Using Collaborative and Activity-Based Learning for engaging IT students

Completed Research Paper

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Abstract
Active and collaborative learning are becoming essential strategies to attract, engage and retain students. These methods have been adopted within the Science and Engineering Faculty of Queensland University of Technology for use in its Science, Information Technology and Engineering degrees. This paper describes the adoption and application of these techniques in a specific first year unit in a new Bachelor of Information Technology degree which has majors in Computer Science and Information Systems. The paper reports on the design, development and implementation of this foundation subject and discusses how it uses active and collaborative learning to teach design thinking through a series of design challenges, and how it uses critiquing and reflection to ensure that students become more aware of design and team processes.

Keywords
Design Thinking, Curriculum Development, First Year Experience

Introduction
Attracting, inspiring and retaining first year students of Information Technology is challenging for several reasons. Firstly, the students’ mode of engagement in first year is changing the way academics plan and deliver their material, with a shift from the ‘sage on the stage’ didactic approach, to more activity-based, collaborative learning, an approach proposed by Chickering and Gamson (1987). Secondly, many students are not well prepared for studies in Science, Engineering, Technology and Mathematics (the so-called STEM disciplines). The National Governor’s Association report (2011) identified a number of issues resulting in poor preparation of secondary students for college study in STEM courses. Universities have responded to these challenges by offering additional preparatory courses and increasing student support as well as changing their engagement strategies for first year students. The type and depth of activities used to stimulate engagement of first year students is different than before, even though the graduate outcomes at the end of the degree remain at the same. Student progression and retention is achieved through a range of appropriate support structures such as student success programs, as well as sequencing curriculum differently and covering the material differently. The third challenge is how to embed the enduring Computer Science and Information Systems concepts, knowledge and skills, while maintaining contact with a rapidly changing technology landscape and seeking to ‘future-proof’ the graduates by encouraging a life-long-learning orientation.

This paper shows how one university has addressed these issues, through a process of curriculum renewal, a focus on the first year experience, and embracing an activity based, collaborative learning approach. The paper first sets the context of curriculum reform and then focuses on the design of the first semester first year experience. It then describes and discusses one subject in depth, detailing its design and execution of activity-based, collaborative learning in purpose built collaborative learning spaces. It
shares student feedback of the pilot program of the previous year, and details changes made to the subject for this academic year. The paper then closes by summarizing the lessons learnt in planning, executing and assessing collaborative learning and makes recommendations for other institutions seeking to move in this direction.

**Background curriculum reform**

The Australian university context is rapidly changing, with mandated requirements for changes in university education brought about by the legislative requirements for university curriculum to conform to the Australian Quality Framework (AQF 2013). This framework sets the standards for all post-secondary education programs in the country, whether public or private. It structures awards on a 10 level continuum, where AQF Level 1 is a post-secondary certificate and AQF Level 10 is a doctorate. University awards are between levels 7 to level 10. Table 1 summarizes the key differences in these awards.

<table>
<thead>
<tr>
<th>Level</th>
<th>Level 6</th>
<th>Level 7</th>
<th>Level 8</th>
<th>Level 9</th>
<th>Level 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of award</td>
<td>Diploma</td>
<td>Bachelor Degree</td>
<td>Graduate Certificate/ Graduate Diploma/ Honors degree</td>
<td>Masters degree</td>
<td>Doctorate</td>
</tr>
<tr>
<td>Summary</td>
<td>Graduates at this level will have broad understanding and skills for para-professional or highly skilled work and/or are prepared for further learning.</td>
<td>Graduates at this level will have broad and coherent knowledge and skills for professional work and/or further learning.</td>
<td>Graduates at this level will have advanced knowledge and skills for professional/ highly skilled work and/or further learning.</td>
<td>Graduates at this level will have specialized knowledge and skills for research and/or professional practice and/or further learning.</td>
<td>Graduates at this level will have systematic and critical understanding of a complex field of learning and specialized research skills for the advancement of learning and/or professional practice.</td>
</tr>
</tbody>
</table>

Table 1 AQF Summary Requirements (Level 6 to 10) taken from AQF 2nd Edition (2013)

Descriptions of the knowledge, skills and application for an AQF7 bachelor degree are in table 2.

<table>
<thead>
<tr>
<th>AQF 7</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge</td>
<td>Graduates of a Bachelor Degree will have a broad and coherent body of knowledge, with depth in the underlying principles and concepts in one or more disciplines as a basis for independent lifelong learning.</td>
</tr>
<tr>
<td>Skills</td>
<td>Graduates at this level will have advanced cognitive, technical and communication skills to select and apply methods and technologies to: • Analyze critically, evaluate and transform information to complete a range of activities • Analyze, generate and transmit solutions to complex problems • Transmit knowledge, skills and ideas to others</td>
</tr>
<tr>
<td>Application</td>
<td>Graduates at this level will apply knowledge and skills to demonstrate autonomy, well-developed judgment, adaptability and responsibility as a practitioner or learner.</td>
</tr>
</tbody>
</table>

Table 2 AQF 7 Generic Requirements for a Bachelor Degree (AQF 2nd Edition, 2013 p. 48).

In addition, because the AQF award specifications are deliberately generic, the Australian Government Office of Learning and Teaching (OLT) appointed domain experts to establish discipline specific threshold
Developing an engaging IT degree suited to the 21st Century

A panel was established for the Engineering and ICT disciplines and these scholars communicated their findings in December 2010. See OLT 2010 for details. These discipline scholars identified five outcome areas that are summarized in Table 3.

<table>
<thead>
<tr>
<th>OLT AQF7 Outcome Areas</th>
<th>Rationale</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Needs, Contexts and Systems</td>
<td>Graduates must be able to recognize, understand and interpret socio-technical, economic and sustainability needs within the context of Engineering and ICT challenges. Systems thinking enables graduates to represent the individual components, interactions, risks and functionality of a complex system within its environment.</td>
<td>Identify, interpret and analyze stakeholder needs, establish priorities and the goals, constraints and uncertainties of the system (social, cultural, legislative, environmental, business etc.), using systems thinking, while recognizing ethical implications of professional practice.</td>
</tr>
<tr>
<td>Problem Solving and Design</td>
<td>Engineering and ICT practice focuses on problem-solving and design, whereby artifacts are conceived, created, modified, maintained and retired (lifecycle assessment). Graduates must have capabilities to apply theory and norms of practice to efficient, effective and sustainable problem solution.</td>
<td>Apply problem solving, design and decision-making methodologies to develop components, systems and/or processes to meet specified requirements, including innovative approaches to synthesize alternative solutions, concepts and procedures, while demonstrating information skills and research methods.</td>
</tr>
<tr>
<td>Application</td>
<td>Graduates must be able to model the structure and behavior of real or virtual systems, components and processes. Decision-making is informed by these processes of abstraction, modeling, simulation and visualization, underpinned by mathematics as well as basic and discipline sciences.</td>
<td>Apply abstraction, mathematics and discipline fundamentals to analysis, design and operation, using appropriate computer software, laboratory equipment and other devices, ensuring model applicability, accuracy and limitations</td>
</tr>
<tr>
<td>Communication &amp; Coordination</td>
<td>Engineering and ICT practice involves the coordination of a range of disciplinary and interdisciplinary activities and the exercise of effective communication to arrive at problem and design solutions usually in team contexts.</td>
<td>Communicate and coordinate proficiently by listening, speaking, reading and writing English for professional practice, working as an effective member or leader of diverse teams, using basic tools and practices of formal project management</td>
</tr>
<tr>
<td>Self Management</td>
<td>Graduates must have capabilities for self-organization, self-review, personal development and lifelong learning.</td>
<td>Manage own time and processes effectively by prioritizing competing demands to achieve personal and team goals, with regular review of personal performance as a primary means of managing continuing professional development.</td>
</tr>
</tbody>
</table>

Table 3 Office of Learning and Teaching

ICT Threshold Learning Outcomes Bachelor of IT (OLT 2010 p. 8).

Of particular interest is the requirement to include the following elements into an IT degree:

- Identify, interpret and analyze stakeholder needs.
- Apply problem solving, design and decision-making methodologies.
• Communicate and coordinate proficiently by listening, speaking, reading and writing English for professional practice, working as an effective member or leader of diverse teams, using basic tools and practices of formal project management.

• Manage own time and processes effectively by prioritizing competing demands to achieve personal and team goals, with regular review of personal performance as a primary means of managing continuing professional development.

Stakeholder needs identification required specific techniques to be taught. In addition, the requirement for the teaching (and assessment) of formal design methodologies was new to the formulation of an IT degree, used to teaching Systems Analysis and Design or Object Oriented Design.

The requirement to teach communication skills and teamwork is often assigned to business faculty subjects, but in the Australian context, IT degrees are often found within specific faculties of IT, as well as faculties of Science or Engineering. These skills were new components to address in the design of an IT degree, presenting new challenges in developing strategies and tactics to make these curriculum elements attractive, engaging and relevant to first year IT students.

**Curriculum development methodology**

The curriculum methodology and outcomes are briefly described in this section in order to provide an overview of the methodology used in designing and developing the new degree, as well as to provide the context for first year learning using collaborative and active learning approaches.

Two working groups were established to manage the curriculum development process: a leadership group and a development group. The Curriculum Leadership Group consisted of the heads of School (both Information Systems and Electrical Engineering & Computer Science, the IT Program Director and the Assistant Dean Learning and Teaching. Their task was to provide the overall degree vision, architecture and teaching approaches. One of the key challenges was to address a key requirement for an AQF 7 award: depth in the underlying principles and concepts in one or more disciplines as a basis for independent lifelong learning (AQF 2nd Edition, 2013 p. 48).

There was much discussion and debate about the meaning and definition of a discipline in IT. The ACM/IEEE discussion paper Computing Curricula 2005 Overview report informed this discussion and its visualizations were particularly useful when conceptualizing the focal areas for the new degree. The analysis of each variant (Computer Science, Information Systems, Information Technology, Software Engineering and Computer Engineering) along the dimensions of (theory, principles and innovation) versus (application, deployment and configuration) for each focal element (computer hardware & architecture, systems infrastructure, software methods and technologies, application technologies and organizational issues & information systems) informed the scoping exercise.

This issue was particularly relevant at this university, as it had just completed another restructuring resulting in the formation of a new faculty of Science and Engineering, with two separate IT schools: the Information Systems School and the Electrical Engineering & Computer Science School. This faculty taught engineering degrees as well as degrees in science, IT, urban development, mathematics and games.

The review of the literature and discussion of the variants of IT areas of study led the Curriculum Leadership Group to identify the primary majors in which depth would be pursued: Computer Science and Information Systems.

Senior academics from Computer Science and Information Systems were then involved in the development of degree learning outcomes relevant to an Information Technology Degree with primary majors in Computer Science and Information Systems. Further analysis was required to determine what content would be delivered. This content analysis was based on the informing ACM/IEEE Ironman draft CS degree and the ACM/AIS Model IS curriculum 2010, as well as relevant professional accreditation requirements (Australian Computer Society 2012). An iterative process was established to develop course outcomes meeting the AQF requirements, the OLT Discipline Scholars’ Threshold Learning Outcomes, the professional society accreditation outcomes and addressing ACM/IEEE/AIS model curricula. These workshops involved the discipline leaders, research leaders and senior academics from each school. The resultant degree course learning outcomes are shown in table 4.
Graduate Attributes

Needs, Contexts and Systems
1-1 Demonstrate depth of knowledge in a discipline area
1-2 Be aware of the relevance and impact of IT (individual, social, business, & environmental)
1-3 Identify, interpret, analyze and consolidate stakeholder needs
1-4 Apply systems thinking to establish priorities goals, constraints, uncertainties and interdependencies within a system
1-5 Collect, accurately record and manage data and information
1-6 Apply professional standards and ethics

Problem Solving and Design
2-1 Apply problem solving, design and decision-making methodologies
2-2 Apply critical, creative, and design thinking, to generate innovative solutions
2-3 Apply information retrieval skills and research methods appropriate to the discipline
2-4 Practice evidence based analysis and design

Abstraction and Modeling
3-1 Develop abstract representations of processes, data, systems, organization and information
3-2 Make appropriate conclusions based on data and models, recognizing limitations.
3-3 Select, deploy, integrate and critique appropriate modeling techniques
3-4 Use models to manage the complexity of real world systems

Coordination and Communication
4-1 Communicate effectively and professionally with peers, stakeholders, and the broader community
4-2 Effectively and persuasively communicate in multiple forms and media
4-3 Engage effectively as a member of multicultural and multidisciplinary teams
4-4 Demonstrate effective project management

Self Management
5-1 Demonstrate autonomy, collegiality and self-direction
5-2 Work efficiently, effectively, responsibly and safely
5-3 Reflect on personal performance & plan professional development
5-4 Demonstrate the ability to effectively work with others
5-5 Deliver project components on time and to the expected standard

Table 4 Degree (Course) Learning Outcomes

The development focus then turned to identify the units in the majors, the foundational units, the secondary majors and the supporting discipline minors. The majors were to address the essential requirements in knowledge, skill and application appropriate for that major. The minors were to provide extension studies supporting the research fields of the schools. These fields were Business Process Management, Information Ecology, Service Sciences, Intelligent Systems, Data Networks, and Human Computer Interaction. All units were to be developed using activity based and collaborative learning, where the student would develop an appropriate IT artifact related to that subject.

Key to student engagement and retention was the detailed design, development and implementation of the foundational subjects. This design was informed by the university principles of first year transition education, which is discussed next.

First year unit teaching approaches

The foundation year design process applied the first year experience principles of the university (QUT 2011). These six first year experience principles are shown in the following table.
<table>
<thead>
<tr>
<th>Element</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transition</td>
<td>Recognizes that first year students are in transition from their previous secondary school learning experiences to the expectations of learning in higher education.</td>
</tr>
<tr>
<td>Diversity</td>
<td>Recognizes that first year students are diverse in social, cultural and academic background, and thus have special learning needs.</td>
</tr>
<tr>
<td>Design</td>
<td>Recognizes that the curriculum design and delivery needs to be student focused, explicit and focused, yielding first year success. This requires additional scaffolding of the learning material, access to support services, and close interaction and support to the first year student.</td>
</tr>
<tr>
<td>Engagement</td>
<td>Recognizes that learning, teaching and assessment approaches need to be engaging, and enable active and collaborative learning, opportunities for peer learning and developing student-teacher interaction.</td>
</tr>
<tr>
<td>Assessment</td>
<td>Recognizes that the assessment needs to target first year target competencies, leaving the higher order elements to later in the curriculum and that early formative evaluation is required to help shape and condition the student towards success.</td>
</tr>
<tr>
<td>Evaluation and Monitoring</td>
<td>Recognizes that regular evaluation of the effectiveness of teaching, learning resources, assessment methods is essential for evidence-based curriculum design, and that regular monitoring of student engagement with the learning and assessment activities is essential for student success, with early intervention in at-risk students.</td>
</tr>
</tbody>
</table>

**Table 5 First year Curriculum Design Principles (QUT, 2011)**

These principles informed the design and development of the first year units, which then influenced the design and development of subsequent units in the program.

In first year, engagement was increased by artifact development appropriate in complexity for first year students to attempt. These artifacts include: designing mobile applications and games; building simple networks and devices using technologies such as Raspberry Pi; developing a range of programming and scripting skills on appropriate sized problem domains; developing an impact assessment of particular technologies on a specific industry and society. Careful attention was paid to the nature of the assessment, its frequency and scope, leading to a rationalized portfolio of assessment across first year. In addition, monitoring student engagement processes were refined, allowing specific student service staff to identify and intervene by direct student contact when required. The units have since been implemented using the evolving best practice principles of active learning in the collaborative learning spaces.

In particular, active learning was adopted in which students are no longer passive recipients of knowledge, but active in their own learning (Bonner 2011, 187). This was achieved through careful scripting of activity based learning elements for each workshop. Workshops were conducted in the newly completed collaborative learning spaces and activities involved students, in pairs or teams, working on a portion of the task required for artifact creation. In this way, the subject designers implemented the best practice guidelines of active and collaborative learning espoused by Bonner (2011, 187). These elements are expanded in the next section.

**Subject descriptions 2014**

Computer Science and Information Systems academic staff teach the foundation subjects. Students have delayed choice for their major, which commences in second semester of first year. In addition, there are core optional units that round out the second semester major, including the pair of the other major (CS students take IS, and conversely), the pair of Games degree foundational units (Games Production, Games Studies) and other foundational subjects relevant to both majors, such as Database, Social Technologies, or Mathematics.
This portfolio of foundational units, together with the major, provides the coverage of most elements in the ACM/AIS 2010 Model IS curriculum as well as the ACM/IEEE Ironman Draft 2013 Model CS curriculum. Table 6 summarizes the foundational units aims and the school in which they are taught: Electrical Engineering and Computer Science (EECS) or Information Systems (IS).

<table>
<thead>
<tr>
<th>School</th>
<th>Subject name</th>
<th>Aims</th>
</tr>
</thead>
<tbody>
<tr>
<td>EECS</td>
<td>Building IT systems</td>
<td>This unit gives students an opportunity to build several small IT applications in order to expose you to the basic features of IT system development. In doing so it also introduces you to several different kinds of computer languages.</td>
</tr>
<tr>
<td>IS</td>
<td>Impact of IT</td>
<td>This unit prepares students to identify, interrelate and quantify the impact IT services, products, systems and artifacts can have, using a variety of frameworks and theories (e.g. Technology-Acceptance Model, Active Theory, Locales Framework, business case models). The unit aims to develop skills and knowledge in relation to the impact of IT solutions in a variety of contexts such as corporate, government, leisure, educational and health environments. The focus will be on examining impact in terms of utility, effectiveness, engagement, ethics, cost and reach.</td>
</tr>
<tr>
<td>IS</td>
<td>Designing IT</td>
<td>This unit introduces students to design thinking as an approach to understand problems and develop practical, innovative and cost-effective IT solutions, putting the user at the center. It also develops their communication, teamwork, and self and peer review skills at a foundational level.</td>
</tr>
</tbody>
</table>

Table 6 First year unit aims

In Building IT Systems, a hands-on approach to learning is taken through an engaging laboratory program which provides students with the opportunity to carry out a number of practical, artifact-driven exercises aimed at building small IT systems. On the larger assignments students work in pairs and present the results of their work in a novice professional manner. There is a progressive range of simple to more complex tasks and its intent is to foster student ability to work on more complex tasks, and perform individually as well as work with their peers, applying the concepts taught in the first-semester Design unit. This pair approach to active and collaborative learning on meaningful tasks seeks to achieve the goals of active learning: intentional design, co-laboring and meaningful learning (Barkley, Cross and Major (2005, p.4) cited in Bonner (2011, p. 188)).

In Computer Technology Fundamentals, students are engaged in learning through an active, artifact-driven set of practical exercises. Each week includes a two-hour lecture and two hour practical class. Lectures motivate, introduce and roadmap computer technologies and associated concepts. Practical classes provide an interactive and participatory forum where students collaborate with peers and interact with a tutor. Practical classes use workbooks to guide student learning through exercises involving research and practical problem solving using different computer technologies. Students undertake a project that allows them to undertake a deeper study into a mix of computer technologies. Educational technologies, such as the Raspberry Pi computer, are used to support their understanding of computer technologies, system architecture and applications. Again, the teaching approaches emphasize active and collaborative learning based on artifact creation.

The Impact of IT subject uses a combination of lectures, readings, collaborative workshop activities and online learning modules to develop students’ knowledge and skills. Students are exposed to various case studies, existing frameworks, methods, tools and techniques. Students’ apply this knowledge and skills in teamwork exercises for a number of real-world and made-up scenarios allowing them to discuss, analyze and reflect on the diversity of often-conflicting impacts deriving from IT.
In Designing IT, weekly one-hour lectures and two-hour workshops are used. Learning is through participation in the workshops in the collaborative learning spaces. The workshops are activity based and involve collaboration with peers to explore design issues and user problems in a manner designed to develop skills in each phase of the design process, as well as in teamwork. The workshops build directly on the stimulus material presented in the lectures, which are designed to be interactive where appropriate. The lectures in the initial weeks lay the foundations of design thinking with later lectures extend knowledge through case based learning. Students be guided through each phase of the design process through real world team projects with a team presentations and exhibitions during the semester. In tandem with the design focus, students practice the techniques required to develop their communication, reflection and teamwork skills. This learning is facilitated by presentations of designs, keeping a reflective journal and undertaking a critique of another team’s design concept.

The assessments are described next to show the engagement of students through artifact creation.

In Building IT Systems, there are three forms of assessment in this unit, due throughout the semester. There are a series of weekly online quizzes that cumulatively review students understanding of the knowledge and skills. There are two workbooks in which students demonstrate their ability to solve non-trivial problems, with two practical assessments at the mid and end of semester periods. Finally, there is an end of semester exam covering all aspects of the subject.

In Computer Technology Fundamentals, there are two workbooks that are maintained and one project. The first workbook is about the low level technologies (dealing with the lower levels of the ISO stack). The second workbook is about the high level technologies (dealing with the higher levels of the ISO stack). The project comprises the design / construction / configuration of a small novel computer system using a mixture of computer technologies.

In Impact of IT, students produce three case studies highlighting the impact of IT, which are due at three intervals throughout the semester. Each case study examines a different impact topic (e.g., political impact) and a different domain (e.g., health). Each of the portfolio case studies includes research related to the topic, and theories and techniques applied to the topic. Students’ produce an impact assessment in the form of written text, diagrams, cost analyses, video, links to published resources / marketing material, interview transcripts, or technical analyses. The second assessment item evaluates the impact of an existing or new IT solution for all stakeholders in a selected domain, requiring the identification and application of a range of interrelated quantitative and qualitative methods, tools and techniques for evaluating various forms of impact. Trade-offs and assumptions for appropriate quantification need to be made clear. The final report summarizes the context of the assessment and identifies and deploys the most appropriate methods, tools and techniques for that problem.

In Designing IT, there are three assessment items. The first assessment runs the entire semester and involves three assessed design challenges: developing a new game; developing a mobile application for specific users and addressing specific problems; addressing a business or social using design thinking. Students also complete an online Reflective Design Journal in which they showcase their ideas, reflect on the application of the Design Thinking Process, and reflect on their effectiveness as a team member, as well as the effectiveness and behaviors of their team. In each design challenge, students form new teams. The final assessment item is a critique of the application of design thinking of another team, and a specific member of that observed team.

To emphasize the activity-learning and collaborative learning approaches taken in the foundational subjects, the Designing IT more fully discussed in the next section.

**Example unit: Designing IT and its evolution**

The unit Design IT was piloted in 2013 when it became apparent that new material on design methods, teamwork and communication (visual, oral, and written) needed to be included in the new degree.

Prior to this, the unit did not use collaborative learning spaces as few had been constructed at the university. Furthermore, students were not engaged in artifact creation; instead, students proposed artifacts that could change the world. Student engagement was not as high as desired and there was confusion about the relationship between this unit and the Impact of IT unit.
A different teaching team took the unit in semester 2, 2012 with a mandate to improve the unit and increase student engagement, but no artifacts were to be designed or developed. This constraint was removed for semester 1, 2013. In addition, the teaching team was trained in the use of collaborative learning spaces, which emphasized student interaction and engagement. Designing IT was piloted with students being taught about Design Thinking and its application in mobile application/mobile game development. The workshops were scripted, emphasizing activity-based and collaborative learning.

An example of a collaborative learning space is shown in Figure 1.

Figure 1 Exemplar Collaborative Learning Space

These rooms have between eight and nine desks, each with six chairs, a large computer screen and a computer with access to the Internet. Students are taught how to use Google docs®, Wordpress®, Blogger® or Tumblr® to interact with each other and share material. In the science degree, problems are team based, with a focus on information gathering, analysis, and presentation. In the Designing IT unit in the IT degree, the emphasis is on creativity, design thinking and artifact creation.

In 2013, the problem posed was to create a mobile application addressing a specific user group and addressing a gap in this user community’s experience. Students were taken through a phased approach to design thinking, developing increasingly refined prototypes (from low fidelity, through medium fidelity to high fidelity), through the interaction with representatives from that user community. In addition, a cycle of presentation, constructive criticism and refinement was used in three weekly cycles (ideation, refinement, presentation & critique). Teams were formed using a team formation algorithm, and team behavior was defined in the generation and adherence to a team compact. Student engagement and satisfaction increased, as demonstrated by a new student satisfaction measure administered both mid-semester and end of semester, increasing from 3.4 to 3.6.

The same process occurred in semester 2, 2013, with attention paid to the stabilization of the workshop material, the clearer articulation of the criteria used in assessment and the development of a better Blackboard presence. This led to increased student satisfaction of 3.9 (mid-semester) and 4.0 (end of semester. During 2013, Design IT was significantly modified for 2014 delivery, based on the curriculum renewal program and unit review process. Though student satisfaction was high in semester 2, 2013, student engagement dropped off in the latter weeks of the semester because most students had ‘solved the problem’ and were addressing assessment requirements in the other units. In addition, the Games students wanted more creative challenges, rather than technical challenges. These aspects led to the following changes of the unit:

- The establishment of three assessed design challenges: 1. Game evolution; 2. Mobile App/Mobile Game for a specific user community; 3. Application of Design Thinking to a business or social problem.
- The inclusion of a Reflective Design Journal showing the experimentation, revisions, user engagement components of the design thinking method.
• The inclusion of a critique of another team against the design thinking method elements, emphasizing the process over the product.

There were four design challenges undertaken in the workshops situated in the collaborative learning spaces.

Design Challenge 0 was the Marshmallow Challenge and held in the first workshop, week 1 of the semester. The purpose of this design challenge is to get students to relax and introduce themselves and to introduce the basic concepts of design thinking in a fun way without assessment. The students, in an ad hoc team, seek to design and build the tallest structure using spaghetti that can support a marshmallow at the top. The only items in their design kit are 20 pieces of spaghetti, 1 yard of string, one yard of masking tap and one marshmallow. See the Marshmallow Challenge by Ted Wujec 2010 for details.

Design Challenge 1 commenced in week 2 of the 13-week semester. New teams were formed with six people per team, using an ad hoc team formation process. Their design challenge was to develop a new story for a popular game (Angry Birds) and design two new characters. In addition, there was a physical design challenge in which the team has to develop an apparatus to transport a ball (either a ping-pong ball or a squash ball) across a gap (minimum gap of 8 inches) where the ball had to knock over an object (paper coffee cup) on the other side of the air-gap. The final apparatus had to be strong, elegant, and accurate and had to be integrated with their story. Students had four week to complete this design challenge. This challenge was specifically to appeal to the enrolled Games and Interactive Entertainment students.

For Design Challenge 2 (DC2), new teams were formed using Jensen et al team formation algorithm (2000, 2003). In this design challenge, students applied design thinking to develop a new Mobile Application for a specific user group, addressing a defined gap in the user experience. Students had to define the problem being addressed, identify the gap in the user experience, clearly define the user community being targeted, undertake a competitor analysis and interview members of the user community who had used an interactive prototype of the mobile application. There were five informing lectures preceding this design challenge's workshops. This lecture sequence followed the design thinking method (Stanford 2009): 1. Empathizing & Problem Definition; 2. Ideation; 3. Prototyping; 4. Testing; and 5. Tools. The students applied that particular technique during the related workshop. There were two desk critiques where the student team presents interim ideas and prototypes to the workshop leader (week 1 and 3 of DC2) and two class presentations, where the student team presents their evolving designs to the class (week 2 and 5 of DC2).

In the final Design Challenge 3, students applied design thinking to a business or social problem. The business problems for semester 1 were: improving Orientation Week (for first entrants to university); improving the uptake and use of City Cycles (a community cycle rental scheme supported by the city council). The social problems were: using community agricultural plots to increase sustainable production; using community agricultural plots to increase social cohesion. This design challenge was also informed by preceding lectures on design led innovation and a series of case studies showing the application of design thinking and design led innovation to business and social problems.

Through the workshops and the mandatory team meetings, students shared their ideas, selected and evolved better ideas, discussed the users and the problems faced by the users as they sought to develop innovative solutions in each of the design challenges. This approach realized Chickering and Ehrmann’s observation (cited by Bonner, 2011, p. 188) that active learning should involve sharing one’s ideas and responding to other’s reactions. This was achieved as students presented their interim solutions to the class in order to obtain useful feedback used to improve their solutions. Students were told that they were not in competition with one another and that they all needed to be critical friends, stating what they liked about the ideas, and suggesting improvements or radically new ideas to consider in the design. All design challenges ended with a summative assessment presentation to the class, using a highly formatted rubric.

This discussion has shown how active and collaborative learning has been implemented through a series of design challenges, integrated with informing lectures and assessed through the use of appropriate rubrics. Enrolment patterns and student satisfaction for this foundational unit over the last five semesters are shown in table 7 and demonstrate increased student satisfaction when Design Thinking was introduced.
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<table>
<thead>
<tr>
<th>Semester and Subject Name</th>
<th>Number of students</th>
<th>Satisfaction rating (5 point scale)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2012 Industry Insight</td>
<td>474</td>
<td>3.0</td>
</tr>
<tr>
<td>2, 2012 Industry Insight</td>
<td>188</td>
<td>3.4</td>
</tr>
<tr>
<td>1, 2013 Industry Insight</td>
<td>428</td>
<td>3.7 (mid semester check)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.6 (end semester)</td>
</tr>
<tr>
<td>2, 2013 Design Thinking Pilot</td>
<td>178</td>
<td>3.9 (mid semester check)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.0 (end semester)</td>
</tr>
<tr>
<td>1, 2014 Designing IT</td>
<td>445</td>
<td>3.8 (mid semester check)</td>
</tr>
</tbody>
</table>

Table 7 Design IT (and predecessors) with reduced Semester 2 intake

Student engagement in foundation subjects 2014

The enrolment patterns for the foundation units are shown in table 8.

<table>
<thead>
<tr>
<th>Type of degree</th>
<th>Computer Technology Fundamentals</th>
<th>Building IT Systems</th>
<th>Impact of IT</th>
<th>Designing IT</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT Single degree</td>
<td>226</td>
<td>214</td>
<td>227</td>
<td>233</td>
</tr>
<tr>
<td>IT degree + another degree</td>
<td>166</td>
<td>107</td>
<td>212</td>
<td>76</td>
</tr>
<tr>
<td>IT degree enrolments</td>
<td>392</td>
<td>321</td>
<td>439</td>
<td>233</td>
</tr>
<tr>
<td>Games Single degree</td>
<td>4</td>
<td>112</td>
<td>137</td>
<td>122</td>
</tr>
<tr>
<td>Games degree + another degree</td>
<td>-</td>
<td>3</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Games degree enrolments</td>
<td>4</td>
<td>115</td>
<td>146</td>
<td>123</td>
</tr>
<tr>
<td>Non-IT degree</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other degree enrolments</td>
<td>11</td>
<td>15</td>
<td>21</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>407</td>
<td>451</td>
<td>606</td>
<td>445</td>
</tr>
</tbody>
</table>

Table 8 Degree enrolment patterns first year units

For Impact of IT, there are over 600 students because this is a second year subject in many of the double degrees. It is pleasing to note the attraction of students from other degrees to this subject. Enrolment into the IT degree and its double degrees has remained steady, even though the academic level for entry has increased. Games degree enrolments and its double degrees have dropped, given the recent collapse of the games industry and the increasing of the academic level required for entry. The overall enrolment pattern is shown in table 9, along with results of a mid-semester student satisfaction survey.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Number of students</th>
<th>Provision of learning opportunities</th>
<th>I took advantage to learn</th>
<th>I am satisfied with the unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building IT Systems</td>
<td>451</td>
<td>4.1</td>
<td>4.1</td>
<td>4.3</td>
</tr>
<tr>
<td>Computer Technology Fundamentals</td>
<td>407</td>
<td>3.7</td>
<td>3.6</td>
<td>3.5</td>
</tr>
<tr>
<td>Impact of IT</td>
<td>606</td>
<td>4.0</td>
<td>3.8</td>
<td>3.9</td>
</tr>
<tr>
<td>Designing IT</td>
<td>445</td>
<td>4.0</td>
<td>4.0</td>
<td>3.8</td>
</tr>
</tbody>
</table>

Table 9 First year subject enrolments and student engagement survey results

Attrition levels are well below the university average, with these units averaging 4% attrition, compared to the national attrition rate between 14.5% to 18% (De Carvalho, 2012, p.9).

Discussion

First year engagement with the curriculum and a focus on retention drove the detailed design of the foundational units in the new IT degree. The principles of first year curriculum design, development and
delivery were applied, with particular attention to ensuring that students were ‘doing IT’ through the creation of appropriate artifacts, where complexity was appropriate to year level. To support artifact creation, new active learning workshops were developed and situated in the new collaborative learning spaces. This required staff training and particular attention to design the workshop structure and activities around student interaction, communication, co-laboring and doing meaningful tasks supporting learning. Particularly in the subject Designing IT, active and collaborative learning was sought that developed design thinking knowledge and skills, teamwork knowledge and skills and presentation skills. These elements were achieved through a series of design challenges that appealed to first year students of IT and Games and Interactive Entertainment. The scripting of the workshop activities provided clarity to the student and to the teaching staff, but the attainment of the curriculum depended on effective training of the teaching staff, as most learning was taking place in the workshops. This required greater attention to the relationship of the lecture material to the execution of the theory in the workshop. Greater attention to the integration of theory to practice is also required as well as ensuring that all teaching staff have a shared understanding of the structure and purpose of each workshop activity, as well as a shared understanding of the intent for each design challenge. Student feedback has shown increased engagement with the material, and there is less subject attrition than previously experienced.

Conclusion and recommendations

This paper described and discussed curriculum innovation for foundation subjects underpinning a new Bachelor of Information Technology with two majors: Computer Science and Information Systems. These foundation units also underpin the Bachelor of Games & Interactive Entertainment degree. The focus was on student engagement through activity-based learning focused on artifact creation and the use of collaborative learning techniques using purpose built collaborative learning spaces. The evolution of one foundation subject (Designing IT) was discussed, demonstrating the impact of the teaching approaches and the focus on artifact creation. The lessons learnt in planning, executing and assessing collaborative learning include the need to fully script the activity learning program for each workshop; to fully develop the assessment items stating clearly the process focus, rather than the product focus; to fully develop appropriate criteria in student-friendly forms which can be used by the students while preparing for assessment, and by all teaching team members for in their evaluative processes. Success for these units depended upon the availability of purpose-built collaborative learning spaces that encouraged movement, interaction and teamwork. It is highly recommended that institutions invest in this infrastructure. In addition, it was essential for the teaching team to be trained in the use of such an environment, as this space impacts and influences the workshop and assessment design. Again, other institutions should consider implementing such training programs. These elements were shown to positively impact student satisfaction of the subject, as well as student engagement with the subject material.

Acknowledgements

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