Final Report 2011

IS-IT learning? Online interdisciplinary scenario-inquiry tasks for active learning in large, first year STEM courses

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The Australian Learning and Teaching Council is an initiative of the Australian Government Department of Education, Employment and Workplace Relations.

Support for this project has been provided by the Australian Learning and Teaching Council Ltd., an initiative of the Australian Government Department of Education, Employment and Workplace Relations. The views expressed in this report do not necessarily reflect the views of the Australian Learning and Teaching Council or the Australian Government.

2011

ISBN

978-0-642-78119-2 [PRINT]
978-0-642-78120-8 [PDF]
978-0-642-78121-5 [RTF]

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Executive Summary

Large-enrolment first-year STEM courses present a significant challenge to academics in terms of catering for student diversity in academic ability, career aspiration, and prior experiences. These issues can be addressed through the introduction of collaborative group work based on clear pedagogical principles. However, the scale of class sizes and task management presents a significant barrier to implementation.

In this project we have developed a new approach to collaborative inquiry learning through the design and implementation of interdisciplinary scenario inquiry tasks. The instructional design has drawn on literature and current pedagogical practices relating to the integration of collaborative and active learning strategies to foster communities of learners. Facilitation and assessment of these tasks in large-enrolment courses is too complex and time-consuming for a single academic course coordinator to manage manually; hence, **i**nteractive **C**ollaborative **A**ssessment **S**ystem (iCAS – a new web-based task-management system) has been developed to achieve these processes. iCAS facilitates flexible group formation enabling promotion of student investment in both the process and outcomes of the task. Interdependency within groups has been generated by combining an individual research quest, which requires students to generate information files, with a collaborative challenge which relies on integration of all the individual sets of information to generate a collective product.

The key findings in this project are:

- Collaborative small-group work can be implemented in very large STEM courses to address issues of student engagement and diversity.
- Engagement is enhanced when students are able to self-select into contexts and group membership; this increases investment in learning outcomes.
- These tasks require a task-management technology to enable academics to facilitate and assess collaborative tasks effectively.
- Technology-enhanced learning is most effective when the facilitation team includes the course coordinator, IT support and teaching assistants.
- Regardless of how streamlined the system is, engaging students in inquiry-based methods is time-consuming; work-allocation and rewards systems need to take this time into account.

The project has produced the following resources:

- Evaluation questions of learning environment, process and outcomes for Interdisciplinary Scenarios-Inquiry Tasks (IS-ITs)
- iCAS (alpha and beta versions) are freely available for other institutions to manage collaborative group work and peer assessment tasks.
- 27 contemporary scenarios that can be adopted or adapted for any problem-solving or inquiry-based learning activity.
- An evaluation framework to analyse collective writing products and explore the learning outcomes from collaborative active learning tasks.
- Guidelines to change the way large courses are presented in institutions.
- A template for implementing interdisciplinary collaborative active learning tasks in a STEM course.

1. Project Background & Aims

1.1. Background

In Australia, the massification of higher education (441,074 students in 1989; 634,094 students in 1996; 978,000 students in 2006) and the blow-out in student-to-staff ratios [13:1 in 1989 to 20:1 in 2006 at The University of Queensland (UQ)] has dramatically changed the educational landscape in universities. Students are challenged as their learning experiences are often characterised by large lecture classes (with course enrolments as large as 1500 at UQ). The transition from a secondary-school context involves students needing to cope with more difficult concepts and a range of teaching methods that also may not be ideally suited to their learning styles (Krause, 2005). Teaching staff and institutions are challenged, as there are insufficient resources available to recognise and value the incredible diversity of students' backgrounds, level of knowledge and career aspirations. There are many obstacles facing students in their transition to higher education and the high levels of student attrition during and following first-year indicate that more is needed to ease new students into the university environment (Krause, 2005; Tinto, 1993). Thus, addressing student transition in the first-year curriculum is crucial (Kift, 2005), and the "first-year experience" in Science, Technology, Engineering and Mathematics (STEM) disciplines warrants particular attention (as explained below).

STEM education is one of the highest profile concerns in contemporary education (Lyons, 2006; Rennie et al., 2001; Tytler, 2007), particularly at the transition into tertiary environments (Seymour & Hewitt, 1997). Given that the STEM areas will make a major contribution to solving the most pressing problems facing the world today, there is a risk that failures in STEM education will have a substantial long-term negative impact on society and our overall quality of life (NSF, 2007; STEM, 2007). Individuals, educational bodies and governments have all recognised the immediacy of the problem. At the national level, the Federal Government has announced a range of policies to encourage students to study the STEM disciplines, including increased cluster funding to these disciplines. Furthermore, the ALTC has supported a number of projects in STEM-related areas (Adams, 2008; Adams & Poronnik, 2006; Broadbridge & Henderson, 2008; Kavanagh, 2007; Kift, 2006; MacGillivray, 2008). State governments are also supporting work in this area; for example, the Queensland Government is developing a ten-year plan to support curriculum reform in an attempt to address this situation.

Large (>1000) first-year classes pose a challenge to instructors who aim to enhance learning in cohorts where diversity in learner's abilities, interests and backgrounds is a common occurrence. In order to overcome this diversity many instructors have introduced collaborative learning tasks. The introduction of such tasks is based on literature which recommends reform in course design using high-impact learning practices to enhance engagement (Kuh, 2003) and the promotion of active learning (Prince & Felder, 2006). Collaborative learning environments offer the opportunity for students to develop shared understanding of concepts (Kagan, 1992; Johnson et al., 1998; Smith et al., 2005; van den Bossche et al., 2006).

1.2. Project Team

The leadership team and project manager, together with available team members, met fortnightly in Year 1 and monthly in Year 2 for planning and monitoring. Two additional teams were formed and met as required in different phases of the project.

Project team:

Professor Lawrence Gahan (School of Chemistry & Molecular Biosciences, UQ)
Dr Gwen Lawrie (School of Chemistry & Molecular Biosciences, UQ)
Kelly Matthews (Teaching & Educational Development Institute, UQ)
Professor Peter Adams (Faculty of Science and School of Maths & Physics, UQ)
Professor Phillip Long (Centre for Educational Innovation in Technology, UQ)
Associate Professor Lydia Kavanagh (Faculty of Engineering, Architecture and Information Technology, UQ)
Professor Gabriela Weaver (Discovery Learning Centre, Purdue University)

Project Manager: Dr Rodney Cusack

Project IS-IT Facilitator and Evaluation Officer: Chantal Bailey

iCAS Development Team (Centre for Biological Innovation in Technology):

Director: Matthew Taylor
Programmers: Michael Rickerby, Enrique Marastoni, Bahareh Razdah

Scenario WritingTeam:

James Haycock (Biochemistry)
Bronwyn Bevan-Smith (Biomedical Sciences)
Marty Gellendar (Physical Sciences)
Chandhi Goonasekera (Biomaterials)
Oscar Haigh (Biology)
Julie Murison (Chemistry)
Cristy & Garry Warrender (Chemistry & Environmental Sciences)

Project External Evaluator:

Professor Carmel McNaught, The Chinese University of Hong Kong

1.3. Project Reference Group

A Reference Group was also invited to be available to the project. The reference group comprised Australian academics who are recognised leaders in science and engineering education in Australia. Feedback was sought from the panel in relation to the formulation of the 1st tier of Interdisciplinary Scenarios-Inquiry Tasks (IS-ITs) scenarios. These academics have been invited to participate in a 1-day workshop in July 2011 with a view to translation of the IS-ITs to other institutions.

Reference group membership:

Professor Ross Barnard (Biotechnology, The University of Queensland)
Professor Bernie Degnan (Biology, The University of Queensland)
Associate Professor Roger Hadgraft (Engineering, The University of Melbourne)
Dr Todd Houston (Chemistry, Griffith University)
Dr Siegbert Schmid (Chemistry, The University of Sydney)
Associate Professor Roy Tasker (Chemistry, University of Western Sydney)
Professor Peter Tregloan (Chemistry & ICT, UQ & The University of Melbourne)
Associate Professor Mauro Mocerino (Chemistry, Curtin University)

1.4. Project Aims

Our broad objective in this project was to develop a model for promoting strategic change in higher-education institutions for the enhancement of student learning in STEM. This project is innovative, tackling emerging issues in STEM education and the first-year student experience, while having the potential to advance student outcomes in large-enrolment courses through the use of enabling technologies to facilitate deeper learning. Additionally, through a course curriculum designed around active learning principles, the needs of diverse student cohorts that are transitioning to a new learning environment will be better addressed. Thus specific aims of the project were:

- to promote active learning in first-year STEM disciplines and ease student transitions
- to provide learning experiences which are interactive, interdisciplinary, contemporary and challenging
- to enable students to develop metacognitive skills that foster deep thinking
- to enhance student engagement and learning outcomes in the context of large first-year classes.

2. Theoretical Framework

Efforts to increase student engagement in the STEM disciplines have seen educators incorporate interdisciplinary contemporary contexts and scenarios within their instructional design. Current science research is rarely based in a single pure discipline and researchers must acquire and integrate cross-disciplinary knowledge to solve research problems. This reflects the demands on professional scientists and engineers who work in environments where they are required to recognise underlying concepts in complex situations and establish interdisciplinary connections. On these grounds, it is easy to justify the introduction of activities that encourage students to become interdisciplinary thinkers in their first year of study in the tertiary environment (Ares, 2004). Small-group collaborative learning is a well-established pedagogical strategy based on social interdependence theory (Johnson & Johnson, 2009) whereby students mutually construct knowledge and share understanding. There has been widespread and increasing implementation of active learning environments based on cooperative and collaborative learning (Prince & Felder, 2006; Smith, 2009). Indeed, creating situations where students constructively engage with each other's ideas enhances the depth of student thinking (Osbourne, 2010).

Central to this project is the concept of students as individual learners who bring prior knowledge, experiences and assumptions to the university academic environment. Learning is a process of constructing and reconstructing understanding about phenomena through active attempts by individuals to make sense of their own experiences (Perkins, 1999). While students are individual learners, interaction amongst them can facilitate the construction of new knowledge, new meaning, and new processes for learning. This is the central tenet of social constructivism (Vygotsky, 1962) and is a foundation of this project, while Biggs' constructive alignment (Biggs, 1999) represents the framework. Recognising the increasing diversity of students entering higher education, a carefully constructed framework of instruction, learning activities and assessment should maximise learning outcomes. The proposed implementation of IS-ITs sits at the nexus of a model for active learning. When integrated within an educational framework in first-year STEM courses, this approach provides a route to meet the diversity in needs and experiences of our learners, while easing their transition into the tertiary learning environment.

2.1. Application of literature to inform instructional design

Large first-year cohorts offer multiple challenges in the provision of effective teaching and learning opportunities. The diversity of student interests, academic ability and programs requires a tactical combination of teaching strategies. The delivery of STEM courses is often content-driven, with summative exams leading to students adopting a surface approach to learning (Biggs, 1999). A goal of this project is to enable students to develop metacognitive skills that foster deep approches to learning (McWilliam et al., 2008), while being engaged in a task that challenges, motivates and promotes independent learning. This is best achieved by designing an active learning experience that addresses the diverse needs of the cohort and engages them in the science learning cycle (Biggs & Moore, 1993; Wilson, Smith & Colby, 2007). The instructional design has drawn on literature across a number of current pedagogical strategies relating to the integration of collaborative and active learning strategies to enhance the formation of communities of learners.

2.1.1 Addressing student diversity

Students enrolled in large (>1000) first-year courses encompass a wide range of academic, social and individual needs. Easing the transition of new students to the university learning environment is crucial and to increase the likelihood of their success, students must adjust to the social and academic culture within the institution. Creating communities of learners engaged in a similar problem fosters peer learning and the formation of social connections. This supports students of differing academic abilities, as well as students with English as a second language (ESL) in their learning. (Smith et al., 2005; Topping 2005; Case et al., 2007).

2.1.2 Engagement

Framing the problems in contexts that integrate multiple STEM disciplines with the relevant enabling science(s) as the common denominator increases the relevance and motivation for students, enhancing engagement. Applying inductive strategies (PBL, discovery, inquiry, or projects) enables students to experience learning gains through information processing, critical thinking, problem solving, teamwork, communication, management, and synthesis of ideas. (Prince & Felder, 2007; Barak & Dory, 2004; Shute 2008).

2.1.3 Self-directed learning

Online learning, when blended with classroom collaborative learning activities, offers greater opportunities for engagement of a cohort of students who are frequently regarded as ‘digital natives’ (Kennedy et al., 2009). This approach can enable independent learners to demonstrate deep approaches to learning instead of surface approaches to learning by promoting reflection, analysis and synthesis. Multiple technologies have been developed to facilitate inductive learning and scaffold deep thinking. (Barak & Dory, 2004; Graesser et al., 2005; Mimirinis & Bhattacharya, 2007).

3. Methodology & Approach

IS-ITs, or **I**nterdisciplinary **S**cenario-**I**nquiry **T**asks are collaborative active learning tasks set in interdisciplinary contexts designed for very large classes. Manual facilitation and assessment of these tasks was perceived as too logistically complex and time-consuming for a single academic; hence, a new web-based task-management system, iCAS (interactive Collaborative Assessment System) was developed to achieve these processes. The transition to a computer-mediated assessment of learning is an approach shown to support the engagement of students in large classes in active learning environments (Kelly et al., 2010). The project was structured with two facets:

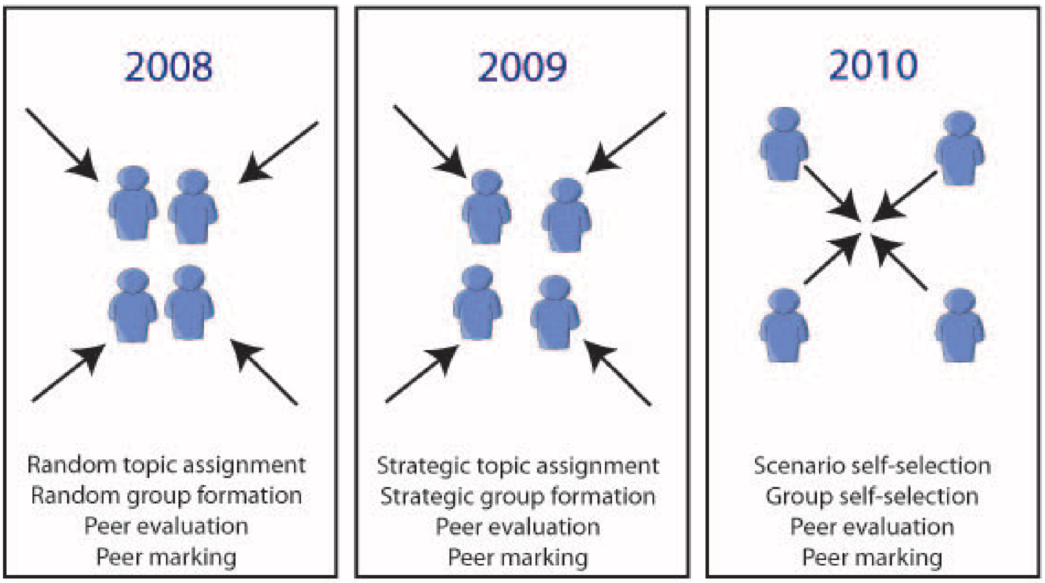
- instructional design and associated student learning outcomes
- task-management technology development and its impact on student learning processes.

3.1. Learning Environment

3.1.1 Instructional Design – IS-ITs

This was an **action research** project with the research team involved in both the administration (coordination) of the courses and as members of the teaching teams. Each implementation of the task informed the instructional design of the next iteration over multiple semesters. This cycle evolved the original unstructured collaborative task (semester 1, 2008) into the formulation and delivery of the IS-ITs that represent the final product of this project (Figure 1).

Figure 1: Evolution of a group task into an IS-IT



Iteration 1 (2008): The context was a first-year Chemistry course containing 1100 students enrolled in up to 40 separate programs. The major programs represented promote a professional career identity, *viz* science, medicine, pharmacy, biomedical science, engineering, biotechnology. A collaborative learning activity was designed to involve students in collaborative groups where they could engage in discourse and identify the chemistry concepts underpinning their assigned topic. The task management included random assignment of students into groups of four by the course coordinator. Research topics were also randomly assigned and students were required to submit a product which was a collective PowerPoint. There was little scaffolding in terms of how to approach the task or in group work. This task generated negative feedback through the institutional course evaluations in regard to both student satisfaction and their perceived learning gains as a result of the task. This iteration preceded this ALTC project and catalysed the current study.

Iteration 2 (Semester 2, 2009): As a result of student feedback, more attention was paid to group formation based on sound pedagogical theory (Kagan, 1992; Johnson et al., 1998). In a very large enrolment general chemistry course, the students were clustered by their program so that they were working with peers with common career aspirations and they were assigned chemistry topics relevant to these programs. Heterogeneous groups of four were assembled based on: mixed academic ability (Felder & Brent, 2001; Kriflik & Mullin, 2007), gender dispersed to minimise the number of same gender groups, and distribution of international students to address hurdles related to English being a second language and to improve their integration into a new environment (Kavanagh & Crosthwaite, 2007). Significant scaffolding was implemented to shift student perceptions of the assessment in relation to learning outcomes (shifting from conceptual gains to teamwork and creativity). Resources were also provided to help students work effectively in groups and address interpersonal issues if they arose. Overall, evidence was found that strategic group formation had a positive impact on student attitudes and learning outcomes and important insights were gained into student perceptions of the factors that influenced their learning gains. The data revealed that a criteria-based approach to group formation, as opposed to a random approach to assignment to groups, had more of an impact on student learning outcomes from collaborative assessment tasks than it did on student attitudes towards working in groups for the same tasks. Student attitudes and perceptions supported published reports that socio-cultural factors strongly influence their learning gains in collaborative work.

Iterations 3 & 4 (Semesters 1 & 2, 2010): Effective group formation is not simply deliberate dispersal of students amongst groups. The balance between social and cognitive factors has emerged as important from the last iteration and, in the 2010 iterations of the collaborative task, students were provided with the option to select both their group members and the topic that they researched. There is strong evidence that effective collaboration promotes mutual knowledge construction through shared discourse resulting in increased performance (van den Bossche et al., 2006). Also, recognition of collaborative learning environments as social constructs where the group function depends on interpersonal relationships and individual values (van den Bossche et al., 2006; Gillespie et al., 2006) is important. The effectiveness of a group is not guaranteed by simply putting people together and, with this recognition, principles for successful group practices (Felder & Brent, 2001; Smith et al., 2005) were adopted.

Iteration 5 (Semester 1 2011): The optimised versions of the IS-ITs and related task management processes have been implemented in the context of a chemistry course delivered to a homogenous cohort of first-year engineering students. An additional modification was the requirement for groups to submit their draft reports to Turnitin for academic integrity.

3.1.2 Five Guiding Principles of Cooperative Learning:

- Positive interdependence
- Individual accountability
- Social skills
- Group processing
- Communication

Insights into the factors which promote positive interdependency in groups as they reach solutions or formulate new ideas are still emerging as are tools to evaluate these processes (Summers et al., 2005). Indeed, there is strong evidence that group formation, and the role of the instructor, are critical in the success of collaborative learning (Gillespie et al., 2006). In 2010, the introduction of positive interdependence and individual accountability was attempted with the objective of enhancing group function through fostering constructive processes.

3.2. IS-IT Design

Informed by the previous iterations of the task and by literature, an innovative approach was taken to the instructional design of active learning tasks. The core attributes of an IS-IT are:

- self-selection of scenario context and group membership. Providing students with choices increases their investment in the task. Students could opt to be assigned to a group by an instructor
- introduction of interdependency between students within a group. This was achieved by moving between cooperative and collaborative processes. Students were required to negotiate with their group members to take

responsibility for one of four individual tasks (individual quests, IQs) in which they gathered information relating to one aspect of the scenario. This results in each student making a unique contribution to the group's resources which is valued by the whole group
- a collective product which represents a response to an over-arching question (metaquestion). The question is framed by a contemporary issue in an interdisciplinary context and requires integration of the information from all four IQs.

A set of transferable skills, applicable across STEM disciplines, were identified as desirable learning outcomes (Table 1). These statements deliberately exclude content mastery to enable the future translation of these tasks across multiple disciplines and institutional contexts.

Table 1: Learning outcomes targeted in the design of an interdisciplinary scenario inquiry task.

Skill	Delivery through an IS-IT
Interdisciplinary thinking	Analysis of real-world scenarios extracting the chemistry concepts while recognising the connections to other disciplines.
Scientific reasoning	Discriminating between theories and hypotheses, and translating between microscopic and macroscopic processes.
Scientific communication	Fluent communication in a scientific language: using appropriate symbols and icons.
Quantitative reasoning	Integration of data with logical arguments including graphical displays, and applying algorithmic relationships to quantify variables.
Information literacy	Information retrieval from a range of sources and validation.
Visualisation	Construction of conceptual models of chemical structures and processes.
Team work	Effectively work within a team to develop a collective product.
Global citizenship	Develop social and ethical responsibility by identifying the societal implications within a scenario.

The tasks were developed to be completed over an 8-week period and the alignment of activities with the learning objectives for each stage is provided below in Table 2.

Table 2: Task schedule (beginning in week 3 of semester)

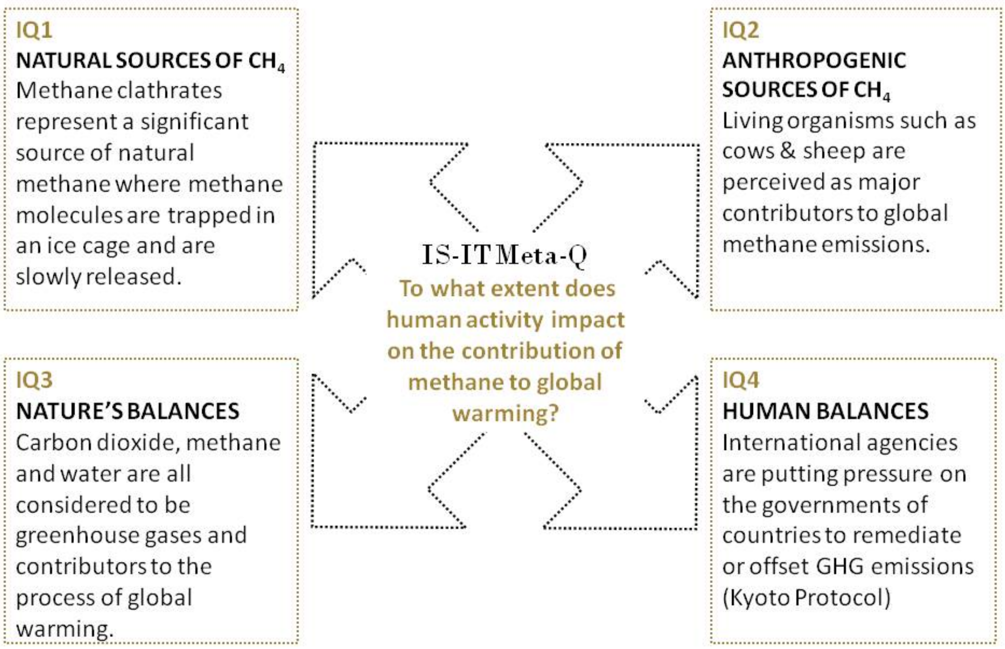
Week	Sequence	Desired Learning Outcomes
1-3	**Select scenario & join group**	Intrinsic engagement in a contemporary issue of perceived relevance
	Nominate for IQ	Explore the chemistry concepts that underpin a contemporary science context to identify key ideas.
	Complete (optional) 'Teamwork Module'	Develop & advance awareness of interpersonal and communication skills.
	IQ submission	Retrieve and organise information from multiple literature sources.
4-6	**Collaboration**	Demonstrate conceptual understanding by identifying connections between different

		contexts that must be linked to solve a problem.
	Research report submission	Collaborate to create a collective product that communicates your response to the metaquestion. Communicate fluently in chemical language (chemical structures, equations, symbols). Construct ideas and present logical reasoning in a written format supported by quantitative data.
7-8	**Internal peer assessment**	Critical appraisal of peer collaborative and communication skills.
9-11	**External peer assessment**	Reflection on how other groups addressed the same problem.
End of Semester	**Moderation, release of marks & feedback**	

3.3. Scenario Development

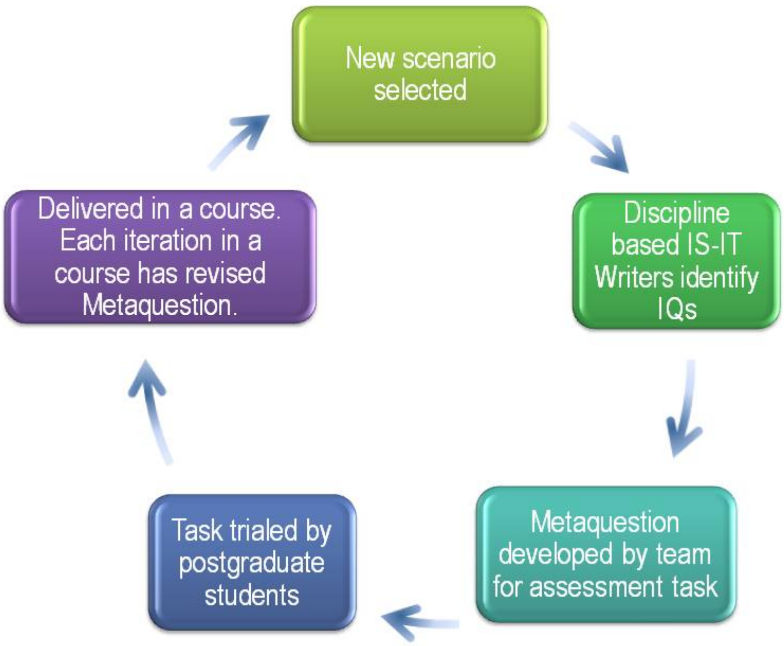
Scenarios were identified that encompassed a range of contexts which mapped against all of the programs represented by students enrolled in the large first-year courses. Twenty-seven IS-IT scenarios were formulated in two stages by a team of writers deriving from multiple science disciplines. The process of writing was iterative with each scenario, suite of IQs and the metaquestion scrutinized for interdependency between the IQs and equivalence of difficulty for equity in assessment. A snapshot of an IS-IT scenario including the IQ contexts and the metaquestion is shown in Figure 2. The full compilation of IS-ITs is provided in **Appendix A**.

Figure 2: Snapshot of the four Individual Quests (IQs) and the metaquestion for an IS-IT.



The IS-ITs were trialled by postgraduate students to assess ease of information retrieval, level of challenge and applicability of the IQs prior to being offered as part of the task. The lifecycle of an IS-IT is shown in Figure 3 below.

Figure 3: The design lifecycle of an IS-IT scenario.



Level of Inquiry:

These tasks meet the criteria to be categorized as inquiry-based learning which promotes student-centred and independent thinking. Scientific inquiry can be categorized according to the level of teacher support and independence that students experience in completion of a task (Fay et al., 2007). IS-ITs require that students create a response to a metaquestion by retrieving, analysing and integrating information. Assessment does not measure achievement against a predetermined outcome but is aligned with evidence of the process.

Requirement for modified or inclusive assessment

An important contingency that needs to be established was the modification of the IS-ITs for groups that collapsed to one or two members as a result of student withdrawals from the course during semester. There are also a number of students with Student Access Disability Plans (SADPs) who required special consideration in their engagement in collaborative environments. This required the development of a modified version of the IS-IT where the metaquestion was modified to address a combination of any two of the IQs. The metaquestion was replaced by an assertion and students were required to develop an evidence-based position in the negative or affirmative in response. The student product of these modified tasks could not be assessed using the conventional iCAS peer-assessment as the criteria did not accommodate the modified task. These reports were marked separately by the course coordinator.

3.4. Task Management Technology – iCAS

3.4.1 Alpha version (pre-ALTC project commencement)

In 2008, a new learning management technology 'iCAS' (**i**nteractive **C**hemistry **A**ssessment **S**ystem) was successfully piloted across two large-enrolment chemistry courses at UQ, enabling cohorts of close to 1000 students to work collaboratively in groups towards two separate types of assessment task. The group collective products submitted through iCAS were a poster (semester 1) and a written article (semester 2). The initial technology development was funded through the UQ Strategic Teaching and Learning grants scheme. In this alpha form, the management system facilitated:

- field-based interface
- directed group membership (by instructor)
- directed task assignment
- scheduling of release and submission dates
- individual group discussion forum
- file submission in a group domain (three files and a final document)
- peer-assessment: intragroup (internal) and intergroup (external)
- administration functionality to enable moderation.

The alpha version involved group formation by the instructor (this could be achieved by prioritising multiple variables including program of study, nationality, gender, age and academic ability). The instructor also controlled task allocation to groups so students did not have choice of topic. These early iterations illustrated that careful and thorough scaffolding of the tasks was required. Informal feedback gained from the initial implementation indicated that many students did not engage well with the task and did not see the value of the task in enhancing their learning experience.

3.4.2 Beta version (ALTC Project)

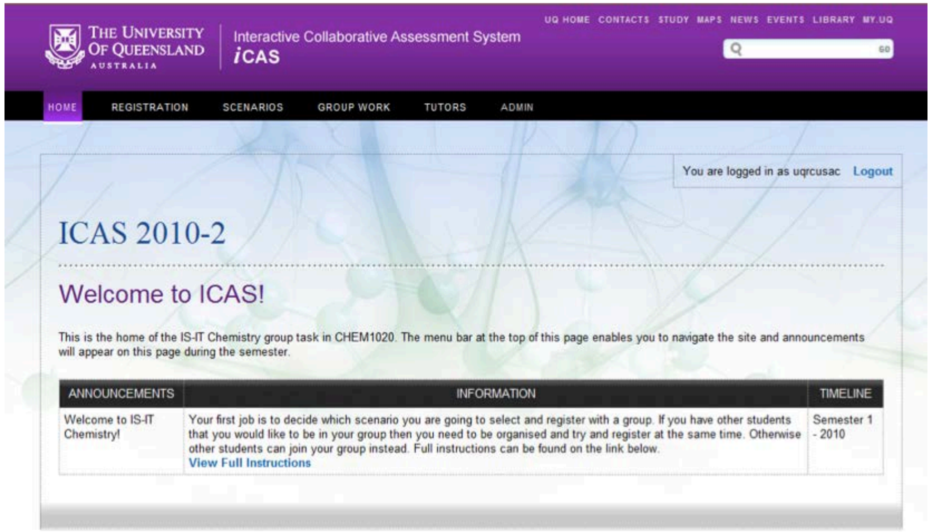
In 2009, funded as part of this project and informed by the experiences from the implementation of the alpha version, the technology was expanded to incorporate advanced functionality in the management system. This beta version included:

- web-based interface (Figure 4a)
- delivery of resources in form of IS-IT scenarios
- students able to choose from a suite of scenarios and self-select their group membership within a scenario (Figure 4b&c)
- enhanced facility for discussion groups including tiered threads
- transition between individual student accountability and collaborative activity (Figure 4d)
- improved peer assessment domain which included: enhanced administrator functionality moderation; individual feedback to the students in the form of the mark, tutor comments and the comments for the group's report which were received during external review by other students.

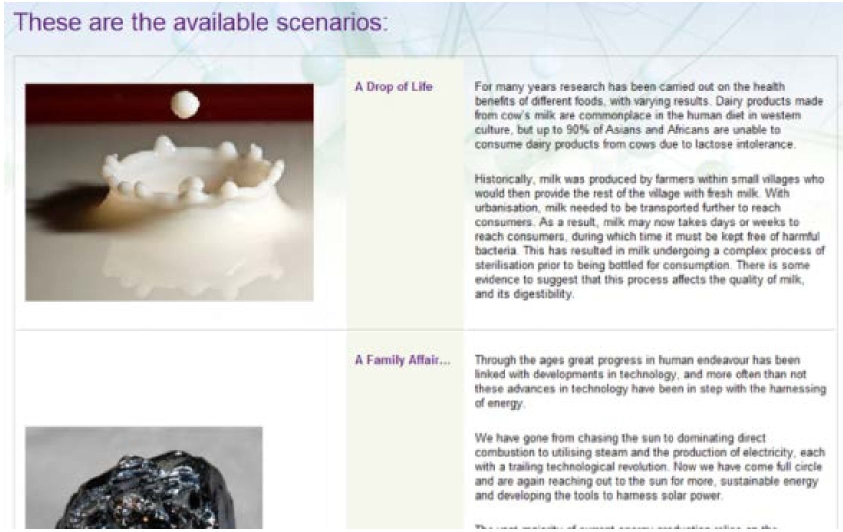
Issues that arose during the major implementation of iCAS in semester 2, 2010 were addressed in real time and included LDAP (Lightweight Directory Access Protocol) inconsistencies, document format and minor programming 'bugs'. The final version is in current use in the first-year engineering chemistry course in semester 1 2011.

Figure 4: Screenshots iCAS Web interfaces.

(a) iCAS welcome page.

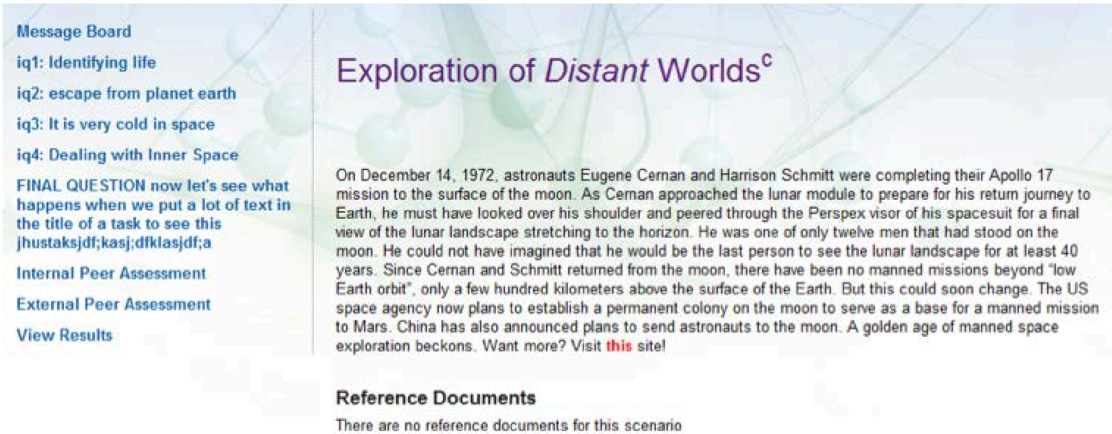


(b) Student view of scenario selection.



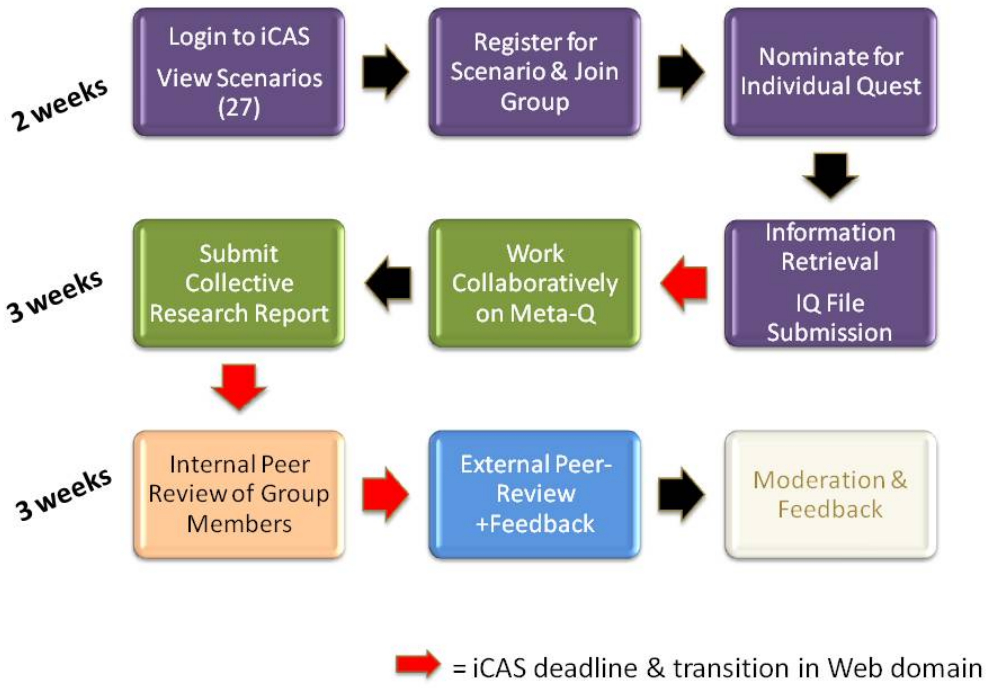
(c) Student view of registration page.

(d) Student working interface.



The flowchart for the sequence of iCAS management of the IS-IT tasks (Figure 5) illustrates the transitions between the different activities in the task. These are formalised by automated electronic deadlines which can be defined by the facilitator.

Figure 5: Task flowchart illustrating transitions between phases of the task.



The final version of iCAS is a web application, developed under the Microsoft .NET Framework, using the C# language, Entity Framework and LINQ within the implementation. Authentication and user management used ASP.NET Membership and LDAP. The web application uses a Microsoft SQL Server database. This final version, labelled iCAS "heavy" incorporates the full suite of capabilities and is suitable for the management of collaborative tasks in large first-year classes (> 1000 students). The alpha version, labelled iCAS "light" which incorporated a reduced suite of capabilities (directed group formation, instructor-directed task assignment) is applicable to classes with smaller enrolments (up to ~100 students) where individual feedback by the academic is more achievable. This latter version has been employed successfully in second-level chemistry course (Chemical Reactions & Mechanism) at The University of Queensland since 2008.

3.5. Learning Process

3.5.1 Team-work skills

The IS-IT is a self-directed task that is situated outside normal course contact hours and as such successful outcomes depend on students' self-regulation, motivation and independent learning. Expectations of the learning objectives are set clearly in the task description provided to students at the commencement of the task including reference to UQ graduate attributes which the task provides opportunity for students to gain:

A University of Queensland bachelor degree graduate will have in-depth knowledge in the field(s) studied and will display effective communication skills, independence and creativity, critical judgement and ethical and social understanding. (UQ HUPP 3.20.5)

These are not skills that you can acquire by simply sitting in lectures or doing experiments – you also need to work together (collaborate) with your peers to solve problems and achieve common goals.

Group processing in collaborative activities involves several cognitive and social factors, including:

- engagement
- communication
- shared understanding of the goals of the task

Students were provided with a range of resources delivered through the course Blackboard (Bb) site to support them in their collaborations, including troubleshooting strategies for when groups are not functioning well. In 2010, students were encouraged to complete an online module 'Working in Teams' developed by A/Prof Lydia Kavanagh as part of an ALTC project which is designed to promote awareness of strategies for team work and build individual collaborative skills. There was no assessment linked to completing this online module and hence only 68 students commenced the module and 6 students completed the whole module. This completion rate indicates that a more structured approach to incorporating the module is required in the future.

Additional support for the task was provided in semester 2, 2010 in the form of a 'drop-in' consultation session during the collaborative phase of the task and dedicated library research-skills workshops at the beginning of the task to support the IQ phase. Uptake in both of these options was low with numbers of < 25 attending each.

3.5.2 Assessment

The core assessment strategy for this task is peer assessment and students were provided with assessment criteria (examples included in **Appendix B**) and full instructions at the beginning of each iteration of the task. Once the final report had been submitted, iCAS transitions into the peer-assessment domain where students are presented with fields to enter a mark and comment for each of their team members (internal assessment). They are given between 10-14 days to complete this component of the task depending on the assessment schedule for that semester. Once this deadline has passed, iCAS transitions into the 'peer review of reports' domain (external) where students are allocated four reports by other groups to mark within the same scenario that they have completed. Each report is then marked by 16 students. However, in instances where groups contained fewer than 4 students, moderation is required. Twenty per cent of the task marks are awarded for each component of peer assessment and students who do not complete the peer assessments are notified in their feedback that their marks were affected by non-compliance.

3.6. Learning Outcomes

The instructional design for the IS-ITs specified the student product of these tasks to be reports but future iterations could adopt a variety of collective products. Reports were chosen to provide an artefact of learning where integration of IQs becomes explicit in the text. The learning outcomes of the task were stated as:

- retrieve and organise information from multiple literature sources
- explore the chemistry concepts that underpin a contemporary science context
- demonstrate your conceptual understanding by developing connections between different contexts that must be linked to answer a question
- collaborate to create a product that communicates your agreed response to the question
- communicate fluently in chemical language (chemical structures, equations, symbols)
- construct ideas and present logical reasoning in a written format.

The structural requirements of the report were specified as follows:

- **Length:** 10 pages (references are outside this limit) – there is no word limit!
- **Font:** 12-point Times New Roman, Arial or Helvetica fonts.
- **Line Spacing:** A minimum of single and a maximum of 1.5 line spacing
- **Margins**: minimum 1.5 cm and maximum 2.5 cm.
- **Diagrams:** A maximum of 5 (eg chemical structures/equations; graphical display of quantitative data (graph or chart)); the diagrams should be integrated (linked clearly) with the text and each should occupy no greater than half of one A4 page.
- **References:** APA **or** Harvard referencing systems used consistently.

<http://www.library.uq.edu.au/services/referencing.html>

Other than these guidelines you can be creative in your presentation to engage your potential reader.

The SOLO taxonomy (Structured Observation of Learning Outcomes) was developed by Biggs and Collis (Biggs & Collis, 1982; Biggs, 2003) for the purpose of categorising the levels of complexity evident in student understanding. The extent of deeper understanding can be measured through application of the SOLO taxonomy to the student problem-solving outcomes (Lucander et al., 2010). The collective products of the IS-ITs are written reports which have been analysed through application of the SOLO taxonomy to evaluate the extent to which the tasks have fostered higher-order thinking in an interdisciplinary context.

4. Project Evaluation

The University of Queensland's ethics committee for research involving human subjects approved ethical clearance for this study. A mixed-methods approach was adopted with perception data collected both via an online survey with Likert scale and open-response questions and by interviews. Given the nature of the research questions, surveys were considered to be effective instruments for collecting attitude data from large numbers of students. In this study, student perception is used as an indirect measure of student learning, a common practice in higher-education research (Kuh, 2003; Seymour, 2000). Four sources of data were collected.

- Online pre/post surveys: students were invited to complete the surveys by email, participation was voluntary and all responses were de-identified. Reminders were sent to students to encourage participation. A one per cent bonus course mark was offered to students who completed both pre and post surveys. Threshold requirements for acceptable survey response rates were achieved across all surveys. The responses were monitored by the central university unit administering the surveys in both years of data collection.

- Focus groups were conducted at the end of a semester to gather feedback in regard to specific questions relating to the student experiences of the task. Incentives to participate in focus groups in the form of a gift card were offered. Additional data have been collected in the form of interviews and reflections from the programmers and academics involved in the action-research process.
- Student collective products in the form of group reports were sampled and analysed. Two assessors evaluated the reports independently and separately and neither was involved in instruction in the course. Analysis of actual student reports using the SOLO taxonomy enabled a more direct measure of student learning outcomes.
- Artefacts of the learning process were collected through iCAS including the timing of student processes, information related to group composition, number and nature of interactions in the collaborative domains and marks.

The quantitative and qualitative data (summarised in Table 3) were analysed using standard research software (SPSS and QSR NVivo). Descriptive statistics, including mean and standard deviation (SD), are used to describe student perceptions. Recurring themes in qualitative data were identified by two analysts independently and cross-referenced to inductively code emerging ideas. The respective counts were cross-correlated to student responses to quantitative questions in NVivo. The qualitative SOLO analysis is described below.

4.1. Literature instruments

- Questions included in institutional course evaluations were informed by the work of Seymour et al., (2000) and the design routinely used across STEM disciplines in the US and a recommended approach of the National Science Foundation (SALG, 2010).
- Pre/post question clusters relating to self-efficacy, real-world connections were sourced from the CHEMX instrument (Grove & Lowery Bretz, 2007). Questions were also sourced from existing instruments relating to collaborative community (Summers et al, 2005) and adaptive learning (Midgely et al, 2000).

Table 3: Sources of data collected.

Context	Student Enrolment	Data Collected (participants)
Iteration 2 Semester 2 2009 *Chemistry Cohort*	1115	• Online course evaluation† (N = 325, response rate = 29%)
Iteration 3 Semester 1 2010 *Engineering Cohort*	277	• Focus groups (N = 8) • SOLO analysis of student reports (20)
Iteration 4 Semester 2 2010 *Chemistry Cohort*	1360	• Pre/post survey (N = 818, response rate = 60%) • Focus groups (Two of N = 8) • Student reports (350)
Iteration 5 Semester 1 2011 *Engineering Cohort*	270	• Focus groups (TBA) • Student reports (74)
iCAS Logs	Various	• Demographics • Timing • Artifacts in collaborative domains • Submitted files

Course instructors & coordinators	4	•	Reflections
Programming team	4	•	Interviews

†Full online course-evaluation data were not available during 2010 due to the introduction of a new institutional course-evaluation instrument that was delivered in hardcopy in lectures.

The question guide for the focus groups is included in **Appendix C** along with the pre/post questionnaire delivered online through SurveyMonkey.

4.2. External Evaluator

The team was fortunate to recruit Professor Carmel McNaught, Director and Chair Professor in the Centre for Learning Enhancement and Research (CLEAR) at The Chinese University of Hong Kong, as external auditor of the project. Professor McNaught visited the project team in September 2010 and reviewed progress, the software system and the rollout of the project. Professor McNaught held discussions with all stakeholders and offered critical comments regarding the project. Subsequent to her visit, Professor McNaught presented a preliminary report on the project, offered suggestions for improvements/changes and made significant recommendations as to the further dissemination of the outcomes of the report. The evaluation of the project was consequently restructured into three components (learning environment, learning process and learning outcomes) based on discussions with Professor McNaught. The original evaluation framework was realigned and extended to address these components to provide coherent insights in the success of the initiatives from the perspectives of the designers, the instructors and the students. Professor McNaught continued to engage as a critical friend of the project team and presented a subsequent written appraisal of the overall project, which has been included as **Appendix D**. She has also supported the team in the translation of outcomes into a publication on which she is a coauthor.

4.3. Evaluation of the Learning Environment

4.3.1 Technology Enhanced Learning (TEL) - iCAS

Evaluation questions:

1. How effective was the iCAS technology in facilitating management of the task: what works well and what requires further optimization?
2. Has the new strategy of self-directed sign-on for scenarios and group membership been effective?
3. How effective was the requirement for submission of IQ files in enhancing collaborative behaviors?
4. Does the collaborative domain support student communication?
5. Is the peer assessment and moderation system optimized?
6. What is the sustainability of the iCAS system?

Evaluation Outcomes:

1. Task-management efficacy

Academic perspectives: iCAS enables the implementation of a self-directed learning activity in large classes because the administrative burden on the academic is lowered in the tasks of group formation, group management and assessment of group products. There is still a level of administration required which requires some support from IT staff and teaching assistants in the following aspects of the IS-ITs.

- Adding/removing students due to enrolment fluctuations once the task has

commenced and addressing issues with students inability to login to iCAS (latter is one or two students per semester).
- Managing modified assessment for groups that collapse to one or two members in the final stages of collaboration due to withdrawals from the course. Some students in a course are unable to work in groups due to disabilities and alternative assessment may be offered.
- Assigning reports to groups for peer review and substituting files in iCAS in the event of extensions or format issues.
- Moderation of task.

Advantages: iCAS enables the introduction of collaborative activities into large-enrolment courses. The ability to set flexible deadlines for each stage of the task, monitor student activity and progress and to implement peer assessment and moderation is a strength of the technology. Ready access to group information and the ability to add and remove students easily is ideal. The beta version is versatile and online peer assessment and moderation overcomes the challenges of marking large numbers of hardcopy reports. Easy access to the individual student marks and related group information represents a transparent assessment process which can be quickly accessed for feedback and reporting at anytime.

Disadvantages: Academics perceive that there is time required to become familiar with the operation of iCAS and this is a barrier to adopting the technology. This barrier is overcome when they are supported by a staff member who is familiar with the technology. At UQ, it is difficult to gain an accurate class list prior to week 4 in semester and the task begins in week 3. This inevitably means that students both enroll and depart from the course during the task which impacts on group formation. Students who are disenfranchised from the course do not sign up for the group task and so are placed in groups, and many eventually withdraw later in semester. These groups did not function well and the quality of the submitted product is low reflecting the importance of investment in the task. The students were placed in the least-subscribed scenarios to make sure there were sufficient groups for peer marking but these scenarios also represented the least popular scenarios.

2. Student engagement in task: scenario sign-on and group membership

A significant change to the beta version of the iCAS technology was the introduction of self-directed choice of topic and group membership. Once they login to iCAS at the commencement of the task, students are presented with a suite of scenarios (which are made available as required by the facilitator). Each scenario is presented as an image with associated text setting the context. Students were able to select a scenario and be taken to a group sign-up page where they could enrol in an existing group or start a new group of four. The number of groups in each scenario was restricted to ensure effective peer marking of reports (no scenario had fewer than four groups). The LDAP interface in iCAS created a database of demographic information which has provided a rich source of data in terms of relationships between gender, program of study and scenario context. The demographics of group membership provides information in terms of factors that influence the engagement of students in collaboration such as relevance to program of study. The scenarios that attracted majority male groups were: *Algae (from little things big things grow)*; *A Pandora's box of oil; Fermentation fever*; and *In the shadow of the mushroom*. The scenarios that attracted majority female groups were: *A sugar rush*; *A drop of life; Immunity (good versus evil); Paper mate?* and *Pharmaceutical journey*. The analysis of the factors that emerged from data in terms of the relationships between social and cognitive factors in collaborative tasks forms the basis of a publication in preparation for submission (Lawrie et al., in preparation).

The popularity of a scenario could also be measured by the rate in which the available 15 groups were filled. The five scenarios that were fully subscribed in order of popularity were: *Chocoholics anonymous*; *A sugar rush*; *Immunity: good versus evil*; *What are you drinking?* and *Bottom(s)-up! A new approach to cancer treatment*. These scenarios all relate to issues that have immediate impact on students' lives. The five scenarios that were last to fill and were not fully subscribed were (least popular first): *Waste not, want not!*; *Cleaning up green with bioremediation*; *The return of the King*; *Copper ore concentrate spill at wharf*; and *We are what we wheat*. Four of these scenarios represented environmental issues created as a consequence of human activity and could be perceived by students as not having immediate relevance to their lives.

In the semester 1 2010 pilot of the IS-ITs, 10 of the IS-IT scenarios were implemented in a lower-enrolment chemistry course (N = 276) which comprised first-year engineering students and a minor number of BSc students. Focus groups (N=10) revealed that these students have selected scenarios based on their chosen engineering major/career demonstrating strong professional perceptions of relevance of the scenario contexts.

> '*the project I did was on waste management which is exactly what I am doing for my Engineering project*' (Student A, 2010 semester 1 Focus Group)

> '*Mine was the ocean floor, so it's to do with mining so like discovering like the mines. Like what you would do*.' (Student B, 2010 semester 1 Focus Group)

> '*There is also like the modern relevance of the topics. Like Alternative Energy is a big thing. So it is good how the topics were all very modern and relevant, cause that is the sort of things that we will be going into once we finish our degree, so that was also good.*' (Student C, 2010 semester 1 Focus Group)

3. IQ submission

Students reported that the IQ submission deadline was important in terms of the accountability of their team members. Many expressed concern via email to either the course coordinator or iCAS facilitator when a team member did not submit timely/useful information or failed to submit an IQ at all. Many students cited failure to submit a satisfactory IQ file via iCAS as a criterion for awarding a lower mark to a student in the internal peer assessment of their group members.

From the perspective of academics, the non-submission of IQ files represented a potential signpost for groups who perhaps were not engaged in the task although, as this was not assessed, many groups were working outside the iCAS domains.

An unexpected outcome of the file-submission process was insight into the currency of software that students were using and their skills in handling files of different formats. There is a misplaced assumption that all students are able to recognize and successfully deal with current technology and deliver the stipulated file formats. From our research, we found that of:

- 1151 IQ files submitted via iCAS (no specified format was required)
    - 666 were docx (58%)
    - 296 were doc (26%)
    - 131 were pdf (11%)
    - 58 documents were of other extensions (.rft .odt .htm .ppt etc) (5%)

- 346 Final Group Reports submitted (a pdf was required for submission)
    - 66 were docx (19%)
    - 51 were doc (15%)

- 229 were pdf (66%)

In particular, a pdf format was specified for the final report submission to enable students to be able to open these files for peer review. It was subsequently discovered that many students did not have the requisite knowledge to convert their work from Word formats into the requested pdf format. These Word documents caused a significant administrative load as some students were unable to open these files. Facilitators converted the files and replaced them in the iCAS database or emailed them to members of a group that reported issues.

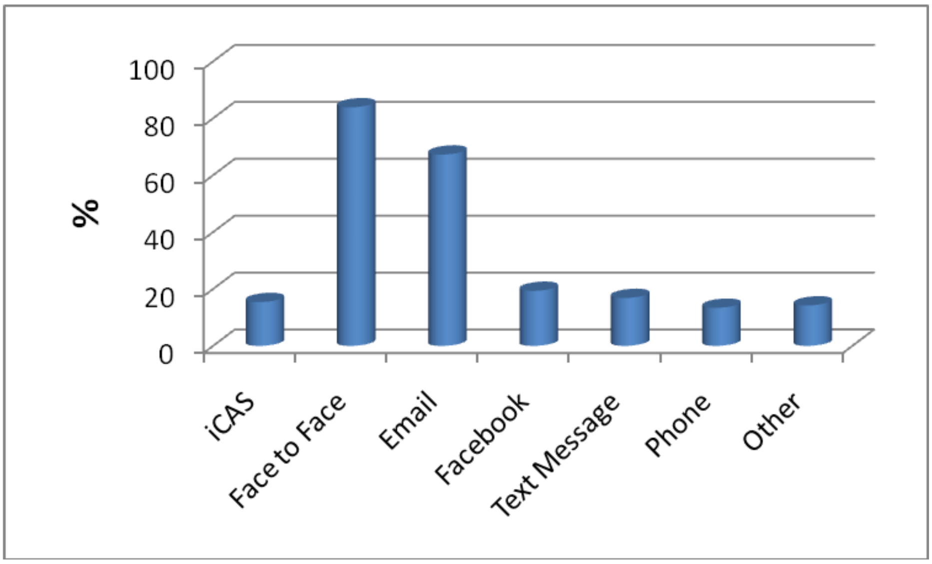
4. Usage of the collaborative domain

During the formulation of the iCAS technology it was perceived that it would be important to provide a group-communication domain in addition to file-upload facility. This evolved in the beta version to be displayed as multiple threads. Students were asked in the post survey in semester 2 2010 'How did your team communicate?' and their responses were coded to demonstrate their preferences (Figure 6). Most students reported multiple modes of communication and each was counted. It is very clear that face-to-face interactions were the preferred interaction with 84 per cent of students who responded (N=818) citing that their group used this form of communication for collaboration. Student usage of the iCAS discussion forum could be classified into five types of activity:

i. Initial contact between students
ii. Allocation of the IQs between group members
iii. The arrangement of face to face (F2F) meetings
iv. Social interactions that extend those in other forums
v. Full collaborative interactions including document review

An additional source of data was the iCAS forum logs and 33 per cent of groups did not use the iCAS collaborative forum at all. Several students cited that they did not regard the iCAS forum as useful because there was no automated message dispatched whenever anyone edited the site. It was regarded as 'out of the way' to go in and check for messages. Future modifications to the iCAS technology should explore this option.

Figure 6: Preferred modes of communication used by groups to collaborate in iteration 4 (Semester 2 2010).



There was strong evidence that students had found face-to-face interactions an easy option to manage either through common lecture streams (common programs of study) and co-residence either in colleges or other student accommodation.

5. Peer assessment

The alpha version of iCAS had a very effective peer-assessment function which was improved only cosmetically in the beta version with academics being able to move effectively between each student's peer-assessment page. This page was optimized to contain all the information relating to the student and their group including marks they awarded, marks they received, the submitted file for the final report and an instructor feedback panel. Moderation was thus very straightforward.

The internal peer-assessment is not popular with students as they perceive that their peers may not be authentic or equitable in marking each other despite clear criteria and consequences for awarding 100 per cent of marks without critical justification of why these marks are appropriate. Comments such as '*It may also be unfair on students who are not able to group up with pre-established friends, as friends would treat the peer assessment aspect very leniently.*' (2010 semester 2 post-survey comment) confirm a sense of inequity.

The external peer assessment was effective despite variability in how students applied the marking criteria that were provided to assist them in the external marking (**Appendix C**). There was some feedback in all of the iterations that a minority of students felt uncomfortable in marking each other's products but this is expected as most have not experienced this process previously. Evidence emerged in focus group interviews that many students had adopted their own approaches to awarding marks to other group's reports (semester 2 2010 focus group). The task design strategy of having multiple groups mark a report resulted in minimization of the impact of spurious marking on the average mark for the report. Moderation of report marks involved checking that the average mark was authentic and not affected by an outlier in terms of a mark that had been entered incorrectly eg 7 instead of 70.

6. Technology Sustainability - iCAS

- What features are still required in the management technology to optimize translation into other contexts?

Some minor optimisation to the administration interfaces would perhaps increase the efficiency of course and scenario setup domain such as the option to link back to accessing the scenario editing domain. Also, some minor optimization is required in the tutor interface such as adding a search option. For translation into other institutional contexts to be achieved, the authentication system would need to be extended. There is also scope for further development in the reporting facilities to allow academics and tutors to view statistics and other valuable higher-level data. Finally, additional administrative functions would also be useful including the ability to reset the database, export of data and a user help function.

- What levels of IT support are required for sustainability?

Once iCAS has been in used for a semester by an academic, the level of support needed is minimal as they become familiar with using the system. Additional functionality can be added to cater for administrative needs and for further reduction in operational costs.

- What is the shelf-life of an IS-IT and how much does it cost to generate new IS-ITs?

IS-ITs have a lifetime which is dependent on the product of the task. Changing the metaquestion each time a scenario is offered provides a number of iterations and changing the format of the product extends this. The task has been demonstrated with the submission of reports but there is capacity to accept PowerPoint files, videos, audiofiles etc. The move to widen the types of files that students submit will require IT support to troubleshoot issues that arise in each first iteration, eg file format for universal viewing by students. This should attract only a minor cost in terms of programming.

- How do we ensure academic integrity?

In semester 1, 2011 the IS-ITs have been implemented in a first-year chemistry course for engineering students (N = 259) where there was an additional task requirement that students submit a draft report to Turnitin through the course Blackboard site. Turnitin is academic plagiarism detection software to ensure academic integrity which has been adopted at UQ. A significant issue arose where multiple students within a single group submitted their reports generating high levels of matches. A method to ensure that a single group member accepts responsibility for this process is required.

- What is the minimum quality-assurance process required for the task?

Each time a modification is made to the resources delivered to students or functionality of iCAS testing by a postgraduate student to identify any unanticipated issues prior to release to undergraduates is necessary.

Additional benefits of iCAS: The beta version of iCAS has demonstrated significant versatility and potential for adaptation. In semester 2, 2010, 36 students were enrolled in the course but were located off-shore in Malaysia and were seamlessly integrated with students located at St Lucia as a result of this technology. There were no restrictions on which group they joined and no evidence of any hurdles in communication or collaboration.

4.4. Evaluation of the Learning Process

Evaluation questions:

1. What factors influence student engagement in the task – when do they start each phase?
2. How did the groups ‘gel’ as a function of formation?
3. What aspects of group processing are characteristic of positive interdependency (communication, commonly agreed strategies)?
4. What supports do students need for teamwork?
5. How do students approaches to learning change as a result of the task?
6. How does motivation to science/chemistry change?

Evaluation outcomes

1. Student engagement in the task.

The ability to self-select into IS-IT scenarios and choose group membership has had a substantial impact on student engagement in the task. In iterations 1 and 2 of collaborative group tasks, there was significant feedback through online course evaluations that students had understood the task objectives or potential learning outcomes. The introduction of the IQs played a significant role in student engagement in the task as there was a perceived accountability for not contributing to the group's processes. Evidence derived from the qualitative responses to the post-task survey in semester 2, 2010, revealed that many groups were formed from students who were enrolled in the same program; however, the iCAS logs indicate that the selection of scenario context did not always align with these program. There is an indication that students opted for contexts that represented personal rather than professional interest.

2. The effect of self-selected group formation on group function.

In 2009, heterogeneous groups of four were assembled based on principles of cooperative learning to maximise peer learning and these included: mixing academic ability (Felder & Brent, 2001; Kriflik & Mullin, 2007), gender dispersed to minimise the number of same gender groups, and distribution of international students to address simultaneously hurdles related to English being a second language and to improve their integration into a new environment (Kavanagh & Crosthwaite, 2007). The role of iCAS is facilitating self-selection of student groups has been discussed above as part of the evaluation of the learning environment. There was evidence across multiple data sources that during iterations 3 and 4 of the IS-ITs in 2010, students perceived that their group construct had enhanced the group processes in the development of a collective product. This data is being evaluated further to investigate the interplay between the social versus cognitive factors. Interdependency introduced through the IQs was a significant factor as students referred to the level and extent of information that their colleagues contributed.

3. Evidence of positive interdependency within groups.

Positive interdependency between members of a group could be characterized by three indicators as evidenced through multiple sources of data (iCAS forum, post-task survey qualitative data and focus groups for iterations 3 & 4).

- An *effective communication* system is established early in the sequence of the task which is then sustained. Students provide supportive comments to each other, fostering productivity and reiterating shared understanding of the expectations of the task.

- A *shared understanding* of how the group will process the information from the IQs to respond to the metaquestion and an agreed format for the report.

- Group products can be categorized by the SOLO taxonomy as evidence for *higher-order learning* (refer to Learning Outcomes below for further information).

4. The nature of the support that students need for teamwork?

Students were asked whether they felt supported during the task in the post-task questionnaire as an open-response question. Most students responded referring to their interactions with their team mates rather than the instructor-student relationships/mechanisms. Those that identified a need for extrinsic support suggested that having an option of consulting with a dedicated tutor would have been useful. There was a strong indication that weekly updates/reminders of deadlines and expectations via the course Blackboard announcements helped groups progress through the task. The provision of workshops by the library staff to support students in their information-retrieval skills or a drop-in consultation session provided by academics were not accessed by students, with numbers fewer than 25 attending any session.

One of the most significant concerns for students was when their groups had fewer than four students and they initially perceived that they were disadvantaged in the task. A clear indication that these situations would be addressed in the moderation of the task allayed these concerns.

5. Changes in students' approaches to learning as a result of the task.

- **Student perceptions**

In semester 2, 2010 students were asked to completed questionnaires at the beginning and end of the task. A 1 per cent bonus mark was awarded to students who completed both questionnaires which resulted in a high completion rate (62 per cent). The survey contained both quantitative scales and open-response questions (**Appendix B**). Descriptive statistics were used to assess the extent of any shift in perceptions and multivariate analysis was conducted to complete a factor analysis. Scale clusters of quantitative items were sourced from validated literature scales and translated to maintain their conceptual integrity. Scales are provided in Table 4 below identifying the questions in the IS-IT questionnaire and the literature source:

Table 4: Sources of evaluation item cluster in pre/post survey.

Cluster	Reference
Effort (Makes the effort to use information available and tries to make sense of it)	Grove & Lowery Bretz, 2007
Concept (Stresses understanding of the underlying ideas and concepts)	Grove & Lowery Bretz, 2007
Reality link (Believes ideas learned in chemistry are relevant and useful in a wide variety of real contexts)	Grove & Lowery Bretz, 2007
Outcome (Believes learning chemistry is essential to ultimate career goals)	Grove & Lowery Bretz, 2007
Group processing	Summers et al., 2005
Attitude to group work	This study
Performance approach goal orientation	Midgely et al., 2000
Performance avoid goal orientation	Midgely et al., 2000
Mastery goal orientation	Midgely et al., 2000
Science identity	Pugh et al., 2010
Chemistry identity	Pugh et al., 2010

The internal consistency of these clusters was measured by a value of alpha and all demonstrated an acceptable level of internal consistency except the items that were created for this study 'Attitude to group work'. The validity of these scales have been measured against the published instruments. Data will be published separately but several observations resulted from the quantitative data in terms of student outcomes and these include:

- the task did not influence students' perceptions in regard to underlying chemistry concepts and problem solving or the way they approach their studies.
- there is a negative shift in students' instrinsic motivation and corresponding positive shift in their extrinsic motivation evident in the pre/post scales.
- there is a positive shift in students' attitudes towards group processing as a result of the task.

Students' responses to the open questions in the same online post survey revealed conflicting data to the pre/post scales in terms of the role of chemistry in interdisciplinary contexts. There was strong evidence of the following:

- fifty-eight per cent of students reported the task had been useful and cited two reasons: 1) working collaboratively with other students on a collective product; and 2) discovering the links in chemistry to real-world contexts. Only 19 per cent students reported that the task had not been useful and 23 per cent were indeterminate in the task utility.
- students who did not find the task useful cited three major reasons: 1) there was no perceived link between the contexts and the course lecture content; 2) the task was too much effort for the value of assessment in the course; and 3) they preferred to work on their own.

Overall, there is net evidence that students had perceived the collaborative component of this task as a positive experience and this links with the positive shift in the group-processing index from the quantitative data.

Focus-group data supported these findings and this highlights the importance of data triangulation – not simply relying on quantitative scales. Further analysis in terms of filtering and coding responses according to the scale items is continuing and outcomes will be published. The depth of information that has evolved in the data sources has exceeded the capacity of the project team to complete a full analysis prior to submission of this report. This point will be further elaborated in the Recommendations.

6. Motivation in learning chemistry/science.

The quantitative scale revealed that while the students maintained a greater science identity than a chemistry identity, there was little change as a result of the task.

4.5. Evaluation of the Learning Outcomes

4.5.1 Evaluation questions:

1. Have students' increased their perception of the role of chemistry in interdisciplinary contexts?
2. Is there a gain in the relevance of scientific thinking to their lives/professional aspirations?
3. Has the instructional design resulted in evidence of higher-order thinking?

Evaluation Outcomes:

1. Perceptions of the role of chemistry in interdisciplinary contexts.

There are two sources of data that have been examined to explore the learning outcomes of the task. The first is the student perceptions of their learning and learning from the task (pre/post quantitative survey and open-response items) in semester 2, 2010. The second is the students' task products – the group reports.

- **Student perceptions:**

The open-response items proved to be a rich source of data in terms of student perceptions of their learning gains as a result of the task. A large number of students cited that the IS-ITs had been useful in enhancing their perception of the role of chemistry in interdisciplinary contexts (this data is still undergoing coding and will be submitted for publication). Representative examples of responses include:

> '*it has shown us how chemistry really does relate to the world in a bigger way than just knowing why things get hot etc. it shows how it can be used to help humanity in several ways we never realised*''

> '*It has allowed me to further understand and connect some of the theory we have learned to real-world applications, which has made me realise that although it may not seem as though much of what we learn can be applied to the outside world, it really can be*'.

- **Student reports:**

The task criteria specified that students use visual representations of chemical structures and processes to support their responses to the metaquestion. They were also required to seek and apply quantitative data in their reports. By explicitly specifying these elements, the majority of reports included their effective use. Students reported that by looking for the chemistry in the scenarios, to meet the task criteria, they were able to recognize the role of chemistry in interdisciplinary contexts. There remained a minority of students who reported that completing this task was not useful to their learning as it was not linked to lecture content.

2. Analysis of collective products through SOLO taxonomy

Learning outcomes were measured against the learning objectives of the task and this required semantic analysis of the student collective products. The SOLO taxonomy was originally developed to enable categorisation of the levels of learning that students had achieved as a result of a learning activity (Biggs & Collis, 1982; Biggs, 2003). The simpler wording used for the categories in the taxonomy is explained in McNaught, Cheng and Lam (2006) who extended the SOLO taxonomy to encompass six levels. To determine whether higher-order student learning had been promoted through the IS-ITs, reports submitted in semester 1, 2010 were sampled and analysed. The context was a chemistry course comprising 276 first-year engineering students who generated 76 reports. The reports were marked out of 100 by peer review and students were provided with marking criteria (**Appendix C**). The sampling strategy was adopted based on a hypothesis that the full range of the levels of SOLO taxonomy would be represented across these reports. Each report was de-identified, analysed and mapped against the six levels of the SOLO taxonomy (Table 5). The SOLO score was developed according to the extent to which students had met the criteria of the assessment task where a score of 6 equated to the lowest level (misses the point) and a score of 1 equated to the highest level (unanticipated extension).

Table 5: Levels of the SOLO taxonomy and extension to simplify terminology and enhance applicability to written work.

Level	**SOLO category** (Biggs & Collis, 1982, Biggs, 2003)	**Extension** (McNaught, Cheng & Lam, 2006)	**Characteristic evidence of attainment of learning level in IQ Reports**
1	Extended Abstract	Unanticipated extension	High-level report where information has been integrated throughout to address the metaquestion. No delineation between the IQ information and additional information that has been sought to support collective position.

2	Relational	Logically related answer	There is evidence of integration of the IQ information to develop a response to the metaquestion. Discussion is supported by appropriate illustrations and quantitative data.
3		Intermediate	Information from all four IQs presented sequentially with minor linking between them and a summary added at the end of the report to address the metaquestion.
4	Multistructural	Multiple unrelated points	IQ information presented sequentially with no attempt to make links between the information or address the metaquestion. May be one IQ missing.
5	Unistructural	Single point	Multiple IQs not addressed and no attempt to respond to metaquestion.
6	Prestructural	Misses the point	Report does not address any of the requirements of the task.

Examples representing each level of the SOLO taxonomy were identified within the sampled reports.

3. Has the task design encouraged higher-order thinking?

Unanticipated extension and deeper thinking was evident within student reports demonstrating high levels of integration of information from all IQs and interdisciplinary thinking. It was anticipated that many groups would opt to 'divide and conquer' the task by simply pasting their IQ information together and submitting a report. The analysis of the student reports in terms of application of the SOLO taxonomy and evidence of deeper thinking forms the basis of a publication in preparation for submission (Lawrie et al. 2, in preparation).

There was substantial evidence from focus groups in two separate iterations in 2010, that students learnt through reflecting on, and critically appraising, the reports submitted by other groups in the same scenario.

> *I think from a learning perspective the external marking was great. To see when you haven't done so good and when people have done better than you in some places and you can improve.* (2010 semester 1 Focus Group)

> *One group did a really good job and the concept of the integrated report. They didn't have any of the IQs separated, they'd integrated it completely and it was all under different headings, and it was really good. And it was really a good opportunity to see something like that and then to think about that for the next time that you do it.* (2010 semester 2 Focus Group)

In summary, the evaluation of the process of implementing the IS-ITs and their impact on learning outcomes has generated substantial data. Analysis of this data is ongoing and will continue beyond the formal conclusion of the project with the aim of publishing research outcomes. Three publications have been formulated from different aspects of the study and manuscripts are in preparation for submission.

5. Project Outcomes

5.1. Principal Project Findings

5.1.1 Learning environment

It was found that the scaffolding of the iCAS management system was effective in guiding students through the task. The formal electronic deadlines provided accountability that they could use to drive their collaborations. Data from the semester 2, 2010, evaluation indicated that students would like the submission of the files containing information retrieved individually to be part of the task assessment. They also found the ability to review the reports from other students invaluable for reflecting on their own achievements but there were issues with viewing certain file formats.

The collaborative domain within iCAS offered an excellent ‘hub’ for students to initiate and facilitate interactions. An additional feature that would enhance the utility of this facility, as identified by the students, is a notification email when a member of their group edits the forum. This project has demonstrated that it is possible to manage small-group work in very large classes when supported by technology.

5.1.2 Learning process

Group function continues to be a major driver for the success of the task in terms of learning outcomes. Students’ investment in both the process and outcomes of the task was promoted by allowing them to choose their preferred scenario topic and by providing the option for them to self-select into/from their preferred groups. A large number of groups were formed from students with pre-existing relationships and co-location of residence (eg colleges) or schedule (lecture stream) were major factors for membership.

Introduction of IQs was a successful strategy for creating interdependency between students improving the collaborative processes for many groups. There are several characteristics of a group that is collaborating in a way that fosters creativity and higher-order thinking in the generation of a response to the metaquestion and these include:

- effective routes to communication established
- students developed collectively agreed structure for collaborative processes
- information provided by individuals for all four IQs available at transition to collaborative phase
- evidence of supportive/constructive exchanges between students.

This project has developed a template for instructional design of collaborative active learning tasks where interdependency is evidenced. Further, through the twenty-seven IS-ITs that have been written, there are clear instructional examples that other teachers can adopt or adapt in their own learning contexts.

5.1.3 Learning Outcomes

Analysis of student collaborative reports enabled through the application of the SOLO taxonomy. There is strong evidence that the structure of the task enabled students to demonstrate multiple levels of achievement and transition to higher order thinking (according to the SOLO categories) through a collaborative activity. Detailed research data will be published (Lawrie et al., in preparation). This project has provided instructors with an evidenced strategy for analyzing student collective products for levels of learning outcomes.

6. Project Recommendations

- The introduction of collaborative inquiry learning tasks is a viable strategy for addressing issues in student diversity and engagement.
- It is important that innovative projects produce evidence of successful learning outcomes to aid dissemination and diffusion. Without such evidence, there is no impetus for other institutions to actively explore adoption or adaption of innovative products. Evaluation should be seen as a significant project component.
- There are number of factors that are required for the successful implementation of technology-enhanced collaborative learning and these include:
  - a supportive IT consultant to provide assistance in enrolling students in iCAS and to troubleshoot compatibility issues
  - a team of tutors that can assist in moderation of student peer-assessment and view student reports to evaluate whether they have met task criteria
  - in projects where there is potential for substantial data sources, a full-time project officer to complete data analysis within the timeframe of the project.
- This project has been successful because of the commitment of the Project Team (see **Appendix E**). Engaging students in inquiry-based methods is time-consuming; work-allocation and rewards systems need to take this time into account.

7. Project Deliverables

7.1. Deliverable 1

The alpha and beta versions of iCAS are freely available for translation into other institutions to manage any task that involves collaborative group work and peer assessment.

7.2. Deliverable 2

A template for the implementation of interdisciplinary collaborative active learning tasks in a STEM course.

7.3. Deliverable 3

Twenty-seven contemporary scenarios that can be adopted or adapted for any problem-solving or inquiry-based learning activity.

7.4. Deliverable 4

An evaluation framework to explore the learning outcomes from collaborative active learning tasks through analysis of collective writing products.

7.5. Deliverable 5:

Guidelines for a capacity to change the way that large courses are presented in universities. Innovative approaches to student learning and assessment can be implemented with initial resourcing and support.

8. Dissemination

8.1. Dissemination for awareness

Dissemination of the instructional design and the task implementation has been achieved through increasing the awareness of the project with potential stakeholders.

8.1.1 Presentations at symposia:

Date/s of the event	Event title, Location (city only)	Brief description of the presentation	Number of participants	Number of higher-education institutions represented
June 2010	2010 National CASTL Institute, Creighton University, US	Institute Scholar's presentation (Lawrie). 'Enhancing creativity in scientific thinking'	30	Multiple US & Canadian institutions
Aug 2010	Biennial Conference in Chemical Education. University of North Texas, US	Symposia paper: 'Can we foster learning communities in large diverse first-year chemistry cohorts through authentic assessment'	25	Multiple US & International institutions
October 2010	UniServe Science Conference, University of Sydney	Presentation: 'Forming groups to foster collaborative learning in large enrolment courses'.	75	Multiple Australian and NZ institutions
Apr 2011	Computer Assisted Learning Conference Manchester Metropolitan University, UK	Paper: 'Computer-Assisted Collaborative Learning in Large 1st Year Classes Through Interdisciplinary Scenario-Inquiry Tasks: IS-IT Chemistry?'	30	Multiple UK, European, Asian and African instituitions
Jun 2011	Gordon Research Conference in Chemical Education & Practice, Davidson College, US	Poster presentation:' 'IS-IT Chemistry? Challenging students to think 'outside the box' through interdisciplinary thinking'	160	Multiple US & International institutions

8.1.2 Institutional Media:

Lawrie, G., Gahan, L., & Matthews, K. (2010). Connecting to Chemistry. *Creating Excellence in Scholarhip of Teaching and Learning eZine.* The University of Queensland. .pp 13-14. Retrieved from: http://www.tedi.uq.edu.au/downloads/CESoTL_2010.pdf

8.2. Dissemination for understanding

8.2.1 Workshop presentations

- **Invited**: GA Lawrie (2010) *Assessment for Learning: Can we foster learning communities in large diverse 1st year chemistry cohorts?* New Zealand Institute of Chemistry Annual meeting of 1st year chemistry coordinators, February 3rd. (University of Victoria, Wellington, NZ).
- GA Lawrie & KE Matthews (2010) *IS-IT CHEMISTRY? Active Learning in Collaborative Groups in Large 1st Year STEM Classes*. STEM in Education Conference Nov 23-24, (Queensland University of Technology, Brisbane).

8.2.2 Final Report

Available online at ALTC website.

8.2.3 Journal Articles

Published:

- Lawrie, GA., et al. (2010). *Forming groups to foster collaborative learning in large enrolment courses.* UniServe Science Conference Proceedings 'Creating ACTIVE minds in our Science and Mathematics students' (Sydney University, Sydney Australia) p66-71.

In preparation for submission:

- Lawrie, GA., Matthews, K.E., Gahan, L.R., Weaver, G, & McNaught, C. (2011) Mapping the learning outcomes of collaborative writing through the application of the SOLO Taxonomy. Manuscript in preparation.
- Gahan, L.R., Lawrie, G.A., Matthews, K.E., Weaver, G, Adams, P., Kavanagh, L., Long, P.D. Bailey, C., & Taylor, M. (2011) Technology-Enhanced Collaborative Learning in Large 1st Year Classes Through Interdisciplinary Scenario-Inquiry Tasks: IS-IT Learning? Manuscript in preparation.
- Lawrie, G.A., Matthews, K.E., Gahan, L.R., Kavanagh, L., & Weaver, G, (2011) The integration of cooperative and collaborative learning principles to foster positive interdependency in small groups in large classes. Manuscript in preparation.

8.3. Dissemination for action

8.3.1 Reference Group Workshop

Reference group members and key invited stakeholders will assemble in June 2011 for engaged dissemination of the outcomes of the project. The workshop will frame the tasks for uptake and implementation in interstate institutions.

8.3.2 IS-IT Learning Scenario Resource Book

The twenty seven IS-IT scenarios have been collated into a resource book which has applicability as a resource across secondary and tertiary contexts and STEM disciplines in supporting design of inquiry based interdisciplinary activities. This resource will be available in July 2011.

9. Links to other ALTC projects

This project builds on the outcomes and findings of the following ALTC projects:

- Adams, P. (2008). A new enabling technology for learning and teaching quantitative skills (ALTC report). Retrieved from: < http://www.altc.edu.au/project-new-enabling-technology-learning-uq-2006>.

- Kavanagh, L. (2007). Developing and disseminating TEAM SKILLS capacities using interactive online tools for team formation, learning, assessment and mentoring. (ALTC Report). Retrieved from: < http://www.altc.edu.au/project-developing-disseminating-team-uq-2007>.

- Kift, S. (2006). Articulating a transition pedagogy to scaffold and to enhance

the first year student learning experience in Australian higher education. (ALTC Report). Retrieved from: < http://www.altc.edu.au/altc-senior-fellow-sally-kift>.

- Kennedy, K., Krause, K.L., Maton, K., Bishop, A., Chang, R., Waycott, J., Judd, T., Gray, K., Bennett, S., & Dalgarno, B. (2009*). Educating the Net Generation: implications for learning and teaching in Australian universities. (ALTC Report*). Retrieved from: < http://www.altc.edu.au/project-educating-net-generation-melbourne-2006>.

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Adams, P., & Poronnik, P. (2006). Embedding quantitative principles in life science education (ALTC Report). Retrieved from: http://www.altc.edu.au/altc-associate-fellow-peter-adams.

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11. Appendices

11.1. Appendix A: Suite of IS-IT Scenarios

Please see separate attachment for the IS-IT Resource Book

11.2. Appendix B: Evaluation Instruments

11.2.1 Focus Group Questions

INTERDISCIPLINARY RELEVANCE

- In what way does chemistry relate to your program of study?
- How effective was the IS-IT activity in helping you link chemistry ideas to other disciplines? Give an example.
- In your group, were any decisions helped by the interdisciplinary perspectives held by any of your group members?

COLLABORATION & LEARNING

- What forms of collaborative assessment have you participated in prior to XXXX? How did these help you in the Scenario activity?
- In your opinion, what is the best strategy for students to work together on an assignment?
- How did being able to view and critique other groups' products help you in your learning?
- How effective was participating in 'gluing' the individual contributions from the group together in helping your understanding of the science behind your scenario?
- What is the most important thing to you that you learnt or can now do as a result of the scenario task?

ASSESSMENT & OUTCOMES

- How does the number and timing of assessment tasks in chemistry suit your study management?
- Which of all the assessment items has been most valuable?
- If an assessment task has no marks attached how much time do you spend on it?
- How did the peer assessment impact on your learning?
- Is there anything that you would do differently in this task a second time around?
- Is this task assessed at the right level for the work that you put into it?
- Do you feel that your mark will reflect your contribution to the task?
- How do you perceive that your outcome in this task will influence your outcomes in future study?

11.2.2 Pre/Post Questionnaire

Pre/post Scales
Scale Key: E= Effort; C = Concept; R = Reality Link; O = Outcome; GP = Group Processing; AG = Attitude to Group Work; PAGO = Performance approach to goal orientation; PAVGO = Performance Avoid to goal orientation; MGO = Mastery goal orientation; SI = Science identity and CI = chemistry identity.

Indicate to what extent you agree with each of the statements below relating to learning chemistry	
Learning chemistry helps me understand situations in my everyday life.	R
The chemical behaviour of atoms and molecules has implications in my life.	R
Chemical theories have little relation to what I experience in the real world.	R
To understand chemistry, I sometimes think about my personal experiences and relate them to the topic being analyzed.	R
It is possible to pass this course (get a grade of '4' or better) without understanding chemistry very well.	O
I read the text in detail and work through many of the examples given there.	E
Problem solving in chemistry means matching problems with facts or equations and then substituting the values to get a number.	C
Learning chemistry requires that I substantially rethink, restructure, and reorganize the information that I am given in class and/or read in the text.	O
Demonstrations of experiments do not provide me with useful information although they can be fun and exciting.	E
The main skill that I get out of this course is to learn how to reason logically about the physical world.	O
Knowledge in chemistry is constructed from many pieces of information which are unrelated.	O
Only a very few specially qualified people are capable of really understanding chemistry.	O
My grade in this course is primarily determined by how familiar I am with the material.	O
Understanding chemistry means being able to recall something I have read or been shown.	C
It is *unnecessary* for me to have to relate chemistry to the real world.	R
When I solve most exam or practice problems, I explicitly think about the concepts that underlie the problem.	C
After I numerically solve a chemistry problem, I check my answer to see if the answer makes sense.	E
In doing a chemistry problem, if my calculation gives a result that differs significantly from what I expect, I'd have to trust the calculation.	E
I use the mistakes I make on practice questions as clues to what I need to do to understand the material better.	E
The most crucial thing in solving a chemistry problem is finding the right equation to use.	C
To be able to use an equation in a problem (particularly in a problem I haven't seen before), I need to know more than what each term in the equation represents.	C
Indicate to what extent you agree with each of the statements below relating to working collaboratively	
I value my group members' knowledge as a resource for learning	GP
I prefer to work on an assessment task in groups or pairs	This study
Learning to work effectively in groups is important to me	GP
At this point in the semester, I have a positive attitude about group work.	GP
Working in groups helps me increase my understanding of a subject	GP

I am looking forward to working with other students on the IS-IT assessment task.	GP
If given a choice, I would work on the IS-IT assessment task alone.	This study
I prefer to work on an assessment task individually.	This study
Read each statement and indicate the extent to which they are true in describing you.	
It's important to me that I improve my skills in this course.	MGO
It's important to me that I thoroughly understand my CHEM1020 work.	MGO
One of my goals in CHEM1020 is to learn as much as I can.	MGO
One of my goals is to master a lot of new skills in this course.	MGO
It's important to me that I learn a lot of new concepts in CHEM1020.	MGO
Read each statement and indicate the extent to which they are true in describing you.	
It's important to me that other students in my class think I am good at my CHEM1020 work.	PAGO
It's important to me that I look smart compared to others in CHEM1020.	PAGO
One of my goals is to show others that CHEM1020 work is easy for me.	PAGO
One of my goals is to show others that I'm good at my CHEM1020 Work.	PAGO
One of my goals is to look smart in comparison to the other students in this class.	PAGO
Read each statement and indicate the extent to which they are true in describing you.	
One of my goals in this class is to avoid looking like I have trouble doing the work.	PAVGO
It's important to me that my lecturer doesn't think that I know less than others in class.	PAVGO
One of my goals is to keep others from thinking I'm not smart in class.	PAVGO
It's important to me that my IS-IT team members don't think that I know less than them.	PAVGO
It's important to me that I don't look stupid in class.	PAVGO
Read each statement and indicate the extent to which they are true in describing you	
I can see myself doing science in the future.	SI
I consider myself a science person	SI
Being involved in science is a key part of who I am	SI
I can imagine myself being involved in a science related career	SI
Read each statement and indicate the extent to which they are true in describing you	
I consider myself a chemistry person	CI
I can imagine myself being involved in a chemistry related career	CI
I can see myself doing chemistry in the future	CI
Being involved in chemistry is a key part of who I am	CI
OPEN RESPONSE ITEMS	
State how many people were in your team and how it was formed (do NOT give names of your team members). Then comment on how this impacted on your group's effectiveness	
How did your team communicate (email, face to face, used iCAS group space, etc)	
Thinking of last question - were these communication strategies effective? Explain.	
Comment on whether you felt adequately supported as you progressed through the task. Please identify anything that might have helped you work more effectively in your group	
Thinking about IS-IT task, what has been the most useful thing about the IS-IT task?	
On reflection, was this a useful activity in a first-year course?	

11.3. Appendix C: Peer-Assessment Criteria

INTERNAL PEER-ASSESSMENT: assessment of group member participation.

You need to assign a mark /100 for each of your colleagues in your group. There are three categories you should consider in assessing your colleague's involvement in the development and production of the report – participation and communication. By considering the following criteria, decide how important each criteria is and arrive at a mark /100 for each member of your group.

Category	Excellent 100-85%	Very Good 84-75%	Good 74-65%	Satisfactory 64-51%	Unsatisfactory 50-0%
Participation	Participated beyond the expectations of the task. Showed leadership in setting & meeting goals; maintaining group cohesion; and encouraging the best from team members.	Participated constructively throughout the task. Demonstrated skills in setting & meeting goals. Actively contributed to assisting the group work well together.	Participated in group. Showed concern for goals. Participated in achieving goals. Contributed to helping the group work together.	Sometimes participated in group activities. Showed concern for some goals. Minimal participation in identifying and meeting goals.	Participated minimally. Showed little concern for goals. Observed but didn't participate in goal setting. Completed assigned tasks late.
Intellectual Contribution	Completed assigned IQ and retrieved high quality information which significantly enhanced the group product. Provided an outstanding contribution to formulating a response to the metaquestion from available ideas & information.	Completed assigned IQ and retrieved useful information. Significantly contributed to formulating a response to the metaquestion from available ideas & information.	Completed assigned IQ and retrieved information. Contributed to formulating a response to the metaquestion.	Mostly completed IQ but information is minimal or irrelevant. Attempted to contribute ideas to constructing a response to the metaquestion.	Completed a minor component of the IQ and submitted incomplete material. Did not contribute in constructing a response to the metaquestion.
Communication	Established and promoted communication networks. Encouraged all group members to share their ideas. Listened attentively to others and proactively addressed other people's feelings and ideas.	Shared many ideas related to the goals. Encouraged all group members to share their ideas. Listened attentively to others. Empathetic to other people's feelings and ideas.	Willingly shared ideas. Listened to others. Considerate of other people's feelings and ideas.	Shared ideas when encouraged. Listened to others. Considerate of other people's feelings and ideas.	Did not share ideas. Did not contribute to discussions. Did not show consideration for others.

IS-IT TASK EXTERNAL PEER ASSESSMENT CRITERIA – assessment of the reports by other groups to the same metaquestion.
You need to assign a mark /100 for the reports of other groups. There are some components that you should consider in assessing these reports.
By considering the following assessment criteria, decide how important each component is and come up with a mark /100 for each report.

Category	**Excellent** **100-85%**	**Good** **84-75%**	**Good** **74-65%**	**Satisfactory** **64-51%**	**Unsatisfactory** **50-0%**
Communication	The report clearly articulates a well constructed and creative response to the metaquestion. The chemical principles which underpin the topic are clearly communicated and chemical reactions or processes are used to illustrate the role of chemistry in the scenario.	The report clearly provides a logical response to the metaquestion with elements of creativity. Appropriate chemical symbols, equations and structures have been included. Chemical principles and processes are presented with minor omissions.	The report clearly provides a logical response to the metaquestion. Appropriate chemical symbols, equations and structures have been included. Chemical processes are used to support the argument.	The report does not clearly convey what the authors intended. The content is does not include either chemical symbols, structures or evidence of chemical processes that occur.	The report is not a good example of communication. An attempt has been made to answer the metaquestion
Conceptual Understanding	Information derived from all of the IQs has been integrated to respond to the metaquestion. The underlying chemistry concepts are explicitly presented and linked to potential impacts on the environment and/or society. Quantitative data is used very effectively to support the discussion. Evidence of in-depth research of the topic using a wide range of sources.	Information derived from the IQs is linked to respond to the metaquestion. Underlying chemistry concepts are presented and the impact of the scientific discovery on the environment and society is stated. Quantitative data is included in the report and cited in the discussion. Some research of the topic evident with multiple sources.	Information from the IQs have been pasted together in response to the metaquestion. Underlying chemistry concepts are included. The impact of the underlying chemistry on the environment and society is stated. Quantitative data is included in the report. Some research of the topic evident with more than one source.	Information derived from some of the IQs is supplied in response to the metaquestion. Minor reference to the chemistry behind the scientific discovery included. A general statement of the impact of the research on society is provided. Very little research of the topic evident.	Of little or no educational value. Superficial coverage of the topic.

Presentation/ Visual Impact	Excellent and engaging report which is visually effective and imparts a well balanced presentation of the argument. Multiple high quality diagrams have been successfully integrated into the text to support the discussion. Minimal grammatical and typographical errors are evident. All sources referenced correctly. Report is the correct length.	Engaging report containing a clear presentation of the response to the metaquestion. Diagrams are of high quality and linked into the text. Report is relatively free from grammatical and typographical errors and is of appropriate length. Most sources referenced appropriately.	Well presented report containing a clear presentation of the argument. Diagrams are clear and referred to in text. Report contains a few grammatical and typographical errors however are of appropriate length. Most sources referenced appropriately with minor errors.	Satisfactory report containing a superficial presentation of ideas. Low quality diagrams not linked to text. Multiple grammatical and typographical errors present. Very few sources referenced. Report is substantially longer or shorter than the required length.	Badly set out, poor presentation of ideas, totally uninformative. Plagiarises literature and electronic sources.

11.4. Appendix D: Evaluators Report

Separate attachment.

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External evaluator's report

CG9-1112: IS-IT learning? Online interdisciplinary scenario-inquiry tasks for active learning in large, first-year STEM courses

This ALTC project on Interdisciplinary Scenario-Inquiry Tasks (IS-ITs) addresses a complex issue at the centre of challenges to science education in universities world-wide. The project has effectively addressed both resource issues (that have led to large classes) and pedagogical issues about how to strengthen capabilities for graduates entering a more varied and rapidly changing workforce. The three focuses of this project are:
1. How to design science tasks for first-year students that are genuinely interdisciplinary;
2. How to ensure that the inquiry-based tasks are cognitively challenging for first-year students; and
3. How to manage very large first-year science classes so that students engage actively in tasks.

The project members have a strong belief that all three focuses need to be addressed together – a conviction that I wholeheartedly share. This triumvirate of focuses (that have been explored and, largely, successfully enacted) positions this project as a significant contribution to science education in Australia and elsewhere.

In a series of meetings in October 2010, the team developed with me a comprehensive evaluation plan that is outlined in Table 1. This table served as an ongoing reference point in the project. Not all cells were completed but the overall plan has grown awareness about the varied sources of data and how each data source can serve an evaluative function. In addition, there is no way that busy academic staff could mine all this data in the time-frame of the project. However, there appears to be an interest for ongoing mining of the evaluation-research data.

The main data that has been examined to date is described in Table 3 of the main report.

The 'LEPO' (Learning, Environment, Processes, Outcomes) conceptual framework for curriculum design (Phillips, McNaught, & Kennedy, 2010, 2011) has informed thinking about the context and interactions involved in curriculum design in this project. Within a *learning environment*, students attain *learning outcomes* by going through *learning processes*.

The project has been well-managed. For example, the team maintained all records on project-management software (cutely called 'Basecamp'). The major challenge has been time – see my comments under *diffusion* below. The time-lines for analysis and dissemination activities have slipped. This is understandable with such an ambitious project but it is an issue that ALTC needs to recognize.

As noted in the main report, I have maintained contact with the group as a ‘critical friend’ at regular intervals since October 2010. I am privileged to be a participant observer in what I consider to be an excellent example of design-based research (DBR). While the Project Team describe their work as action research – and it does fit into that research methodology – my own perception it that the outcomes of the project are contributing to theoretical understandings as well as practical resources and guidelines. It is this dual nature of theoretically informed planning and evidence-based outcomes that makes DBR so useful for projects such as ALTC projects.

Reeves (2006) described the iterative nature of DBR as involving:

- analysis of practical problems;
- development of solutions based on existing knowledge;
- evaluation research of the solution in practice; and
- reflection to produce *design principles*.

It is not the purpose of this brief report to examine the intricacies of DBR; additional useful references are Barab and Squire (2004); Herrington, Reeves, and Oliver (2009); Phillips, McNaught, and Kennedy (2011); Van den Akker et al. (2006); and Wang and Hannafin (2005). Rather it is to record that this project is a good example in the Australian context of DBR in university science education.

A key point I want to make is that unless innovative projects have *both* a good theoretical basis *and* good evaluation evidence, they are unlikely to make an impact on the higher-education sector. Colleagues will not investigate a set of resources with accompanying pedagogy unless they have a compelling reason to do so. This means that projects need to produce a persuasive educational rationale and a convincing set of data about student learning outcomes.

The IS-ITs project has produced the rationale and has preliminary convincing evidence about student learning outcomes. I will comment later on the implications of the word ‘preliminary’.

It is my considered opinion that the IS-ITs project has been conducted well and is successful in its outcomes. The findings of the project are endorsed, as are the recommendations.

This brings me to the ‘Catch 22’ of project work – and the reason I think the sector (world-wide) has such a poor record in diffusion of project outcomes. There are three main steps in innovation from the base of a funded project.

1. The first is *sustainability* – will the project be able to continue once funding has ceased? Because the IS-ITs project invested a considerable amount of creative energy and time in the development of a technology system to support large-scale collaborative projects with first-year students (iCAS), it is well-placed to get a ‘tick’ on sustainability. Other aspects of sustainability include having ongoing staffing and this is something I cannot comment on.

2. The second is *dissemination*. The IS-ITs project has been reported already quite well on a number of occasions and robust publications are in an advanced state of preparation. Further, the planned workshop in July 2011 with senior academics from seven Australian universities is an impressive plan for active dissemination. A good ‘tick’.

3. The third (and this is the critical step) is *diffusion* – to what extent does the project genuinely impact on student learning in the sector? Is the design taken up by others? Are the resources reused in any fashion?

   Here, I think we have some hard questions to answer. What rewards exist in the sector for university teachers to adopt and/or adapt innovative learning designs and resources? How do universities – at department, faculty or institutional level – plan and enact work-allocation procedures? Is sufficient time for a) innovation; and b) intensive student-centred activity given to teachers, teaching support staff and IT support staff?

   It is my belief that the answer is that the sector needs to address these questions as a matter of high priority. If the sector is to reap the benefits of scholarly projects, such the IS-ITs one, then policy decisions are needed to ensure the outcomes can be successfully diffused.

Table 1. Overall evaluation plan for the IS-ITs project.

Aspect	*Possible evaluation questions*	*Data sources and comments*
1. Learning environment		
Design of iCAS	1.1 What works really well? Which aspects are to be optimised?	• Teacher reflection. *A 'key milestones' table was suggested. This is a checklist of a few questions regularly addressed in order to record details of successes and challenges. However, for reasons of workload, this level of evidence of reflection was not achievable in this formalized fashion. There was good communication and reflection but in a less formal fashion. For example, details of the evolutionary thinking can be found in the conference papers.*
		• Student focus group (FG). FG data can provide data on pragmatic matters and also learning-related matters. *The protocol in Appendix B contains both aspects.*
		• CBIT interviews – key staff *Interview data exists and provides evidence of technology sustainability.*
IS-IT template	1.2 How are the 4 IQs clearly differentiated?	• Evolution: rationale for versions over time – teacher reflection. *Such discussions enabled a more systematic process for refining iCAS.*
		• Log data. Is there any evidence for one IQ being more engaging/ taking more time than others? *Still to be mined but evidence does exist in FG data.*
		• Student FG using critical incident. Qs such as: "Tell me about the best part of the IS-IT?" See if there are differences in the responses from students with different IQs. • Ditto for "Tell me about the worst part of the IS-IT?" *Examples of good evidence are cited in the main report.*
	1.3 Is there enough scaffolding?	• Student FG using critical incident. As above, but add in Qs such as: "Did you get lost/ frustrated at any point?" *Examples of good evidence are cited in the main report.*
	1.4 How long does it take to write an IS-IT?	• IS-IT writer interviews (selected). *Not the most prolific writers. Process in train.*
Sustainability	1.5 How do we reduce moderation workload?	• Examine university policy around moderation – data log from moderation to see what patterns exist when marks are changed. *Not done at this stage.*
	1.6 How are levels of IT support to be provided?	• Interviews with key CBIT staff and budget analysis data. *Analysis in train.*

	1.7 What is the shelf-life of an IS-IT?	• Student choice data. *Reported in the main report*.
	1.8 How do we ensure academic integrity?	• Peer-assessment flagging to be monitored. *Analysis in train*. • Selection via Turn-it-in. *Preliminary exploration has been done*.
	1.9 What is the Q/A process?	• How are writers selected? • How are IS-ITs peer-reviewed? *A clear document is under development*.
	1.10 How much does an IS-IT cost?	• Costs – from CBIT (development vs maintenance) and time. *To be analysed*. • Budget analysis *Analysis in train*.
IS-IT topic choice	1.11 How are choices catering for student needs?	• Basecamp records may show the origin of writing of IS-IT mapped to program *A useful resource for ongoing monitoring*. *This is included in the IS-ITs resource book*
2. Learning process		
Student timing	2.1 When do students start each phase?	• iCAS data log. *Awaiting analysis*.
Group formation	2.2 How did they select a group? 2.3 How did the group gel?	• Student FGs • iCAS log data – selection of IS-IT vs assigned IQs • Qs in post-survey or student FG such as "How did you form your group?". *Reported in the main report*.
Intra-group communication	2.4 What were the mechanisms for ongoing communication?	• Peer-assessment comments • Analysis of discussion forum • Qs in post-survey or student FG such as "How did your group communicate?" "Were these strategies effective?" *Details included in main report*.
Negotiation (decision-making) and integration	2.5 What supports do students need for teamwork?	• Blackboard data on access to supporting material. • Qs in student FG such as "What supports did you want/ need?" "How did you find support?" "Were you ever left in a situation where you were really stuck?" • Christy's analysis of reports with respect to integration • Pre-/post-survey data (*analysed with identified scales*) *Evidence that support in this area might need to be embedded more*.

Approaches to learning	2.6 How do students' approaches to learning change?	• Pre-/post-survey data (*analysed with identified scales*)
Motivation for science	2.7 How does motivation to do science/ chemistry change?	• Pre-/post-survey data (*analysed with identified scales*)
Different disciplinary groups – engineers and science	2.8 Are their disciplinary differences in group formation and mechanisms for ongoing communication? What evidence do we have these teamwork choices facilitated learning?	• Pre-/post-survey data (*analysed with identified scales*). *Details included in main report*.
3. Learning outcomes		
Applies to individual IS-IT analysis (27)	3.1 Is there evidence of (insert rubric criteria)? 3.2 What are the sources of literature used by students?	• Analysis of student work using SOLO taxonomy. *Details included in main report*. • Analysis of grades • Open comment on post-survey "What has been the most useful thing about the IS-IT?" "On reflection, was this a useful activity in a first-year course?" Other survey items as appropriate. *Reported in the main report*.

References

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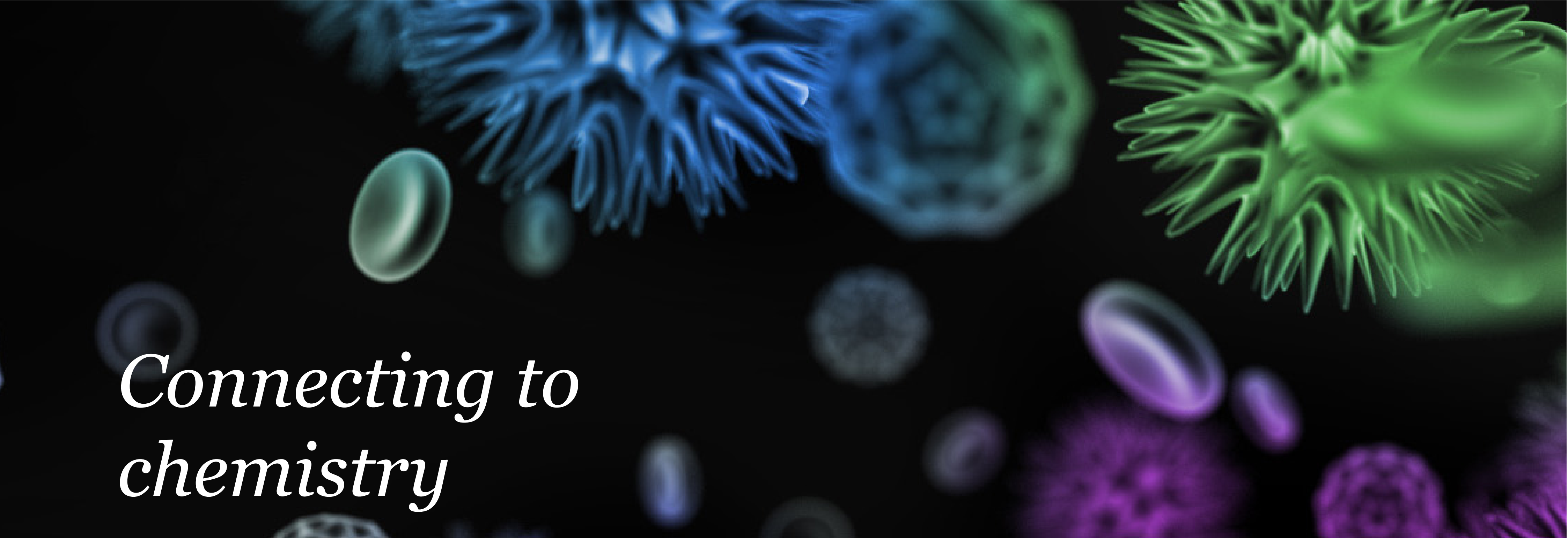
18 May 2011

11.5. Appendix E: UQ Teaching & Learning 2010 E-zine Article

Separate attachment.



Connecting to chemistry

Gwen Lawrie and Lawrence Gahan, School of Chemistry and Molecular Biosciences, and Kelly Matthews, Teaching and Educational Development Institute

Inspiring first year chemistry students to connect to chemistry is a challenge. However, helping them see the connections to contemporary issues has become an effective way forward.

'IS-IT Chemistry' has evolved through an Australian Learning and Teaching Council project to enhance engagement, interdisciplinary thinking and active learning through collaborative tasks. Students are challenged to create a solution to an overarching question in one of 27 real-world contexts. To achieve this, and utilizing a large interdisciplinary project team, scenarios that recognize the diverse range of interests and career aspirations among the 1360-strong student cohort in CHEM1020 have been formulated. Students have been able to choose contexts they find interesting and assemble their own working groups if preferred.

The instructional design behind these tasks is grounded in literature relating to collaborative learning environments, active learning and authentic assessment. Interdependency is established through individual quests that require each student to contribute core information to the collaborative group report. Students are ‘scaffolded’ through various phases to maintain engagement in the task and troubleshoot group dynamic issues.

While students have to discover the molecules and chemical processes underpinning their scenario (the chemistry is often imbedded and not immediately obvious), they are able to consider social and ethical issues. Students recognise that working collaboratively, communicating science and peer review are professional qualities that can be assessed alongside chemical concepts. Choosing a scenario has enabled them to link the chemistry to their own discipline.

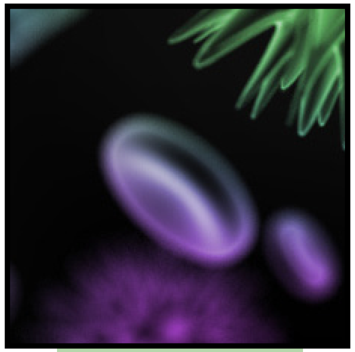
Student reports are being analysed for integrative thinking and creativity, while student perceptions of the collaborative process and outcomes have been gathered through focus groups.

A successful pilot in semester 1 in 2010 with a smaller, more coherent professional group has evolved into a full implementation in semester 2.

The implementation has drawn on the expertise of project team members Lydia Kavanagh, in working in teams; Gabriela Weaver (Purdue University), in collaborative inquiry learning; Peter Adams, in interdisciplinary thinking; Phil Long, in innovation in educational technology; and CBIT (Centre for Biological Information Technology), in the development of a task management technology.

The tasks and assessment are currently situated in chemistry, but the framework is applicable to other disciplines (particularly Science, Technology, Engineering and Math disciplines) and the next stage is to expand the group products into new discipline areas and genres.

So, if you want to know whether it is possible to replace all your organs with biomaterials, or what surviving on the bottom of the ocean floor has to do with designing the next chocolate sensation – ask a first year chemistry student!



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