Visualising Career Progression for ICT Professionals and the implications for ICT Curriculum Design in Higher Education

Brian R. von Konsky  
Curtin Teaching and Learning  
Curtin University  
Perth, Western Australia  
B.vonKonsky@curtin.edu.au

Asheley Jones  
ACS Education  
Australian Computer Society  
Melbourne, Victoria  
asheley.jones@acseducation.edu.au

Charlynn Miller  
Science, IT & Engineering  
University of Ballarat  
Ballarat, Victoria  
c.miller@ballarat.edu.au

Abstract
The current environment in higher education calls for more consideration of the linkages between ICT curriculum development, skills capabilities and industry, particularly in light of recent changes in quality and standards agencies. This paper evaluates ICT career progression visualisation methodology and has a threefold purpose: to contribute to a holistic approach to curriculum design and management; to add to materials that aid graduates to better prepare initial professional practice choices for employment in the ICT profession; and to facilitate further dialogue with industry representatives, higher education providers and other ICT stakeholders to ensure undergraduate curricula authentically reflects the skills required within the ICT profession. This paper evaluates SFIA-based tools intended to enable educational designers to visualise ICT career progression pathways and thus inform curriculum design in higher education. Several visualisation techniques are compared using SFIA-based skillsets that were previously published in the literature. The evaluation demonstrates extended radar diagrams are an effective visual representation for capturing the level at which SFIA skill sets are practiced. The research indicates that such representations are well positioned to enhance dialogue amongst stakeholders and contribute to the design of ICT curriculum in a manner that better prepares students for ongoing development in the profession.

Keywords: SFIA, curriculum, ICT education, professional practice, skills, competencies

1 Introduction
ICT education worldwide is in flux, partly as a result of the imperative to better align educational curriculum with industry needs. The Skills Framework for the Information Age (SFIA) is a dynamic two-dimensional skills matrix managed by the SFIA Foundation, a consortium formed in July 2003 by the Institution of Engineering and Technology (IET), Institute for the Management of Information Systems (IMIS), e-skills UK, and the British Computer Society (BCS). This reference model, now in its fifth iteration, can be used for describing Information Communication Technology (ICT) skills and the levels of responsibility at which they are practiced (SFIA Foundation, 2011a). Similarly, the framework can be used by organisations providing ICT products and services as a standardised means by which to manage the recruitment, assessment, and development of ICT professionals (SFIA Foundation, 2011b).

The Australian Computer Society (ACS) also uses SFIA for member certification (ACS, 2012b) and the accreditation of higher education programs that prepare students for initial professional practice in the ICT industry (ACS, 2012a). ACS recommends that higher education institutions adopt a top-down approach to curriculum design that begins with SFIA to define ICT career roles for which a given program prepares graduates (ACS, 2012a, 2012c). Using such an approach, SFIA has been embedded in the ACS Computer Professional Education Program (CpeP). This is a postgraduate program that offers an articulation pathway to a number of Australian masters programs.

This paper examines techniques to visualise SFIA skillsets along a career path that includes: those skills developed in undergraduate ICT programs; and in positions held by graduates in the early stages of their career development. A goal is to take a holistic approach to curriculum design and management, such that graduates are adequately prepared for initial professional practice in the ICT industry. A further goal is to facilitate dialogue with industry representatives and other stakeholders to ensure that the undergraduate curriculum authentically reflects the skills required by industry.

2 Background
SFIA defines generic attributes that encompass business skills and the extent to which an individual demonstrates autonomy and influence. These are defined across the 7 levels of responsibility that are shown in Table 1 (SFIA Foundation, 2011a, 2011b).

<table>
<thead>
<tr>
<th>Type</th>
<th>Characterisation</th>
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<tbody>
<tr>
<td>1</td>
<td>Follow</td>
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<td>2</td>
<td>Assist</td>
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<td>3</td>
<td>Apply</td>
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<td>4</td>
<td>Enable</td>
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<tr>
<td>5</td>
<td>Ensure, Advise</td>
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<tr>
<td>6</td>
<td>Initiate, influence</td>
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<tr>
<td>7</td>
<td>Set strategy, inspire, mobilise</td>
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Table 1: SFIA Levels

The standard also defines 96 ICT specific skills in 6 categories and 19 sub-categories. Descriptors are provided for each skill and for each of the 7 responsibility levels at which a skill is defined.
Not all skills are defined for each of the 7 levels. For example, the Service Desk and Incident Management (USUP) skill is practiced between Levels 1 (follow) and Level 5 (ensure, advise). At the low end of this range, an individual handles customer support and associated record keeping, usually under the direct supervision of a more senior colleague. At the higher end of this range, an individual maintains policies and standards associated with the provision of client support. In contrast, the Consultancy (CNSL) skill is only defined at the higher end of the responsibility range from Levels 5 (Ensure, advise) to Level 7 (set strategy, inspire, mobilise). At Level 5, a consultant is responsible for understanding user requirements, collecting data, analysing results, and delivering solutions to clients. At Level 7, a consultant operates with significant autonomy and responsibility in the provision of a wide range of consulting services. The reader is referred to the SFIA documentation for specific descriptors associated with these roles and levels (SFIA Foundation, 2011a).

In designing ICT curricula, it is possible to demonstrate the alignment of SFIA categories to knowledge areas in the ACS Core Body of Knowledge (ACS, 2012c). Similarly, it is possible to align professional competencies and skills to institutional graduate attributes used in curriculum maps that link learning experiences and assessments to the intended learning outcomes (Oliver, Jones, Ferns, & Tucker, 2007). However, potential complications include: graduate attributes that overlap with respect to the set of professional skills and competencies that vary in number in a manner that makes tabular representations problematic (Oliver, 2013).

None-the-less, the use of tables to document course structures and their alignment with specified knowledge areas and skills are commonplace. This includes the use of tables associated with course accreditation. For example, the ACS provides standard forms with tables to be used by institutions requesting accreditation. These forms show the program structure and its alignment with knowledge areas from the ACS CBOK.

The University of Tasmania has used a tabular approach to identify SFIA skills to be embedded in new ICT curriculum that is currently being designed for implementation commencing in 2014 (Herbert, de Salas, et al., 2013). It is important to note that aligning a course with SFIA is subtly different from embedding these skills directly in the curriculum (Bailey, 2012). That is, embedding SFIA in the curriculum should not be a “tie the box” exercise to demonstrate compliance. Rather, SFIA should directly inform the design and structure of learning activities and add value to the learning experience with respect to their authenticity and relevance to industry.

Tabular curriculum maps have also been augmented with geometric symbols to convey further information about the mapping. For example, Spencer, Riddle and Knewstubb (2011) added geometric symbols of varying size and colour to produce heat maps. These symbols capture the confidence and quality of evidence that a given graduate attribute has been taught, practiced and assessed. This approach provides a visual representation of current practice and indicates where curriculum redesign activities should be focused in further design interactions.

Tabular maps based on Quality Function Deployment (QFD) with House of Quality (HoQ) graphical features, adapted from use in industrial applications, have been described in the curriculum design of a hypothetical Master of Information Systems course (Denton, Virginia Franke, & Nanda, 2005). Tables using this approach contain graphical symbols in five areas that link graduate attributes to: a common body of knowledge or skillset; the expectations of prospective employers; critical prerequisite areas; feedback received from program graduates and employers; and the relative amount of time devoted to each knowledge area.

Other visualisation approaches to convey skills and competencies have also been reported in the literature. For example, Armstrong (2011) used a network diagram to visually decompose the entire SFIA framework by category and subcategory. A network diagram provides a good visual representation of the overall hierarchy of the SFIA framework, but does not convey the specific set of skills or the level at which they are practiced for a given career role. To facilitate the latter, Armstrong proposed the use of a two-dimensional grid that uses colour-coded cells to denote the level at which a given skill is practiced. He argued that this approach provides for a visual representation in which a number of applicants for an ICT position could be quickly compared against a position description that was similarly encoded.

von Konsky, Hay and Hart (2008) used SFIA-based radar diagrams to compare advertised ICT industry positions at various levels of seniority with those developed in an undergraduate software engineering program. Visualising career paths using this approach required considering multiple spider diagrams for each educational and professional development program and industry position along a given career path. Given the large number of SFIA skills defined in the framework, this adds to the cognitive load associated with such a visual analysis as the viewer switches between diagrams.

A visual approach to demonstrate the transition from formal study to junior and then significantly more senior positions in the ICT industry has been developed by the Queensland government (Queensland Government Chief Information Office, 2013a). This approach divides concentric rings into four quadrants that categorise ICT career roles according to those associated with technology/application building, technology services, enterprise implementation, and enterprise governance. The outer ring denotes the type of formal study required for entry to roles in a given quadrant (e.g. high school, TAFE or university qualification or industry experience). The next ring denotes roles associated with junior and first-line management positions. The inner ring contains very senior ICT career roles, whilst the centre of the diagram is limited to the Chief Information Officer and Chief Executive Officer roles. Each role listed in the diagram is hyperlinked to tables containing the SFIA skills and levels of responsibility associated with that role (Queensland Government Chief Information Office, 2013b). Visualising career progression from study and from role to role requires moving back and forth between
the figure and the hyperlinked tables containing the SFIA skillset associated with each role.

ICT career roles defined by the Queensland government have been used to facilitate dialogue amongst stakeholders in the design of a new undergraduate degree (Herbert, de Salas, et al., 2013). Input from industry representatives included an evaluation as to whether the Queensland government defined ICT career roles that were relevant to their organisation, and whether they had hired or would hire graduates possessing the skills associated with each role. A goal of the process was to ensure that graduates of the new program would be industry-ready for initial professional practice in the intended roles, or partially prepared to assume other roles pending additional development. Although this approach was based on an evaluation of initial skills required by graduates in industry, the process did not entail visualising career progression into the latter roles.

The principal contribution of the current paper is to evaluate approaches to visualising the career progression of ICT professionals beginning with the outcomes associated with undergraduate degree programs, and as a further aid to enhance curriculum design and inform meaningful interaction with industry stakeholders.

3 Methodology

A web application was written to enable SFIA skillsets to be combined and visualised based on published data available from multiple sources. This included intended skillsets from an undergraduate program in software engineering, ICT positions from industry at various levels of responsibility and seniority (von Konisky et al., 2008), and postgraduate subjects that develop SFIA skills in conjunction with the ACS CPeP (ACS, 2013a).

Multiple visualisation techniques were compared to evaluate their suitability for use in planning career progression, taking note of the compactness of visual representation and the range of levels defined by SFIA for each skill. This included tabular representations, radar diagrams, and extended radar diagrams.

Tabular representations were loosely based on an A3 poster published by the SFIA foundation. This poster lists all 96 skills in the framework on the vertical axis, along with a visual representation of the levels at which each skill is defined. These were colour-coded in the table by SFIA category using the same colour scheme used in the Foundation’s A3 poster. The horizontal axis contained a column for each skillset in the sample and indicated the level at which a given skill is practiced. Table cells were blank if a given skill was not included in a skillset. It was assumed that a given skill is practiced at a single level for each skillset. That is, an undergraduate program intends to develop a skill to a specified level. It is not intended to develop the same skill at multiple levels. However, a subsequent skillset for a postgraduate program might develop the skill to a higher level.

Radar diagrams were based on those used by von Konisky et al. (2008). In that approach, background cells were colour coded by SFIA category. However, the original approach was modified so that radar bars originated a fixed distance from the centre to avoid artefacts associated with small cells near the origin.

Extended radar diagrams used colour-coded cells to represent the levels for which a SFIA skill is defined in the framework. This is similar to those used in the tabular format except they are displayed radially. If a skill at a given level was included in the skillset, it was represented in the corresponding cell using a brighter shade of the colour used to represent that category. If a level is not defined in the SFIA framework for a given skill, the cell for that skill and level was not coloured.

4 Results

Figure 1 shows results in the tabular format for the following skillsets: intended skills developed in an undergraduate software engineering program (BEng (SE)); skills identified in advertised positions in industry for a Graduate Software Engineer (SE Grad) and a Software Manager (SW Mgr); and postgraduate units in the ACS CPeP including: Risk Management; Professionalism and Compliance (RMP); Business Strategy and ICT (BST); New Technology Alignment (NTA); and Business Analysis (BAS).

Intended SFIA skills developed by core subjects from an undergraduate software engineering program are shown using a radar diagram in Figure 2. It demonstrates that most of the intended skills are in the Solution Development and Implementation category (yellow). This skill category includes specific skills such as: Programming/Software Development (PROG); Testing (TEST); Safety Engineering (SFEN); Data Analysis (DTAN); System Design (DESN); Database/Repository Design (DBDS); and System Integration (SINT). Skills developed in the Strategy and Architecture category (red) include: Solution Architecture (ARCH); Methods and Tools (METL); and Software Development Process Improvement (SPIM). Additionally, the Configuration Management (CFMG) skill from the Service Management category (brown), the Quality Assurance skill from the Procurement and Management Support/Quality and Conformance category (blue) are also intended to be developed in this program. Further, the figure shows that the intended level to which these skills are developed range from Level 2 (assist) to Level 4 (enable). There are no skills in the skillset from the Business Change (purple) or Client Interface (green) categories. Complete descriptors for each skill and level can be found in documentation available from the SFIA foundation (SFIA Foundation, 2011a). It should be noted that the skillset shown in Figure 2 is for a particular software engineering program as previously reported in the literature, and is therefore not intended to characterise all undergraduate software engineering programs.

The data for an undergraduate software engineering program is also shown in Figure 3 using an extended radar diagram. Unlike Figure 2, the extended radar diagram shows the range of levels for which SFIA defines each skill in the framework.
Figure 1. Tabular visualisation for several skillsets.

Figure 2. Radar diagram for an undergraduate software engineering program.

Figure 3. Extended radar diagram for an undergraduate software engineering program.

Strategy and architecture
Business change
Solution development and implementation
Service management
Procurement and management support
Client interface
Figure 4 through 6 are extended radar diagrams showing SFIA skills associated with advertised positions from industry. Figure 4 shows skills for a Graduate Software Engineering position. Not unexpectedly, the skills associated with this entry-level position are similar to those of the undergraduate software engineering program in that most of the skills are from the Solution Development and Implementation category. However, the Graduate Software Engineering skillset includes the Database Administration (DBAD) skill from the Services Management category. The skillset also includes Sales Support (SSUP) from the Client Interface category and the Service Desk and Incident Management (USUP) skill from the Services Management category.

Figure 7. Postgraduate skills developed in ACS CPeP core subjects with a Business Analysis elective

Strategy and architecture
Business change
Solution development and implementation
Service management
Procurement and management support
Client interface
Management categories, both at Level 1. That is, this graduate position includes low-level client facing responsibilities even though the role is largely development focussed.

As shown in Figure 5, the skillset for the Software Manager position continues to be focused strongly in the Solution Development and Implementation category. Compared to the Graduate Software Engineer, however, the Software Manager position requires a richer set of skills from this category. Moreover, they are generally performed at a higher level of responsibility. The Software Manager position also requires skills from the Business Change and Strategy and Architecture categories. Skills include: Professional Development (PDSV); Stakeholder Relationship Management (RLMT); Portfolio, Programme and Project Support (PROF); Project Management (POMG); and Business Risk Management (BRUM).

Figure 6 combines the Graduate Software Engineer and the Software Manager skillsets into a single image. Combining the skillsets in this way visually demonstrates that the Software Manager position requires growth and development with respect to the level at which some skills are practiced. For example, the visualisation shows that both the System Integration (SINT) and Systems Installation/ Decommissioning (HSIN) skills advance from Level 2 (assist) to Level 5 (ensure, advise). Similarly Testing (TEST) advances from Level 2 (assist) to Level 4 (enable).

Figure 7 shows the intended SFIA skillset associated with the ACS CPeP. The skillset for this postgraduate program includes skills developed by three core subjects and an elective subject called Business Analysis. All skills in this set are from the Business Change and Strategy and Architecture categories only. It is intended for skills to be developed at Level 5 (ensure, advise) or Level 6 (initiate, influence).

As demonstrated in the Figures 1 through 7, extended radar diagrams have a compact representation, capture the range of levels defined for each skill in the framework, and can infer skills progression at increasing levels of responsibility. In comparison, radar diagrams do not capture defined levels for each skill. Tables can capture this range, but are longer and less compact in nature.

5 Discussion
The Software Manager position requires practicing skills with additional responsibilities above and beyond those required for the graduate position. The position also includes the addition of new skills from other SFIA categories. While there are many potential pathways that a Graduate Software Engineer may take to add skills from the missing categories, one pathway includes completion of postgraduate programs such as ACS CPeP.

That is, the Graduate Software Engineer position possesses skills from the Solution Development and Implementation, Service Management, and Client Interface categories only. The position does not require any skills from the Strategy and Architecture, Business Change, or Procurement and Management Support categories. Core ACS CPeP subjects and the Business Analysis elective develop skills from the Strategy and Architecture and Business Change categories, while the Green Computing elective (not shown) adds skills from the Strategy and Architecture and the Procurement Management Support categories. This suggests that postgraduate study is one possible path to the more senior position since it adds significant skills from the missing SFIA categories. However, this observation comes with the caveat that the specific skills developed depend on the program and choice of electives.

It is also worth noting that the undergraduate software engineering program intends to develop skills that are generally practiced at a lower level of responsibility compared to those of the postgraduate CPeP.

For example, the four-year undergraduate program develops 12 SFIA skills from 4 categories. Of these, 2 skills are at Level 2 (assist), 3 skills are at Level 3 (apply), 5 skills are at Level 4 (enable), and only 2 skills are at Level 5 (ensure, advise). The focus of the program is clearly on skills from Solution Development and Implementation category, which comprises 7 of the 12 skills in the set.

In contrast, the shorter ACS CPeP develops 9 skills from 2 categories. Of these, 8 skills are at Level 5 (ensure, advise), and 1 is at Level 6 (initiate, influence).

It is also worth comparing the skillsets for the Graduate Software Engineering position with the undergraduate software engineering program as shown in Figures 3 and 4. These skillsets are aligned in the sense that both focus on solution development and implementation. However, it is not a perfect match. For example, the undergraduate software engineering program does develop some skills from the Strategy and Architecture category that are useful for those in the Software Manager role, but not necessarily the graduate level position. Does that mean that the time spent developing Strategy and Architecture skills in an undergraduate software engineering program could be better spent developing skills required for the graduate position? This answer is "probably not". Software architecture is a component of the Software Engineering Body of Knowledge (IEEE Computer Society, 2004). It is therefore appropriate that this be included in a course that prepares students for a role in software engineering. Even if an undergraduate program was preparing students for some other ICT role, it is reasonable to argue that exposure to the breadth of SFIA skill categories lays an appropriate foundation for future growth and development. It is further reasonable to suggest that developing depth for important skills in a specific SFIA category associated with the intended professional role is also necessary; hence the focus on solution development and implementation in this particular example.
ACS expects that academic institutions will undertake curriculum design in consultation with external stakeholders (ACS, 2012a), which often takes the form of advisory boards and focus groups that include representatives from the ICT industry (Herbert, de Salas, et al., 2013; Herbert, Dermoudy, et al., 2013; von Konsky, 2008). As these stakeholders increasingly use SFIA to identify the skills they require in the ICT professionals they employ (Banks, 2010), it makes sense that academic consultation with external stakeholders will also be based on SFIA. Moreover, SFIA-based visualisations have the potential to facilitate a shared understanding of the skills required by industry and potential career paths for early career ICT professionals as illustrated in Figure 8.

This visualisation has the potential to change processes for curriculum mapping offering a more comprehensive first phase career mapping exercise that directly links academic programs to positions in industry at increasingly higher levels of seniority.

It should not be overlooked that students and early career ICT professionals are also stakeholders in such a process. Beginning with their choice of an undergraduate program and the electives they choose, SFIA and SFIA-based visualisations have the potential to inform the decisions made by early career ICT professionals as they plan their professional development (Figure 8). Career mapping visualisation techniques such as those provided in this paper can also influence students' choice of co-curricular and extra-curricular activities such as those sponsored by the ACS which include: monthly branch forums; the Young IT and ACS Women programs; and involvement within special interest groups (SIGs).

In the ACS CPeP program, students maintain evidence of SFIA skills in an electronic portfolio and keep an online journal in which they reflect and evidence their attainment of SFIA skills and the level of responsibility at which they practice currently (Jones & Lindley, 2010; Jones & Miller, 2012). These electronic portfolios are collated by students and assessed by a mentor. The intended learning objective from this process is to inform ongoing professional development once students successfully complete the program and become Certified Professional members of the ACS. Although CPeP is a postgraduate program, such an approach may also be applicable in undergraduate settings.

Not dissimilarly, the ACS requires that members with Certified Professional status undertake 30 hours of professional development annually. This is logged electronically on the ACS web site and can be linked to SFIA skills and levels. SFIA assessment is also available to members via the MySFIA tool, which includes a radar diagram representing SFIA skills and their level of attainment (ACS, 2013b). Finally, it should be noted that aligning the ICT curriculum with industry-based positions using SFIA is not incompatible with the development of so-called “soft skills”. These include communication and lifelong learning. Many SFIA skills recognise that the ICT profession can change quickly. This requires that professionals be agile in their response to new technologies as they emerge, and be able to communicate the impact of emerging technology to stakeholders. For example, this is well described in the Emerging Technology monitoring (EMRG) skill.

6 Conclusions

The object of this study was threefold: to contribute to a holistic approach to curriculum design and management; to add to materials that aid graduates to better prepare initial professional practice choices for employment in the ICT profession; and to facilitate further dialogue with industry representatives, higher education providers and other ICT stakeholders to ensure undergraduate curricula authentically reflects the skills required within the ICT profession.

In order to achieve the objectives, this study has evaluated and compared various visualisation techniques for the representation of SFIA skillsets. An examination of the efficacy of these visualisation tools, specifically: tabular formats; radar diagrams; and extended radar diagrams was undertaken. The paper has demonstrated that extended radar diagrams can be seen to enable compact representation of current skill sets, with the added potential to show career progression when skill sets from different courses and positions are combined. This paper has argued that such SFIA-based tools are an important component in informing curriculum design in higher education. Visual representations such as the diagrams used to support this research have the potential to facilitate interaction and dialogue amongst stakeholders and better prepare students for ongoing development in the ICT profession. The extended radar diagrams methodology offered in this paper provides a common understanding and an opportunity for further research into holistic curriculum design. The authors of this paper expect the outcomes from the development of these models can begin to address the requirements of ICT curriculum developers in aligning learning outcomes in higher education with the needs of the ICT industry.
7 References


