ICT Curriculum and Course Structure: the Great Balancing Act

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Abstract
This paper reports on an ICT curriculum development process that involved balancing a number of constraints that, in the words of an external academic advisory panel, resulted in a “very coherent, strong, contemporary” ICT curriculum. Instigated by an external school review that recommended the implementation of a single degree, the curriculum had to contain the knowledge requirements for students to develop the necessary skills for a set of ICT graduate level career outcomes identified by the local and national ICT industry. Due to a shrinking staff profile coupled with pressure for increased research output the School was instructed to offer only thirty undergraduate coursework units. Finally, the curriculum and course structure had to be attractive to domestic and international applicants and the curriculum also had to inspire graduate progression to a research higher degree.

Keywords: ICT career outcomes, ICT curriculum

1 Introduction
The School of Computing and Information Systems, as the only Information and Communication Technology (ICT) school at the University of Tasmania (UTAS), is responsible for developing work-ready graduates for a very broad local ICT industry, and for providing research collaborations with industry and government. An external school review conducted in 2011 recommended the removal of the two existing undergraduate degrees (a Bachelor of Computing and a Bachelor of Information Systems) and the creation of a single bachelors degree. This degree would be the only undergraduate ICT degree within Tasmania.

To ensure that any one individual did not overly influence the new degree, the development was led by a working party consisting of eight academics heavily interested and experienced in teaching and learning with a variety of different characteristics and backgrounds. During the development phase the working party met on an almost weekly basis for approximately six months, with regular meetings with all School staff. It has been shown that involving academics that will be responsible for the implementation of a new curriculum during the design phase builds a sense of ownership that will facilitate change (Elizondo-Montemayor 2008).

To identify and incorporate crucial employability skills for graduates five forums were held with local and national ICT industry, government and pre-tertiary educators: three forums near the start of the process to identify career outcomes, and role specific and complementary knowledge; and two forums near the end of the process to receive feedback on the proposed course structure and curriculum. Over thirty different industry representatives participated, with some overlap between the people that attended the early and late forums. Organisations with varying numbers of ICT employees from one to thousands were represented. Most almost exclusively employed ICT graduates, with the local businesses predominantly hiring UTAS ICT graduates.

The development process was strongly guided by the seven-step process for curriculum design recommended by the Australian Computer Society (ACS 2011). Herbert, de Salas, et al (2013), reported on the methodology used to complete the first three steps — the identification of career outcomes, skill sets and the skill level of responsibility, including details on how feedback from each step was used to refine the list of career outcomes and skills. Herbert, Dermoudy, et al (2013) reported on the discussions held during the forums to complete steps four and five that identified the role specific and complementary knowledge that broadens graduate employability. This paper reports on the complexities of step six: “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” (ACS 2011).

As illustrated in Figure 1, ten months after commencing the curriculum development the final proposal was presented to an external academic review panel consisting of three leading academics in the field of ICT nationally, and along with cautionary advice relating to the implementation of the degree they concluded that it was a “very coherent, strong, contemporary” ICT curriculum (CIS 2013).

The new curriculum and course structure were developed to ensure:

- graduates can achieve career outcomes;
- inclusion of the body of knowledge for accreditation;
- a minimal number of units was required;
- adherence to course structure policy;
- increased commencement rates and decreased attrition rates of domestic and international students; and
- increased progression rates to research higher degrees.

This paper focuses on the influence of the above constraints on the final curriculum and course structure and how a balance between these at times conflicting constraints was achieved.
Graduates can achieve career outcomes

Graduate career prospects are one of the major factors influencing applicants when they select their course. Unfortunately, it is often unclear whether the careers were identified as part of the curriculum development process and there is little evidence that advertised career outcomes are really attainable by graduates. Calitz et al. (2011) stated “universities must link and publish computing programs, linking each program with specific career tracks, indicating specific career specialisation and knowledge”. To ensure that graduates can achieve the stated career outcomes it was necessary to identify the career outcomes for which there was demand by local and national industry, identify the combinations of skills required for the attainment of those career outcomes and finally, to ensure the curriculum included the knowledge requirements to enable each of the skills to be practised.

The fast-changing nature of technology has implications for ICT careers, as existing career titles and their attendant skill sets are disrupted, transformed or replaced (AWPA 2013). Our investigation, in 2012, indicated that there appeared to be no nationally recognised standard set of ICT career titles and definitions, despite many calls for this to be established (AGIMO 2007; Koppi & Naghdy 2009). An interactive ICT career streams diagram with 55 ICT careers (QLD Government 2013), 38 of the 96 skills were included: HFIN (Human factors integration) and UNAN (Non-functional needs analysis).

Guided by the recommendation that undergraduate degrees should produce graduates with skills around SFIA level 4 of responsibility (ACS 2011), the identified skills were reviewed to determine whether each could be developed to the required level in the degree. There were some careers (Help Desk Operator, Technical Support Specialist) that were initially selected that had skill levels that were too low or too high for an undergraduate degree.

Discussions were held at each forum to gather information about the role specific knowledge required to practise the skills and the complementary knowledge required to support the skill set or to broaden graduate employability. The following considerations to the curriculum design were raised:

- Similar to the findings of Pilgrim (2012), industry members believed it was essential that graduates be exposed to concepts in business analysis and process modelling, and project and change management.
- The issue of an increased use of off-shoring was identified as a possible impact on graduate software developer positions; this was mirrored in a report by NIEIR (2012). Software developer careers related to mobile application development were identified as a possible impact on graduate software developer positions.
- The industry members were in favour of an “all-rounder” graduate. In accordance with the national findings (AWPA 2013), Tasmanian employers are more likely to choose a graduate with a broad range of ICT skills, with enough technical ICT content, as they have the ability to understand the needs of clients.
- The interviewees were insistent that the graduates are articulate professionals; there is no longer room in the industry for graduates who cannot relate well to business and clients. This supports the findings of Pilgrim (2012) that there are widespread views of “common deficiencies in the workplace readiness of new graduates particularly regarding the development of essential generic skills such as interpersonal and professional communications, business awareness and problem-solving abilities”.
- In Tasmania the demand for quality graduates is
currently exceeding domestic supply. Hence, as is the case nationally (AEI 2012), improving the quality — and in particular improving the quality of communication and interpersonal skills — of the international graduates was seen as a priority.

- Industry members wanted to participate more in the teaching program to bring in real-world examples and industry perspectives to the content. Koppi et al (2010), reported that in responses to a recent student survey, respondents requested greater industry involvement in teaching with practical and relevant industry-based technologies and real examples.

Using insight developed from the collected data and the discussions a final set of career outcomes was identified that would guide the curriculum development. Categories were developed to distinguish the differences in the attainability of these career outcomes to assist potential applicants. These were:

- **Graduate roles** — all skills are to be fully developed and the role is suitable for graduates;
- **Career roles** — all theoretical skills are included and the role is suitable for graduates who have acquired a years experience and shown a detailed understanding of ICT and how it works in the business;
- **Non-goal roles** — all the skills would be developed but the delivery of the content and discussion would not be focused towards these roles; and
- **Partially qualified roles** — some key skills may be omitted or not developed to the required level.

30 career outcomes were identified and categorised for the curriculum, shown in Table 1. Table 2 lists the 37 SFIA skills from four SFIA categories (thirteen to level 4, twenty-four to level 5) that were identified. Herbert, de Salas, et al (2013) includes a different table relating the skills to career outcomes. Herbert, de Salas, et al (2013) includes a different table relating the skills to career outcomes, but the delivery of the content and discussion would not be focused towards these roles; and

Industry members insisted that a graduate has to understand how all the ICT content link together as this helps with understanding the needs of clients. The development of each skill has been integrated across a wide range of ICT topic areas. An extract from a table that illustrates for each SFIA skill what units those skills are developed within is shown in Table 3; the full table of categories is shown in Table 4 relates the unit code to unit title. Table 3 also demonstrates that to develop depth in a skill, the knowledge requirements have been embedded in units over the full three years of the course.

The final course structure includes elective units, which either expand on the material in a knowledge area covered in the core units, or introduce new knowledge areas to the curriculum as essential building blocks for some career outcomes, or are within the research directions of the School. Table 4 indicates the core and elective units that should be taken to qualify a student for a particular career outcome based on the skills required for that career, the complete table for all identified career outcomes can be found at CIS (2013).

**Table 1: Categorised career outcomes**

<table>
<thead>
<tr>
<th>Category</th>
<th>Code</th>
<th>Skill</th>
<th>Level</th>
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<tbody>
<tr>
<td>IRTG</td>
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<tr>
<td>SCTR</td>
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<td>DINN</td>
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<td>IECG</td>
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<td>CNSL</td>
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<td>TECH</td>
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<td>BPRE</td>
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<td>BURM</td>
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<td>ARCH</td>
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<td>EMRG</td>
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<td>SPIM</td>
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<td>METL</td>
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<td>RSCH</td>
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<td>PRMG</td>
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<td>BUAN</td>
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<td>CIPM</td>
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<td>PROF</td>
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<td>BENM</td>
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<td>RLMT</td>
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<td>DLMG</td>
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<td>DESN</td>
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<td>NTDS</td>
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<td>DBDS</td>
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<td>PROG</td>
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<td>INCA</td>
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<td>TEST</td>
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<td>UNAN</td>
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<td>HFIN</td>
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<td>ITMG</td>
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<td>FMIT</td>
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<td>DBAD</td>
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<td>PBMG</td>
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</tbody>
</table>

**Table 2: SFIA skills and level of responsibility**

with all 37 skills can be found at CIS (2013). Note Table 4 relates the unit code to unit title. Table 3 also demonstrates that to develop depth in a skill, the knowledge requirements have been embedded in units over the full three years of the course.

The final course structure includes elective units, which either expand on the material in a knowledge area covered in the core units, or introduce new knowledge areas to the curriculum as essential building blocks for some career outcomes, or are within the research directions of the School. Table 4 indicates the core and elective units that should be taken to qualify a student for a particular career outcome based on the skills required for that career, the complete table for all identified career outcomes can be found at CIS (2013).
Table 3: Extract of a table linking a SFIA code with the units that develop the skill

<table>
<thead>
<tr>
<th>SFIA Code</th>
<th>Introductory Units</th>
<th>Intermediate Units</th>
<th>Advanced Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUAN</td>
<td>KIT105</td>
<td>KIT203, KIT204</td>
<td>KIT301, KIT303</td>
</tr>
<tr>
<td>DTAN</td>
<td>KIT102</td>
<td>KIT202, KIT203, KIT204, KIT206</td>
<td>KIT301, KIT306</td>
</tr>
<tr>
<td>PROG</td>
<td>KIT101, KIT102, KIT103, KIT104, KIT107, KIT108, KIT109</td>
<td>KIT202, KIT205, KIT206, KIT207, KIT208, KIT212</td>
<td>KIT301, KIT302, KIT305, KIT307, KIT308, KIT309</td>
</tr>
<tr>
<td>ITOP</td>
<td>KIT101</td>
<td>KIT201</td>
<td>KIT304</td>
</tr>
<tr>
<td>HFIN, UNAN</td>
<td>KIT102, KIT105, KIT106, KIT109</td>
<td>KIT202, KIT206, KIT207, KIT208</td>
<td>KIT301, KIT302, KIT305, KIT311</td>
</tr>
<tr>
<td>SCAD, SCTY</td>
<td>KIT102, KIT104</td>
<td>KIT201, KIT202</td>
<td>KIT304</td>
</tr>
<tr>
<td>PRMG, CNSL</td>
<td>KIT105</td>
<td>KIT203, KIT204, KIT206</td>
<td>KIT301, KIT302, KIT303</td>
</tr>
</tbody>
</table>

Table 4: Units that develop the skills for a particular career outcome

<table>
<thead>
<tr>
<th>Core units in ICT Professional major</th>
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</thead>
<tbody>
<tr>
<td>KIT101: Programming Fundamentals</td>
</tr>
<tr>
<td>KIT103: Computational Science</td>
</tr>
<tr>
<td>KIT105: ICT Professional Practices</td>
</tr>
<tr>
<td>KIT106: ICT Impact and Emerging Technology</td>
</tr>
<tr>
<td>KIT203: ICT Project Management and Modelling</td>
</tr>
<tr>
<td>KIT204: ICT Solutions Analysis for Business</td>
</tr>
<tr>
<td>KIT301: ICT Project A</td>
</tr>
<tr>
<td>KIT302: ICT Project B</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Core units in Information Technology minor</th>
</tr>
</thead>
<tbody>
<tr>
<td>KIT102: Data Organisation and Visualisation</td>
</tr>
<tr>
<td>KIT104: ICT Architecture and Operating Systems</td>
</tr>
<tr>
<td>KIT201: Data Networks and Security</td>
</tr>
<tr>
<td>KIT202: Secure Web Programming</td>
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</tbody>
</table>

Core units in Software Development major and Games and Creative Technology major

<table>
<thead>
<tr>
<th>Core units in Software Development major</th>
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</thead>
<tbody>
<tr>
<td>KIT107: Programming</td>
</tr>
<tr>
<td>KIT205: Data Structures &amp; Algorithms</td>
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<tr>
<td>KIT305: Mobile Application Development</td>
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</tbody>
</table>

Remaining core units in Software Development major

<table>
<thead>
<tr>
<th>Remaining core units in Games and Creative Technology major</th>
</tr>
</thead>
<tbody>
<tr>
<td>KIT108: Artificial Intelligence</td>
</tr>
<tr>
<td>KIT206: Software Design and Development</td>
</tr>
<tr>
<td>KIT303: ICT System Acquisition and Integration</td>
</tr>
<tr>
<td>KIT304: Server Administration and Security Assurance</td>
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</tbody>
</table>

Remaining coursework elective units

<table>
<thead>
<tr>
<th>Remaining coursework elective units</th>
</tr>
</thead>
<tbody>
<tr>
<td>KIT208: Virtual and Mixed Reality Technology</td>
</tr>
<tr>
<td>KIT212: Games Physics</td>
</tr>
<tr>
<td>KIT306: Data Analytics</td>
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<tr>
<td>KIT308: Multicore Architecture and Programming</td>
</tr>
<tr>
<td>KIT309: 3D Games Programming</td>
</tr>
<tr>
<td>KIT311: Social &amp; Cultural Issues in Digital Media Technology</td>
</tr>
</tbody>
</table>

Key

- Essential unit for this career
- Recommended unit for this career
- Contains relevant material for this career
3 Includes the knowledge for accreditation
The Australian Computer Society (ACS) is our accrediting body; accreditation demonstrates to industry and applicants that a course contains the requirements of the ICT profession. To attain ACS accreditation a course must include the core body of knowledge (ACS 2011). Rather than using a curriculum-driven approach, where the degree is based purely on existing curricula that have been developed elsewhere, an approach was used which blended:

- Curriculum-driven — based on externally-endorsed curricula to ensure the inclusion of fundamental knowledge and informed by experts in ICT curricula design, rather than outspoken staff members (Gruba et al 2004) which results in an ‘individualistic’ curriculum (Henkel and Kogan 1999) with a loose coupling of units as well as a large number of units;
- Market-driven — based on career outcomes in demand by local and national industry members to ensure the inclusion of the required underlying knowledge. When emphasis is placed on employment objectives the resulting curricula are more directed and coherent (Henkel and Kogan 1999); and
- Discipline-driven — encompassing study across the boundaries of traditional disciplines to create a graduate who can become the “T-shaped” professional, described in AWPA (2013) as having broad knowledge and deep expertise, including technical skills, subject knowledge and soft skills (such as communication and business skills).

The ACS core body of knowledge (ACS 2011) is based on the Association for Computing Machinery (ACM 2013) curricula recommendations. The ACM provides curricula recommendations in five sub-disciplines: Computer Science, Computer Engineering, Information Systems, Information Technology, and Software Engineering.

Prior to commencing the identification of career outcomes it was considered important for all staff to renew their understanding of contemporary international curricula. This was partially to counter the issues raised by Gruba et al (2004) that outspoken individuals, rather than academic merit and external curricula predominantly drive curriculum change. The content recommendations for all ACM curricula were reviewed, as was the International Game Developers Association curriculum framework (IGDA 2008). These curricula were useful but the age of some diminished their utility. Curricula of national and international providers of ICT courses were also investigated to augment the curricula recommendations. In doing so, a portfolio of broad knowledge areas that a graduate would reasonably be expected to have was developed.

To ensure ACS accreditation the ACS core body of knowledge (ACS 2011) was included in the final curriculum. To ensure the curriculum included the knowledge requirements to enable each of the skills for each identified career outcome to be practised most topics from three ACM curricula were also included. All topics from the ACM IT core curriculum (ACM 2008) are included as are the majority of the ACM IT elective topics — either in the core or elective units of the degree.

Everything from the core of the beta version of the ACM CS curriculum (ACM 2013) has been included in the core of the degree, with the exception of parallel and distributed computing which is included in two elective units. From the ACM IS core curriculum (ACM 2010) only IS strategy, management and acquisition, and enterprise architecture are not totally covered in the curriculum, but they are to be fully covered in an accompanying postgraduate coursework degree. From the ACM IS elective curriculum quite a large number of topics are covered as a result of the skills analysis for the career outcomes.

4 A minimal number of units
Due to a contracting staff profile, the cross campus nature of the School and significant pressure for increased research output an external School review conducted in 2011 recommended a reduction in undergraduate coursework unit offerings from 50 units to just 30 units.

Such pressure mandated that each unit maximized its contribution by:
- providing graduates with the essential technical and non-technical ICT skills and professional skills to enhance the Tasmanian ICT industry;
- inspiring students towards an ICT research career to increase the research output of the School; and/or
- attracting non-ICT students into the units by providing complementary knowledge to their chosen discipline.

Table 4 also shows the complete set of undergraduate coursework units. The equivalent of 28 coursework units (15 core units, and 13 elective units) were identified to cover the ACS core body of knowledge (ACS 2011), the knowledge requirements to develop the skills to the required level, and the core from the three ACM curricula (2013). To further reduce the load a few units will be offered on a two-yearly rotation basis and two units are being co-delivered by the School of Maths and Physics.

Every unit facilitates the development of a set of SFIA skills. An extract of this mapping is shown in Table 5; the full table with all units can be found at CIS (2013).

As a result of the curricula review the ACM IT curriculum (2008) was chosen as the basis for the new curriculum but it was resolved to include some aspects from the ACM IS (2010), ACM CS (2013) and IGDA (2008) curricula to encompass study across the boundaries of disciplines to ensure coverage of complementary knowledge to create a well-rounded graduate. For example Secure Web Programming works towards the partial development of nine SFIA skills; 22 hours of related material is included in the core of the ACM IT curriculum, yet none is in the ACM CS core curriculum. Another example is Data Structures and Algorithms that works towards the partial development of three SFIA skills; 28 hours of related material is included in the core of ACM CS curriculum but very little in the ACM IT curriculum. The final example is ICT Solutions Analysis for Business that works towards the partial development of sixteen SFIA skills; extensive material for this unit is extracted from the ACM IS curriculum but very little is in either the ACM IT curriculum or the ACM CS curriculum.
five-year degree — while also providing opportunity for
have a three-year degree rather than the recommended
the students to develop as professionals.

polling and there was overwhelming support for the more
this was that it allowed coverage of enough technical
skills. UTAS (2013) has two course structure models
had a balance of technical, non-technical and professional
intensive (Specialist) structure. The main argument for
having a single degree with a reduced number of electives
pre-tertiary educators) welcomed the recommendation of
further coursework and professional development.
career may append a one-year Honours degree and
University — a three-year degree was developed.

UTAS there are only a few four-year undergraduate
degrees and nationally there are very few four-year ICT
degrees. To remain competitive with ICT degrees offered
in other States and local degrees in other disciplines —
which was essential for the local industry and the
University — a three-year degree was developed. Qualified graduates that want to continue into a research
career may append a one-year Honours degree and
consideration is being given to an alternative one-year Professional Honours for graduates that want to pursue
further coursework and professional development.

When asked, the stakeholders (academia, industry, and
pre-tertiary educators) welcomed the recommendation of
having a single degree with a reduced number of electives
and a few distinct majors as this would remove confusion
for applicants and would ensure that all ICT graduates
had a balance of technical, non-technical and professional
skills. UTAS (2013) has two course structure models
summarised below. The industry representatives were
polled and there was overwhelming support for the more
intensive (Specialist) structure. The main argument for
this was that it allowed coverage of enough technical material and more of the ACM curricula (2013) core
content — particularly important given the decision to
have a three-year degree rather than the recommended
four-year degree — while also providing opportunity for
the students to develop as professionals.

Summary of UTAS' course structure policy
At UTAS a full-time student completes eight units a year. A unit
can be at one of three levels: introductory (typically completed in
the first year), intermediate, and advanced. At UTAS a major is
an 8-unit sequence of related material, with two units at both the
introductory and intermediate levels and four units at the
advanced level. A reversed major has four units at the
introductory level and two units at each other level. A minor has
two units of related material at the introductory and intermediate
levels. For a degree to receive approval at UTAS it has to adhere
to what is called the common course structure (UTAS 2013).
UTAS allows two course structures: Generalist or Specialist. The
fundamental differences relate to the ratio between discipline-
related content to elective content. In the Generalist structure the
students complete one major, one minor, four degree-restricted
elective units, and eight student elective units (any units on offer
at the university). In the Specialist structure students complete
two majors, one minor and only four student elective units.

Table 5: Extract of a table illustrating which SFIA skills that will be developed within a unit

<table>
<thead>
<tr>
<th>Unit Title</th>
<th>SFIA code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Organisation and Visualisation</td>
<td>METL, PROG, DTAN, HFIN, UNAN, ICPM, SCAD, SCTY, INAN, TECH, DBDS, DBAD, IRMG, INCA</td>
</tr>
<tr>
<td>Computational Science</td>
<td>METL, PROG, TECH, RSCH</td>
</tr>
<tr>
<td>ICT Professional Practices</td>
<td>METL, BUAN, HFIN, UNAN, SCTY, CNSL, RLMT, ARCH</td>
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<tr>
<td>ICT Impact and Emerging Technology</td>
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<td>Secure Web Programming</td>
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<td>Data Structures and Algorithms</td>
<td>METL, PROG, TECH</td>
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<tr>
<td>Mobile Application Development</td>
<td>METL, PROG, ICPM, HFIN, UNAN, TECH, RSCH, EMRG, INCA</td>
</tr>
<tr>
<td>Data Analytics</td>
<td>METL, DTAN, RSCH, SCAD, INAN, TECH, DBDS, IRMG, INCA</td>
</tr>
</tbody>
</table>

5 Adhere to course structure policy
The ACM IT curriculum (2008) recommends a four-year
course. Discussions were held within the School and also
with the industry representatives regarding the duration
for the new degree. A four-year degree was not supported
if the knowledge requirements could be covered in three
years — partly because the graduates continue to learn and
consolidate their skills during their employment. At
UTAS there are only a few four-year undergraduate
degrees and nationally there are very few four-year ICT
degrees. To remain competitive with ICT degrees offered
in other States and local degrees in other disciplines —
which was essential for the local industry and the
University — a three-year degree was developed. Qualified graduates that want to continue into a research
career may append a one-year Honours degree and
consideration is being given to an alternative one-year Professional Honours for graduates that want to pursue
further coursework and professional development.

When asked, the stakeholders (academia, industry, and
pre-tertiary educators) welcomed the recommendation of
having a single degree with a reduced number of electives
and a few distinct majors as this would remove confusion
for applicants and would ensure that all ICT graduates
had a balance of technical, non-technical and professional
skills. UTAS (2013) has two course structure models
summarised below. The industry representatives were
polled and there was overwhelming support for the more
intensive (Specialist) structure. The main argument for
this was that it allowed coverage of enough technical material and more of the ACM curricula (2013) core
content — particularly important given the decision to
have a three-year degree rather than the recommended
four-year degree — while also providing opportunity for
the students to develop as professionals.

Having identified a possible set of units it was
necessary to identify what should be core units and what
should be electives. It was also necessary to sequence the
units into majors and minors. In the main, decisions about
what should be core was determined by the requirements
for ACS accreditation (2011). Using this constraint as a
guide the units were grouped into possible majors and
minors and then the remaining units for the majors were
selected on the basis of either meeting the skill
requirements for particular career outcomes or to ensure
that the degree content was attractive to applicants. Table
4 also demonstrates how the units are divided into three
majors and minor and electives. Within the Bachelor of
Information and Communication Technology (BICT) at
UTAS students will complete two majors and a minor:

• All students complete an “ICT Professional” major. This
reversed major provides a breadth of professional
skills such as teamwork, ethics, communication and
interpersonal skills, entrepreneurship, and problem
solving within the four introductory-level units. In
response to the demands for business acumen in our
graduates all students will be required to complete
units in entrepreneurship, project management,
requirements analysis, as well as business modelling
and analysis at the intermediate-level. The major
culminates in a capstone project at the advanced level
to ensure these professional skills are reinforced
throughout the course.

• All students also complete an “Information Technology” minor, which includes elements of the
core ACM IT curriculum (2008) in the areas of
Information Management, Networking, Web Systems
and Technologies, Platform Technologies, and System
Administration and Maintenance. The latter is also
covered in depth in an accompanying major.

• Students will choose their second major based on their
desired career outcomes and interest areas. The two
majors: “Software Development”, or “Games and
Creative Technology” have the same compulsory
programming units at each level, including a mobile
application development unit at the advanced level.
Both majors have an ICT-restricted elective at the
advanced level allowing some choice. The remaining
units in the majors vary to give the students specific
skills for their desired career paths. This structure
allows students the flexibility to change their major
easily should their interests change.

The ACM IT curriculum (2008) comes with two
recommendations for presenting the core curriculum: Integration-first approach (an early integrated view of the
six key knowledge areas of the IT pillars) or the Pillars-first approach (introduce the detail of the IT pillars first, integration later). A Pillars-first approach was adopted as it was noted that this was better for allowing students to transfer into the degree from another course — most international students articulate into the intermediate-level. A noted disadvantage of the Pillars-first approach is that it does not provide an overview of how all the core material of an IT curriculum fits together and tends to present the details of each pillar in a more-isolated context. To overcome these disadvantages some of the features of the Integration-first approach were used:

- Breadth in ICT topics is introduced through the range of units provided at the introductory level. The degree is structured such that all eight first year units are pre-defined; the students primary opportunity for choice is that of their major. Depth has been created with units to be offered at all year-levels in a hierarchy requiring pre-requisites and with integrated content.

- There are two key pervasive topics to be developed throughout the degree: security and information assurance, and HCI and user-centredness. Both these elements are core in both the ACM IT (2008) and ACM CS (2013) curricula. As was stated in the ACM IT curriculum, these topics did not seem to belong in a single specific unit. As shown in Table 3, the SFIA skills HFIN (Human Factors Integration), UNAN (Usability Requirements Analysis), SCAD (Security Administration), and SCTY (Security Information) are developed across a number of units relating the skill to a wide-range of ICT application areas at all levels of the degree.

- Information such as that contained in the tables throughout this paper will be used to demonstrate to students how the curriculum content relates to each career outcome and also how skill development towards a career is integrated across a number of units. This information will be made available within the core unit ICT Professional Practices which is structured for their first semester so it will also be timely help for students to identify the relevant major and elective units for their chosen careers.

6 Attractive to domestic and international applicants

ICT degrees continue to rank poorly on the list of preferred courses for students applying for university places. In 2013, the broad field of IT ranked second lowest of highest preference applications out of ten fields of education (DIISRTE 2013). In 2012, the ACS released figures (ACS 2012) indicating that the number of domestic students graduating from ICT courses had halved over the last decade; down from 9093 in 2003 to an expected 4547 in 2013. Of those who commence only 54.6% complete their ICT course. And yet, since 2003 there has been a 31% growth in ICT industry employment. This indicates that there is a huge disconnection between supply and demand; this shortfall between people starting and finishing an ICT course poses a major risk to the ICT sector and even the national economy (ACS 2012).

There is a general consensus that ICT has an image problem at a time when the need for skilled ICT professionals has never been greater, and that there is a lack of awareness of the wide range of career possibilities in ICT (AWPA 2013). A career in ICT is perceived as male-dominated, repetitive, isolated, and focused on the technical rather than the professional (AWPA 2013). To counter this negative and inaccurate perception, and to promote the future growth of the industry, it is essential that the career outcomes for modern ICT curricula reflect the ever-expanding reality of ICT careers now available (ACM IT 2008) and the curriculum is designed such that graduates can attain these careers (von Konsky 2008).

To meet the demand for ICT graduates the advertised curriculum has to spark enough interest in a range of potential applicants, not just those currently studying ICT related subjects at pre-tertiary level. Also with such a reduced set of units, each unit has to be attractive, and not just to students completing the BICT degree but also as electives to students within other degrees (e.g. business, science, and arts degrees where students can take eight elective units). Alongside identifying a wide range of career outcomes and ensuring the necessary skills were developed a number of measures were taken to increase the attractiveness of the degree and the units in order to increase commencement rates and decrease attrition rates:

- ICT courses are seen to lack a workplace or business focus and to lack practical application leading to high attrition rates (Roberts et al 2012). By incorporating business and professional skills the course should be more attractive to applicants through balancing the technical and non-technical focus and also through creating a balance between the application and theory (Roberts et al 2012) and will also deliver stronger graduates to the industry (AGIMO 2013).

- Pollitzer (2012) recommended including information and knowledge about the impact that ICT has on society to excite students about an ICT career. Consequently, a unit on the Impact of ICT and Emerging Technology has been created at the introductory level.

- An introductory Artificial Intelligence unit will be developed to attract and intrigue students from a range of disciplines (e.g. science, psychology, life science, fine art, etc) by research material from the field.

- An important predictor of attrition is previous ICT experience (Roberts et al 2012). The compulsory first-year programming unit will have a pre-requisite — hence ensuring that all students have some programming experience. The requirement for pre-requisite knowledge will facilitate a more interesting and challenging unit — which should have a positive impact on the retention of students with prior programming knowledge. Alternative pathways will be available to qualify students that do not have prior programming experience. For example, students could take an additional programming unit in their first year that provides the opportunity to develop the foundational skills, and confidence, to be successful. This approach has been shown to particularly address the attrition of female students as they are less likely to have the prior experience and a stronger foundation leads to higher marks thus increasing the satisfaction for female students (Roberts et al 2012).
To attract increased applications for ICT-related courses, many universities create programs to allow students to combine subjects from a number of disciplines and enabling students to extend their studies into ICT application areas (AGIMO 2013). Related courses that don’t impact on the available resources (e.g. staffing, number of units) that will attract additional students to the units have been created. Six four-year combined degrees have been created allowing students to complete 16 units in ICT and 16 units in another discipline. In particular, a combined degree with the Bachelor of Visual Communication has been created to attract the large number of students doing computer graphics at pre-tertiary level. This particular degree is designed for students aiming for a career in Graphic Design which industry members indicated were in high demand (Herbert, de Salas, et al 2013). A Computer Science major within the Bachelor of Science degree and an ICT major within the Bachelor of Business will also allow students that don’t want to do an entire degree in ICT to develop a subset of ICT skills.

Pollitzer (2012) recommended giving priority not only to the workforce-related skills but also to ICT skills needed for entrepreneurship and creativity in order to attract more applications for ICT courses. Entrepreneurship has been embedded as a theme throughout the ICT Professional major and creativity is a stream within the Games and Creative Technology major. At the forums, very few industry members identified a demand for the Game Developer career, but they did recognise that content related to games was a strong draw-card for applicants and they welcomed the potential increase in graduate numbers its inclusion could provide.

As indicated by the attrition rates the way in which ICT is taught clearly requires urgent consideration — particularly to reduce the attrition in female students (Roberts et al 2012). As recommended by Roberts et al (2012) there will be an increased use of small group class activities, which provide students with opportunities to undertake more active learning and increased interaction with other students and staff, allowing students to feel that they are active participants in their own learning.

International student commencements in Australia in university-level ICT courses over the last five years have consistently been at least 20% higher than domestic enrolments, and in contrast to only 54.6% per cent of domestic students that complete, international students had a completion rate in 2012 of 85.8% per cent (ACS 2012). At UTAS in 2010 74% of commencing ICT students were international students (many studying offshore in China), whereas across all disciplines only 24% were international students, and, 22% of the international students enrolled were enrolled in an ICT degree (ACS 2012). With the School and the University dependent on these continued international enrolments it was essential that consideration be given to the extra features desired in an ICT degree by international students. With these students choosing to study in Australia making substantial investments in their future, there is scope for improvement to help these students to gain the tools to find appropriate jobs once they graduate (AEI 2012). A number of measures were taken to make the degree attractive to international students other than developing a degree that would receive accreditation (a key immigration factor for students):

According to an AEI employer survey (AEI 2012) employers want more emphasis on developing communication skills and English-language skills among international students. Many international students are given advanced standing on the basis of prior learning in their country of origin. This often results in them being ‘slotted’ into second year and by-passing units that provide explicit and/or incidental induction to the institution, and which develop communication and teamwork skills. As a result many are technically competent but are not best able to compete for employment on graduation. The initial experiences of international students are extremely important, laying the foundation for their success in Australia (AEI 2012). A bridging unit, just for articulating students, has been created to redress these issues. This unit will contain all the core induction material and allow international students to develop the introductory-level teamwork and communication skills. Throughout the ICT Professional major units will focus on providing opportunities for interaction and engagement via teamwork and problem-based learning activities, to help all students to develop the communication and language skills desired by industry.

An AEI survey of employers conducted in 2010 found that providing practical work experience was one of the main areas requiring more emphasis in an Australian education for international graduates (AEI 2012). Another AEI survey of Australia-educated international graduates found that the most commonly perceived barrier for graduates who had been unable to find work was a lack of work experience (AEI 2012). An elective industry placement unit has been created and is available to all students to gain genuine work experience in their second year in addition to the core capstone project experience that all students receive in their final year. Pilgrim (2011) noted the importance of introducing work-integrated learning early in the curriculum, rather than just relying upon the capstone units at the end. Roberts et al (2012) identified that team-based industry projects and work placements enable students to gain professional skills and strengthen their sense of the relevance of their ICT course while also ensuring that the curriculum is aligned with industry needs.

7 Increase progression to research degrees

Like many Australian universities, UTAS is repositioning itself and seeking to increase its research reputation. The new curriculum needs to reflect the research directions of the School and it has to inspire more graduates to continue onto a research higher degree to increase the research output of the School.

The “teaching-research nexus” has been described in a variety of ways in the literature. Perhaps the most widely cited is Healey’s (2005) categorisation that proposes students experience research in four main ways:
• research-led — in which students learn about research findings;
• research-oriented — in which students learn about research processes;
• research-based — in which students learn as researchers; and
• research-tutored — in which students learn in small group discussions about research findings.

Within the new curriculum Artificial Intelligence, a key research field of the School, will be offered as a research-led introductory unit. Data Analytics is another research-led elective unit at the advanced level in which students will gain an understanding of the major research issues in the area of ‘big data’.

Koppi and Naghdy (2009) introduced the concept of the teaching-research-industry-learning (TRIL) nexus in ICT education. They highlighted that in addition to the relationships between teaching and research, industry is often at the forefront of ICT research and that understanding and strengthening the TRIL nexus would lead to curriculum improvements. Within the new curriculum there is an intention to embed research and industry guest speakers throughout all units to relate the content of each unit to research that is happening in the field and to what the students will experience in employment. Increased use of case-based teaching and learning will tie ICT content to application, enabling students to understand the context in which their knowledge will be applied (Roberts et al 2012).

Strazdins (2007) described a comprehensive effort to introduce a research culture throughout an entire undergraduate Computer Science curriculum. He notes, however, that a research-based ICT education may not be suitable for all students — especially those of lower ability and at lower undergraduate levels. Within the new curriculum there will be a steady increase from problem-based approaches in introductory and intermediate units to research-based approaches in the advanced level units.

Strazdins (2007) also comments on the view of some academics that it can be hard and time-consuming to include research-based assignments and group work when classes are large and teaching loads are high. In the new curriculum the number of coursework units has been significantly reduced decreasing the teaching load for staff. There will be a number of elective research-based units in the new curriculum that will have pre-requisites that restrict enrolment to the top students. Small class sizes and special experiences for these top students will hopefully inspire in them a desire to stay to complete higher degrees and pursue a career in research. ICT R&D project units have been introduced at all three levels of the degree for top students. As well as being research-based these units are also research-oriented as students will learn about research processes while conducting a research project. Finally, three advanced level ‘elite’ research-based and research-tutored units will be offered annually in which students will learn in small classes about research findings that relate to research focuses of the School delivered by research-intensive academics. For example, in 2014 elite units in eHealth, sensor networks, and artificial intelligence will be offered; each a significant research focus area of the School.

8 Conclusion

Curriculum design is a complex process that must be informed by stakeholders and developed from multiple perspectives. This paper reports on the development of an ICT curriculum that involved balancing a number of constraints, which, in the words of an external academic advisory panel, resulted in a “very coherent, strong, contemporary” ICT curriculum (CIS 2013).

A broad range of career outcomes and skill sets were identified by a balanced view of academic insight and industry demands — both being further supported by externally-validated and industry-standard definitions. Decisions about what to include in the curriculum were guided by these career outcomes and skill sets and the curriculum was aligned with ACM international curricula (ACM 2013) and the ACS core body of knowledge (ACS 2011). The curriculum includes features that will be attractive to domestic and international applicants alike, and will promote progression to a research higher degree.

The pervasive themes (security and information assurance, and HCI and user-centredness) alongside the depth areas (professionalism, software development, games and creative technology, information technology) and the fact that development of each skill has been integrated across a wide-range of ICT topic areas and that the curriculum encompasses study across the boundaries of disciplines will generate well-rounded graduates who have a much better understanding of the relationship between the ICT content.

In focusing on a set of career goals, a course structure was designed that required a small number of units which consequently yielded a reduced teaching load for staff, and hence the creation of increased time for research. Although the number of units is relatively small they contribute to a broad range of career outcomes allowing enough choice for applicants to pursue their individual interests. Students can be assured that the advertised career outcomes are genuinely attainable and that the degree was developed with these career outcomes in mind. Furthermore, employers of the graduates can have confidence that the course contains the relevant skills that are expected of graduates.

9 References


