ACIS 2020 Proceedings | Australasian (ACIS)

2020

Five Principles to Integrate Professional Skill Development within a Curriculum to Ensure Industry-Ready Graduates

Nicole Herbert
School of Computing and Information Systems, University of Tasmania, Hobart, TAS, Australia., Nicole.Herbert@utas.edu.au

David Herbert
University of Tasmania, Australia, david.herbert@utas.edu.au

Five Principles to Integrate Professional Skill Development within a Curriculum to Ensure Industry-Ready Graduates

Nicole Herbert, David Herbert
School of Information and Communication Technology
University of Tasmania
Tasmania, Australia
Email: Nicole.Herbert@utas.edu.au, David.Herbert@utas.edu.au

Abstract

There is an increasing expectation that tertiary institutions will produce industry-ready graduates. Reportedly, there is industry concern that information and communication technology (ICT) graduates are not industry-ready as they are weak in the critical professional (soft) skills, such as communication and collaboration. In response, an ICT curriculum that integrated the development of professional skills alongside the development of technical skills, such as programming, networking and databases, was designed and implemented, and the impact on graduate competency was evaluated. This paper proposes five principles that can be employed by curriculum designers to guide the inclusion of professional skill development throughout a curriculum to enhance the professional competence of ICT graduates without having a detrimental impact on their competency with ICT technical skills.

1 Introduction

Information and communication technology (ICT) curriculum incorporates core knowledge and skills from the discipline fields of Computer Science (CS), Information Technology (IT) and/or Information Systems (IS) to create graduates for a range of ICT career outcomes (ACM 2020). Increasingly, tertiary ICT curriculum is expected to create industry-ready competent graduates. Industry employers expect ICT graduates to be prepared for rapidly evolving technology, and to be productive and to assist with solving complex business problems on commencement of employment.

Industry members claim that ICT graduates are not industry-ready (productive on commencement), and ICT graduates are subsequently not being employed by the ICT industry (AWPA 2013; Palmer et al. 2018). ICT graduates lack competence with some generic employability skills that preclude them from functioning productively in the workplace; ICT graduates are generally strong in their technical ability but weaker in their professional (soft) skills, in particular their ability to communicate and collaborate (Anderson et al. 2015; Burge et al. 2014; Hamilton et al. 2015; AWPA 2013; Herbert et al. 2014). The lack of quality ICT graduates has economic implications for the Australian ICT industry as it limits its ability to provide a timely response to the growing demand for ICT-related products and services. There are also serious implications for the ICT higher education sector as industry employers were reportedly bypassing ICT graduates by employing high-performing students from non-ICT degrees and subsequently training them in the required ICT technical skills (AWPA 2013). The ever-increasing demand for industry-ready ICT graduates warrants the need for more effective ICT curriculum design.

Professional skills (also referred to as generic, soft or graduate skills) are transferrable across a number of ICT domains (e.g. system development, project management, networks, and databases) and other disciplines (e.g. science, business, law, and the arts) (Stevens and Norman 2016; Palmer et al. 2018). Professional skills are considered an essential component of employability by employers and include skills like problem-solving, initiative, critical thinking, creativity, digital literacy, logic, communication and teamwork (Exter et al. 2018; Coldwell-Neilson 2017; AIIA 2017). One of the key findings from an investigation into whether ICT graduates are industry-ready was that most employers consider professional skills to be untrainable in the work environment and consider them a critical hurdle for employment (Stevens and Norman 2016; Hamilton et al. 2015). A recent study completed by Palmer et al. (2018) using the 2017 Australian national census data, found that even though there is significant jobs growth in the Australian ICT industry, a third of ICT graduates do not seek employment in the ICT industry. As professional skills are required in most professions, by developing these skills ICT courses will be equipping graduates to be productive in many industries. It is worth noting that professional skills are also invaluable for a research or academic career, but that is not the focus of this paper.

Incorrect curriculum design has serious implications many years later for graduates and the industry. Graduate employment outcomes could be improved by including more professional skill development in the curriculum (Hamilton et al. 2015). Numerous studies, as discussed in the next section, have reported on different approaches for developing professional skills within an ICT curriculum. Most studies use examples of one or two subjects to develop a professional skill, though a few report on a wider approach where a professional skill is developed across a set of subjects across the curriculum.

This paper reflects on a case study ICT curriculum, implemented from 2014-2018, that integrated professional skill development throughout the curriculum. This paper explores the research question: *How can an ICT curriculum effectively enhance professional skill development whilst maintaining technical skill competency to ensure industry-ready graduates?* Five principles are identified to assist curriculum designers to integrate professional skill development to ensure competent ICT graduates.

2 Related Work

The term "competence" links education with industry-readiness. The latest Association for Computer Machinery (ACM) curriculum guidelines recognise the importance of developing competent graduates and provides a succinct definition of IT competence (ACM 2020; Anderson et al. 2015):

IT Competency = (Knowledge + Skills + Dispositions) in a Professional Context (ACM 2020)

Competency is a series of abilities that when combined make a competent person within a professional context. Knowledge is an understanding of core concepts in ICT and the ability to know what to do in new contexts. Skills refer to ICT capabilities that demonstrate ability in how to apply knowledge. Skills develop over time with practice and interaction with others. Dispositions are attitudes such as motivation and sensitivity towards when and why to carry out tasks. Professional contexts can be simulated in a learning environment by providing an authentic experience such as projects with industry clients, a reflective report on a complex project, and presentations judged by external assessors (ACM 2020). A competent ICT graduate has acquired the ability to combine disciplinary knowledge with a range of skills and dispositions to effectively accomplish professional tasks to industry standards.

The goal of an ICT curriculum should be to create professionally competent graduates who can perform to the required industry standard for a range of ICT career outcomes (Herbert et al. 2014). Achieving this level of competency can be difficult (Anderson 2013). Due to the shortage of skilled ICT personnel, employers are not interested in extending the duration of study for students to acquire professional skills, nor are they interested in solutions that lower a graduate's technical foundation to acquire professional skills (Herbert et al. 2014; Stevens and Norman 2016). A reduction in technical competence is a concern of curriculum designers and industry members when integrating professional skill development with technical skill development as there is a perception that students will spend less time developing technical skills (Pollock 2001; Al-Mahmood and Gruba 2007; Herbert et al. 2014; Stevens and Norman 2016; Anderson et al. 2015). The challenge for ICT curriculum designers is how to resolve the tension between balancing ICT-specific content, that remains relevant to the rapidly evolving technology, and professional skill development within a standard timeframe of three years (Al-Mahmood and Gruba 2007; Anderson et al. 2015).

Several studies have reported on the benefits of integrating professional skills development within an ICT subject, rather than abstracted away in separate subjects; however, most do not expand their approaches beyond one or two subjects and do not attempt to measure the impact on competency. Dankel and Ohlrich (2007) and Bennett and Urness (2009) described how they included student presentations alongside programming content to develop oral communication skills. Anewalt and Polack (2017) implemented a curriculum-wide approach for oral communication skill development. A survey of randomly selected alumni had 82% of respondents indicating they had adequate oral communication skills for their post-graduation environment. Garvey (2010), Gruba and Al-Mahmood (2004), Pollock (2001), Dugan and Polanski (2006) identified writing activities that can be included throughout an ICT curriculum in different domains. Falkner and Falkner (2012) present a methodology, which builds upon established frameworks, to integrate written communication skill development with discipline content and they illustrated its use in a pilot study of two subjects. Their analysis of students that were exposed to the subjects demonstrated higher overall pass rates. Burge et al. (2012) and Anderson et al. (2015) demonstrated a framework for curriculum-wide integration of written communication into ICT curriculum and their results suggested improvement in both written communication and the student's understanding of the technical content. Fell et al. (1996), Hoffman et al. (2014) proposed using workplace scenarios to integrate communication skills with technical content to better prepare students for the transition to industry; the latter study identified how written communication skills could be integrated with technical content without sacrificing the technical skills. Coleman and Lang (2012) described a curriculum-wide approach to teaching collaboration skills without compromising technical content. The size of their cohort prevented a full analysis, though anecdotal evidence and qualitative feedback leads them to conclude that students learnt to collaborate.

Building on this previous research, Herbert et al. (2020a) proposed a methodology to guide the development of a range of professional skills across a curriculum to achieve industry-ready ICT graduates. This methodology adapts, extends and combines existing approaches established by others and illustrates the breadth and depth of professional skill development within a curriculum. The efficacy of this methodology was demonstrated with a case study ICT curriculum that integrated professional skill development throughout the curriculum. This case study curriculum was evaluated using a longitudinal study conducted from 2014 to 2018 and demonstrated an improvement in graduate competency with professional skills without degrading technical skills (Herbert et al. 2020b).

3 Case Study Curriculum and Longitudinal Study

Discussions with more than thirty local ICT industry members in 2012 revealed that they were satisfied with the University of Tasmania (UTAS) ICT graduate's technical skills but desired improvement in their professional skills (Herbert et al. 2014). This lead to the design of a renewed ICT curriculum that integrated the development of professional skills (communication, collaboration, creativity, and critical thinking) alongside the development of the technical skills (such as programming, networking, security and databases) and non-technical ICT skills (such as project management, business analysis, and system integration) to create professionally competent industry-ready graduates for a broad range of careers (Herbert et al. 2014). This integrated ICT curriculum implemented in 2014 incorporated the core knowledge and skills from three discipline fields: Computer Science (CS), Information Technology (IT) and Information Systems (IS) (ACM 2020), making the findings relevant to each discipline.

Professional skill development was integrated across the renewed curriculum (Herbert et al. 2020a). The development of each professional skill was embedded across numerous subjects throughout the curriculum. When a skill is integrated within a subject, knowledge for the skill is typically taught, practiced and assessed together with other domain knowledge and skills to complete domain specific activities. The outputs (reports, presentations, etc) from the learning activities within the integrated curriculum are not particularly novel. What is novel, is that students commence development of each professional skill from their first-semester and that the technical, non-technical and professional skills are inextricably woven together to complete complex learning activities, just as they are in professional practice (Hoffman et al. 2014; Frezza et al. 2018; Al-Mahmood and Gruba 2007). Students have multiple opportunities to practice and further develop each professional skill throughout the three-year course, and each professional skill is assessed within an authentic professional context before graduation.

This paper refers to results from a longitudinal study into the impact on graduate competency levels with professional skills; Herbert et al. (2020b) provides a full discussion of this longitudinal study. Competency levels were measured by reflecting on a student's behaviour (e.g. for teamwork) and by comparing the quality of outputs from learning activities. This study compared academic results using the same students from a first-year first-semester subject, and their final-year capstone experience where the students are working in a simulated professional context in teams each completing an authentic software development project for an industry client (Herbert 2018). The majority of students that completed the capstone experience from 2016-2018 commenced the course between 2014-2016. Comparisons were also made with the results of students from the capstone experience in the previous curriculum from 2012-2014; these students had not experienced an integrated curriculum. With the exception of items assessed by the industry client, all capstone activities and the first-year activities used in the study were assessed by the first author of this paper. T-tests with $p < 0.05$ were used in the analysis to identify if there was a significant difference between the means of two samples. Performing a controlled longitudinal study is difficult and controlling variability as much as possible, this study provided significant evidence that the students' competency with professional skills had improved under the integrated curriculum. Based on the assessment of a complex software system and technical design report that each team was required to prepare, there was no evidence of a decline in technical skills; technical skill competency had remained at the acceptable levels achieved by the previous curriculum.

4 Five Design Principles

The five curriculum design principles presented in this paper were developed and determined over time as a result of integrating professional skill development throughout a curriculum to ensure industry-ready competent graduates for a broad range of career outcomes. Integrating skill development across the curriculum provides more opportunities for practice and reflective development, allowing students to develop depth of learning, make connections across domains to see the wider applicability of a skill, have competence with generic employability skills, and transition into professional practice (Coleman and Lang 2012; Falkner and Falkner 2012; Hoffman et al. 2014; Anderson et al. 2015).

4.1 Principle 1 – Breadth of experience

Principle 1: To ensure industry-ready competent graduates for a broad range of career outcomes, develop professional skills across ICT domains and disciplinary boundaries.

Within a curriculum, developing a skill across different domains and disciplines facilitates students developing habitual use of the skill resulting in a competent graduate who can adapt to any professional context faster (Falkner and Falkner 2012; Stevens and Norman 2016). While isolating the development of a professional skill to a single subject can make the skill appear irrelevant to other domains (Anewalt and Polack 2017), ensuring skill development is spread across ICT domains enables students to develop a sense for the relevance of the skill to professional practice and identify application similarities as well as apply the skill to previously unexplored tasks (WAC 2020; Falkner and Falkner 2012; Anderson 2013). Integrating the skill development across domain and discipline boundaries also makes the skill development the responsibility of the entire course staff membership (WAC 2020).

4.1.1 Case Study – Breadth

In the previous ICT curriculum students experienced limited written communication skill development. During the curriculum design process, industry members emphasised the importance of graduates having experience with industry standard models and templates, as well as improved communication skills (Herbert et al. 2014). Within the renewed curriculum, written communication activities have been integrated across a wide spread of domains, as illustrated in Figure 1 – some written communication activities that occur infrequently are not included, such as manuals, papers, research plans and wikis.

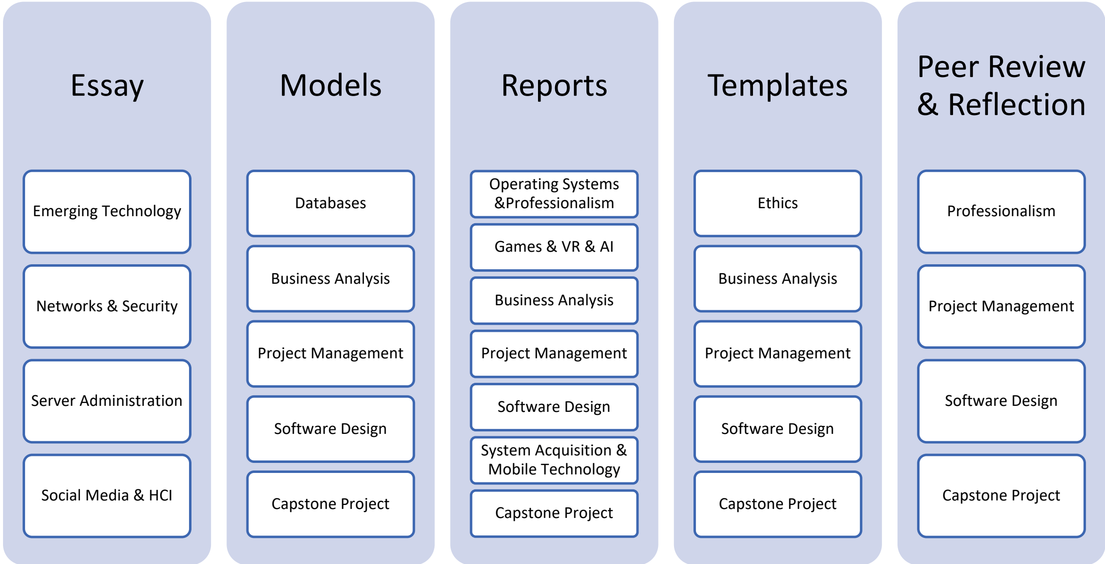

Figure 1: Written Communication Activities across the Integrated Curriculum

The longitudinal study concluded that students' written communication skills significantly improved. A t-test, Table 1, comparing the results for the final-year individual document with students who had attempted the first-year individual document (thus they had completed the entire integrated curriculum) indicates there is a statistically significant improvement in their individual written work. While improvement between first- and final-year would be expected, the same significant level was not achieved by those students who had not experienced the full three years of integrated curriculum (mainly due to transferring across with advanced standing from the previous curriculum).

	First-year 2014-2016			Final-year 2016-2018					
	N	Mean	sd	N	Mean	sd	t	df	p
Individual Document	183	68.5	11.9	173	74.7	8	5.729	320	<0.0001
Team Document	377	74.8	12.5	202	80.6	11.6	5.38	577	<0.0001
Presentation	338	65.5	15.9	34	74.7	9.1	5.14	56	<0.0001
Video	331	61.5	20.5	202	80.6	11.6	13.69	528	<0.0001

Table 1. T-Test Results from First-year and Final-year Integrated Curriculum Assessment Activities

	Capstone 2012-2014			Capstone 2016-2018					
	N	Mean	sd	N	Mean	sd	t	df	p
Risk Log	30	82.8	8.61	33	83.48	9.58	0.282	61	0.7783
Testing Report	30	74.03	13.78	33	80.58	10.87	2.102	61	0.0397
Design Report	30	74.2	10.9	35	76.1	8.1	0.818	63	0.4162
Manuals	30	73.4	7.2	35	80.4	10.8	3.11	59	0.0029
Presentation	16	76.8	14.9	25	85.6	8.8	2.119	21	0.0461
Video	30	78.4	9.3	35	73.8	8.5	2.094	63	0.04
Software	27	78.6	13.1	27	84.3	9.96	1.825	52	0.074

Table 2. T-Test Results from Previous and Integrated Curriculum Capstone Assessment Activities

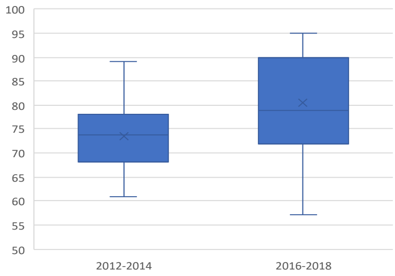

Figure 2: Capstone Experience Manual results

Another t-test, Table 2 and Figure 2, indicates a statistically significant improvement in the manuals produced in the capstone project by students who have completed the integrated curriculum when compared to the results for the manuals by the students who completed the previous curriculum. The results for manuals are noteworthy because the students have no specific prior practice with developing manuals in either curriculum, but they are now more proficient as a result of the breadth of experience and the opportunities to practice and develop written communication skills across different domains.

4.2 Principle 2 – Depth and Complexity

Principle 2: To ensure industry-ready competent graduates for a broad range of career outcomes, develop professional skills throughout the duration of study with increasingly complex activities.

Within a curriculum, for graduates to achieve competency at the desired industry standard the complexity of the activities needs to increase as a student progresses through the course, culminating in an opportunity to perform a complex activity within a (simulated) professional context (ACM 2020; Herbert et al. 2020a). A complex activity requires using a combination of different skills, both technical and professional, to complete a cognitively challenging task over multiple phases. The complexity of a task can be increased by varying the audience, the types of mediums and levels of interactivity (Falkner and Falkner 2012). The curriculum should have constructive alignment of the subject's intended learning outcomes (ILOs) with the course learning outcomes (CLOs) (Biggs 2014; Burge et al. 2012). This means the subject ILOs align to build toward the CLOs, which should reflect the desired competency standards for industry. Within the course hierarchy, each successive subject builds upon the knowledge and increases the complexity of the activities to further develop the skill – students shouldn't be expected to perform at professional standard the first chance they get to practice a skill. It is important to scaffold learning by providing a bridge with informal learning activities to allow practice of skills before being exposed to a professional context (Falkner and Falkner 2012; Hoffman et al. 2006).

4.2.1 Case Study – Depth

An issue with the previous curriculum was the first oral communication learning activity was a presentation to industry clients in the student's final-year capstone experience. In the renewed curriculum this was addressed by integrating the development of oral communication skills and creativity skills at all year levels. Learning activities were introduced throughout the curriculum that required presentations and pitches (both in front of class and via video) of innovative ideas for the application of technology, the complexity increased by varying the mediums and audiences. For example, in first-year, students deliver an individual 30-second elevator pitch to a tutorial class about an entrepreneurial idea to "Change the World" and then teams are formed around the best ideas to develop an entrepreneurial video to further pitch the idea to the lecturer (Herbert et al. 2020a). In their capstone experience, the students deliver a presentation and demonstrate the final software system to an assessment panel including the industry client and an external academic. Even though oral communication skills were only integrated across six core subjects at all year levels, the longitudinal study (Herbert et al. 2020b) provided evidence that a graduate's competency with oral communication has improved. There was significant improvement between the videos and the presentations, delivered in the students' first- and final-years as assessed by the same academic, Table 1. There was also significant improvement in the presentations assessed by the industry clients in the capstone experience, Table 2, between the previous and renewed curriculum, indicating that industry is perceiving an improvement in oral communication competency.

Within the integrated curriculum students have improved after the introduction of "writing to learn" activities and "writing in the discipline" (WAC 2020) activities as evidenced by the t-test results in Table 1. The outcomes of the analysis for the testing report and risk log illustrate the impact of providing a bridge with informal learning activities, both activities within the capstone experience. After "writing to learn" activities were introduced at first-year, a "writing in the discipline" activity was introduced into second-year requiring the completion of a testing report as part of an in-house project. The impact of this change was a significant improvement in the testing reports produced in the capstone experience compared to those produced in the previous curriculum, Table 2. To be able to confirm that this improvement was a result of this bridge, the results for the risk log can be considered. In the capstone project the teams prepare an extensive risk log that involves identifying comprehensive contingency plans. In both the previous and renewed curriculums, students were introduced to risk logs at second-year. As shown in Table 2, there is no significant improvement between the two curriculums for the risk logs, whereas there is the significant improvement for the testing report after introducing bridging testing reports at second-year.

4.2.2 Case Study – Complexity

An issue with the previous curriculum was there were no "writing to learn" activities, students were catapulted straight into "writing in the discipline" activities related to project management and software design in their second-year. An example of increased complexity with written communication is to consider the introduction of essays at each year level. The aim of an essay is to research an answer to a question with the author constructing their own substantiated opinions and arguments (Pollock 2001; Garvey 2010). The student's skills are developed by writing essays across different domains throughout the integrated curriculum. The complexity of the task is increased by requiring higher word counts which allow for more depth in the discussion and the opportunity to review and cite more sources and the inclusion of analysis using figures and tables by the final-year. As already discussed, the breadth of experience and depth of complexity has improved writing proficiency, see Table 2 – manuals, testing report, and technical competency hasn't deteriorated, see Table 2 – design report, and software.

An example of increasing the complexity using the level of interactivity and the type of interactivity is the development of oral communication and collaboration skills. As shown in Figure 3, groupwork in first-year involves a group of 3 students that interact with their peers and tutor, and the activities have short durations of a tutorial class or a small assignment over a week or two. In second-year, groups are increased to 4-5 students and the groups interact first with a lecturer and then with an industry member, typically by interviewing them in relation to a project conducted over 4-5 weeks. In their final-year, the learning experience culminates with teams of 6-8 students completing their capstone project; teams hold professional meetings with their industry client throughout the 26-week experience. While the industry clients have for a long time lauded the professionalism of the teams (Herbert 2018), in 2018 five teams received 100% for professionalism from their clients – the only other time this was achieved was for one team in 2016.

4.3 Principle 3 – Knowledge as well as skill development

Principle 3: To ensure industry-ready competent graduates for a broad range of career outcomes, provide knowledge of professional skills to help students understand the skill.

Within a curriculum to develop competency, it is not sufficient to have activities that require students to use a skill without providing the knowledge to help students understand the skill, including professional skills (Burge et al. 2012; Largent 2016). For example, if a network administrator role is identified as a career outcome of a course then it is necessary to teach students about network protocols. Likewise, if the identified career outcomes require graduates to be productive team members, such as project manager roles, it is necessary to provide knowledge of the principles and characteristics of good teamwork. Students should also have multiple opportunities to apply the knowledge and practice the skills and receive feedback to improve and gain confidence (Anewalt and Polack 2017). Students should be provided with both formative and summative feedback, with opportunities to revise work for resubmission, facilitating continuous improvement (Herbert 2018, Dugan and Polanski 2006).

4.3.1 Case Study – Knowledge

An issue with the previous curriculum was that students only experienced teamwork in two second-year subjects and the capstone experience, and knowledge was mostly acquired via the assessment tasks. Initially, within the renewed curriculum collaborative activities were introduced into most subjects, but student feedback during an internal review after two years indicated it was being overused. The better students were concerned that they were not given enough opportunity to show individual prowess, and that under-performing team members were damaging their grades. As a result, the team activities were restricted to nine subjects (students complete 24 subjects to graduate), and peer review and reflection was included in team assignments weighted above 15% of the overall subject assessment.

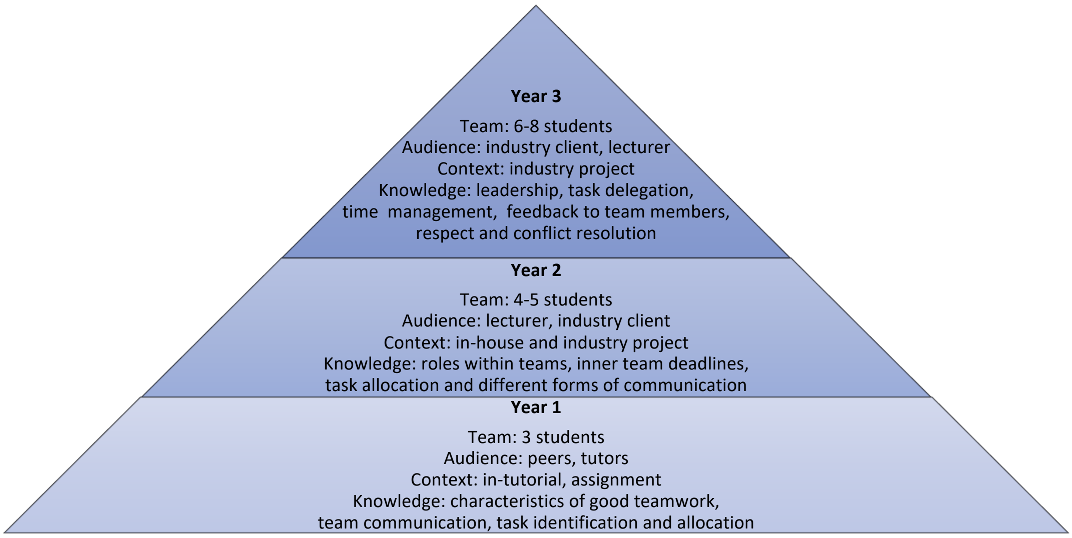

Figure 3: Collaboration Complexity throughout Integrated Curriculum

Introducing collaboration, like any professional skill, early into a curriculum can result in the students being more comfortable (Largent 2016). As shown in Figure 3, within the integrated curriculum knowledge of good teamwork practices are provided each year. The early experiences allowed students to practice their collaborative skills with opportunities to receive feedback to improve performance. In their final-year, the extensive quantitative and qualitative peer review provided formative feedback on an almost monthly basis. This allowed early identification of collaboration issues and opportunities to resolve the issues throughout the 26-week experience (Herbert 2018). Another feature of the capstone experience is that teams are given extensive formative feedback on all outputs by the lecturer, generally a week before they are due for submission, allowing opportunity to improve the outputs. Once an output is submitted, teams are again given formative feedback, and teams have an opportunity to resubmit the work and potentially gain a few more marks (though not full marks for a resubmission) (Herbert 2018). A t-test, Table 1, comparing the first-year team document results with the last team document results (the manuals), indicates there is a statistically significant improvement in their team written work and it has already been discussed how other team results (Table 2 – testing report, presentation) have significantly improved in the renewed curriculum in comparison to the previous curriculum.

4.4 Principle 4 – Authentic tasks

Principle 4: To ensure industry-ready competent graduates for a broad range of career outcomes, students should complete authentic activities that combine the use of professional and technical skills.

Within a curriculum to ensure a successful transition to industry, students should be required to complete complex and authentic domain-related activities that require the use of professional skills to be interweaved with the technical skills, just as they are in professional practice (Hoffman et al. 2014; Falkner and Falkner 2012; Frezza et al. 2018; Al-Mahmood and Gruba 2007). As noted by Falkner and Falkner (2012) linking professional skill activities with domain activities can provide motivation and improve engagement and promote active learning. By giving students learning activities with an authentic context demonstrates that professional skills are important to the industry (Dugan and Polanski 2006). Students will use their professional skills more effectively when they are given opportunities to practise them within authentic discipline contexts (WAC 2020).

4.4.1 Case Study – Authenticity

In the previous curriculum, the assessment tasks lacked authenticity until the final-year. Within the renewed curriculum, "to learn" activities were introduced to develop professional skills throughout first-year. For example, students were required to prepare reports, across a broad range of domains, that are supported by evidence and include recommendations for action. This allowed a greater number of authentic experiences to be introduced from second-year. For example, in second-year, teams now approach local businesses to discuss business processes and prepare a report on how ICT could be used to solve some of their business problems. This has resulted in improved outcomes in the capstone experience, as evidenced by the client assessment of team professionalism, presentations and software.

4.5 Principle 5 – Variability of tasks

Principle 5: To ensure industry-ready competent graduates for a broad range of career outcomes, provide experience with the wider applicability of professional skills.

Within a curriculum to improve the employability of graduates, not only should the application domains vary but also the types of tasks should reflect the different types of activities undertaken in the profession so that students gain experience with the wider applicability of a skill (Falkner and Falkner 2012). For example, instead of directing the students to write essays in every subject introduce a variety of written communication tasks such as reports, templates, wikis, and papers to achieve breadth of learning and also increase engagement (Gruba and Al-Mahmood 2004; Falkner and Falkner 2012). Additional activity types can be identified using taxonomies (Dugan and Polanski 2006; Hoffman et al. 2006; Fell et al. 1996; Pollock 2001) or through studies such as those detailed in section 2 to identify activity types.

4.5.1 Case Study – Variability

As shown in Figure 1, in the integrated curriculum the types of written communication activities varied across the curriculum and they could be categorised as reports, essays, templates, and models and a few other types. The variety even extended to the sub-category of an activity, for example, within reports there were game concepts, operating system recommendations, software designs, testing, business analyses, and responses to request for proposals. As already discussed, the analysis found the variety has resulted in a significant improvement in written communication skills.

As was discovered in the renewed curriculum, a lack of variety can lead to a lack of student engagement. In the capstone experience teams prepare a video that demonstrates their software. A t-test, Table 2, indicates a statistically significant decline for the videos produced in the integrated curriculum in comparison to the ones produced in the previous curriculum. This anomalous result, in comparison to the increases shown for other outputs, is possibly a consequence of having students produce videos in each year of the integrated curriculum, resulting in a lack of engagement due to lack of novelty (Herbert 2018). In the previous curriculum the students were very engaged in developing videos as they had not experienced them prior in the course and producing them involved new technology and tools.

5 Conclusion

The purpose of this paper was to address the research question: *How can an ICT curriculum effectively enhance professional skill development whilst maintaining technical skill competency to ensure industry-ready graduates?* This paper reflected on a case study ICT curriculum and discussed the results. Five design principles were developed over a significant period of curriculum development to assist curriculum designers with integrating professional skill development to ensure industry-ready competent graduates for professional practice in a broad range of career outcomes:

1. develop professional skills across ICT domains and disciplinary boundaries;
2. develop professional skills throughout the duration of study with increasingly complex activities;
3. provide knowledge of professional skills to help students understand the skill;
4. students should complete authentic activities that combine the use of professional and technical skills; and
5. provide experience with the wider applicability of professional skills.

These five principles can help ensure graduate proficiency with professional skills, which will improve the employability of the graduates and enable a successful transition to industry. The principles were examined within the context of a case study ICT curriculum, and to illustrate the efficacy of the principles the academic outcomes of graduates were examined. This integrated curriculum has demonstrated how activities that develop professional skills, that have previously been applied within a single subject by others, can be integrated across a curriculum to achieve professional competency. Evidence was provided that a curriculum-wide approach improves a graduate's competency with professional skills to industry standard without having a detrimental impact on their level of competency with ICT technical skills. A limitation of the analysis was that it only investigated employers' impressions of graduate competency with professional skills via feedback from industry clients in the capstone experience. This will be further explored in a future industry study that reflects on competency in graduate employees.

6 References

ACM. Association for Computing Machinery. 2020. Association for Computing Machinery Curricula Recommendations http://www.acm.org/education/curricula-recommendations. Accessed 3 August 2020.

Al-Mahmood R., and Gruba P. 2007. Approaches to the Implementation of Generic Graduate Attributes in Australian ICT Undergraduate Education, Computer Science Education, 17:3, 171-185

Anderson D. 2013. Overarching Goals, Values, and Assumptions of Integrated Curriculum Design, SCHOLE: A Journal of Leisure Studies and Recreation Education, 28:1, 1-10,

Anderson P., Heckman S., Vouk M., Wright D., Carter M., Burge J., and Gannod G. 2015. CS/SE instructors can improve student writing without reducing class time devoted to technical content: experimental results. In Proceedings of the 37th International Conference on Software Engineering - Volume 2, IEEE Press, Piscataway, NJ, USA, 455-464.

AIIA. 2017. Skills for Today. Jobs for Tomorrow https://www.aiia.com.au/__data /assets/pdf_file/0020/81074/JOBS-FOR-TOMORROW-FINAL.pdf

Anewalt K., and Polack J. A Curriculum Model Featuring Oral Communication Instruction and Practice, Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education, March 08-11, 2017, Seattle, Washington, USA

AWPA. 2013. Information and communications technology Workforce study. http://www.awpa.gov.au/publications/Documents/ICT-STUDY-FINAL-28-JUNE-2013.pdf. Accessed 3 Aug 2013

Bennett C., and Urness T. 2009. Using daily student presentations to address attitudes and communication skills in CS1. In Proceedings of the 40th ACM technical symposium on Computer science education. ACM, New York, NY, USA, 76-80.

Biggs J. 2014. Constructive alignment in university teaching. HERDSA Review of Higher Education, 1, 5-22.

Burge J., Anderson P., Gannod G., Carter M., and Vouk M. 2012. First Steps Toward Integrating Communication Instruction Throughout Computer Science and Software Engineering Curricula, Computers in Education Journal, April-June 2012

Burge J., Gannod G., Carter M., Howard A., Schultz B., Vouk M., Wright D., and Anderson P. 2014. Developing CS/SE students' communication abilities through a program-wide framework. In Proceedings of the 45th ACM technical symposium on Computer science education. ACM, New York, NY, USA, 579-584.

Coldwell-Neilson J. 2017. Assumed Digital Literacy Knowledge by Australian Universities: are students informed? Proceedings of the Nineteenth Australasian Computing Education Conference. ACM, New York, NY, USA, 75-80.

Coleman B., and Lang M. 2012. Collaboration across the curriculum: a disciplined approach to developing team skills. In Proceedings of the 43rd ACM technical symposium on Computer Science Education (SIGCSE '12). ACM, New York, NY, USA, 277-282.

Dankel D., and Ohlrich J. 2007. Students teaching students: incorporating presentations into a course. In Proceedings of the 38th SIGCSE technical symposium on Computer science education (SIGCSE '07). ACM, New York, NY, USA, 96-99.

Dugan R., and Polanski V. 2006. Writing for computer science: a taxonomy of writing tasks and general advice. J. Comput. Sci. Coll. 21, 6 (June 2006), 191-203.

Exter M., Caskurlu S., and Fernandez T. 2018. Comparing Computing Professionals' Perceptions of Importance of Skills and Knowledge on the Job and Coverage in Undergraduate Experiences. ACM Trans. Comput. Educ. 18, 4, Article 21 (November 2018), 29 pages.

Falkner K., and Falkner N. 2012. Integrating communication skills into the computer science curriculum. In Proceedings of the 43rd ACM technical symposium on Computer Science Education. ACM, New York, NY, USA.

Fell H., Proulx V., and Casey J. 1996. Writing across the computer science curriculum, Proceedings of the twenty-seventh SIGCSE technical symposium on Computer science education, p.204-209, February 15-17, 1996, Philadelphia, Pennsylvania, USA

Frezza S., Daniels M., Pears A., Cajander A., Kann V., Kapoor A., McDermott R., Peters A, Sabin M, and Wallace C. 2018. Modelling competencies for computing education beyond 2020: a research based approach to defining competencies in the computing disciplines. In Proceedings Companion of the 23rd Annual ACM Conference on Innovation and Technology in Computer Science Education (ITiCSE 2018 Companion). ACM, New York, NY, USA, 148-174.

Garvey A. 2010. Writing in an upper-level CS course. In Proceedings of the 41st ACM technical symposium on Computer science education (SIGCSE '10). ACM, New York, NY, USA, 209-213.

Gruba P., and Al-Mahmood R. 2004. Strategies for communication skills development. In Proceedings of the Sixth Australasian Conference on Computing Education. Raymond Lister and Alison Young (Eds.), Vol. 30. Australian Computer Society, Inc., Darlinghurst, Australia, 101-107.

Hamilton M., Carbone A., Gonsalvez C., and Jollands M. 2015. Breakfast with ICT Employers: What do they want to see in our Graduates? In Proceedings of the Seventeenth Australasian Computing Education Conference (ACE2015), Sydney, Australia. January 27- 30, 2015.

Herbert N., de Salas K., Lewis I., Dermoudy J., and Ellis L. 2014. ICT curriculum and course structure: the great balancing act. In Proceedings of the Sixteenth Australasian Computing Education Conference Volume 148, pp. 21-30. Australian Computer Society, Inc.

Herbert N. 2018. Reflections on 17 years of ICT Capstone Project Coordination: Effective Strategies for Managing Clients, Teams and Assessment, Proceedings of the 49th ACM Technical Symposium on Computer Science Education, February 21-24, 2018, Baltimore, Maryland, USA

Herbert N., Acuna T., de Salas K., and Wapstra E. 2020. A methodology to integrate professional skill development throughout an ICT curriculum, 25th Annual ACM Conference on Innovation and Technology in Computer Science Education Conference. ACM, New York, NY, USA.

Herbert N., Herbert D., Acuna T., de Salas K., and Wapstra E. 2020. Integrating the development of professional skills throughout an ICT curriculum improves a graduate's competency, 2020 International Conference on Computational Science and Computational Intelligence (CSCI), Las Vegas, NV, USA, 2020.

Hoffman M., Dansdill T., and Herscovici D. 2006. Bridging Writing to Learn to Writing in the Discipline in Computer Science Education. SIGCSE'06, (Houston, TX, March 1-5, 2006).

Hoffman M., Anderson P., and Gustafsson M. 2014. "Workplace scenarios to integrate communication skills and content: a case study", 45th ACM Technical Symposium on Computer science education, March

Largent D. 2016. Measuring and Understanding Team Development by Capturing Self-assessed Enthusiasm and Skill Levels. ACM Trans. Comput. Educ. 16, 2, Article 6, 27 pages.

Palmer S., Coldwell-Neilson J., and Campbell M. 2018. Occupational outcomes for Australian computing/information technology bachelor graduates and implications for the IT bachelor curriculum, Computer Science Education, 28:3, 280-299,

Pollock L. 2001. Integrating an intensive experience with communication skills development into a computer science course. In Proceedings of the thirty-second SIGCSE technical symposium on Computer Science Education (SIGCSE '01). ACM, New York, NY, USA, 287-291.

Stevens M., and Norman R. 2016. Industry expectations of soft skills in IT graduates: a regional survey, Australasian Computer Science Week Multiconference, February

The WAC Clearing House https://wac.colostate.edu, retrieved 3rd August 2020

Copyright – Revised paper only