manages time and processes effectively, prioritises competing demands to achieve personal, career and organisational goals and objectives. 3.5 Thinks critically and applies an appropriate balance of logic and intellectual criteria to analysis, judgment and decision-making. 3.5 Presents a professional image in all circumstances, including relations with clients and stakeholders, as well as professional and technical colleagues across wide ranging disciplines. 3.3 Is aware of broader fields of science, engineering, technology and commerce from which new ideas and interfaces may be may drawn and readily engages with professionals from these fields to exchange ideas.

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Professionalism: Basic concepts of professionalism (expertise, certification, competence, autonomy, excellence, reflection, responsibility and accountability); and· ICT-specific professionalism issues. …possesses the capacity for independent action, operating with a high level of responsibility and autonomy… ...engages in continuing professional development, enhancing relevant technical and professional skills.	Being a professional in any discipline, ICT included, requires a level of 'professionalism', which means exhibiting a degree of autonomy and responsibility, behaving in an ethical manner. Demonstrate the ability to work in a self-reliant and independent way and have the capacity to take initiative and embrace innovation in responding to change and leadership issues relevant to information technology. Demonstrate the in-depth knowledge and skills required to pursue a career in information systems, including the software development life cycle, analysis, design, programming, testing and implementation; be prepared for lifelong learning in pursuit of personal and professional development.	Lifelong learning (12) Recognise the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.

Appendix 3: Abbreviations

ACED	Australian Council of Engineering Deans
ACARA	Australian Curriculum, Assessment and Reporting Authority
ACDICT	Australian Council of Deans of Information and Communications Technology
ACM	Association for Computing Machinery
ACS	Australian Computer Society
AIS	Architectural Information Services
ALTC	Australian Learning and Teaching Council
AQF	Australian Qualifications Framework
AQTF	Australian Quality Training Framework
AUQA	Australian Universities Quality Agency
EA	Engineers Australia
EQF	European Qualifications Framework
IEA	International Engineering Alliance
IEEE - CS	Institute of Electrical and Electronics Engineers Computer Society
ISCs	Industry Skills Councils
LTAS	Learning and Teaching Academic Standards Project
NQC	National Quality Council
RPL	Recognition of prior learning
RTO	Registered training organisation
SFIA	Skills Framework for the Information Age (UK)
TEQSA	Tertiary Education Quality and Standards Authority

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