Faculty of Science – Curriculum Renewal Pilot
Embedding Research-Enriched Learning And Teaching

The Curriculum renewal pilot in the Faculty of Science was focussed on Principle 2 from the CCPC Guidelines: Embed Engaged Enquiry, with a particular focus on embedding research-enriched learning and teaching, to develop graduate attributes.

Principle 2: The curriculum renewal process should support faculties in being confident that their degree program curricula are aligned with the University’s strategic directions. In particular it should support the embedding in disciplinary curricula of ‘Engaged Enquiry’ as a Sydney signature learning experience using research–enriched and community-engaged learning and teaching, which facilitates the development of the ‘Sydney Graduate Attributes’ by our students. (Embed Engaged Enquiry to foster graduate attributes)

The renewal process should support the achievement of desired graduate outcomes by explicitly linking the outcomes of teaching and learning with the process of teaching and learning in a way that supports the University in delivering an undergraduate education with a clear point of difference to that of our competitors. These outcomes are articulated in the faculty statements of The University’s graduate attributes. The University has now also identified Engaged Enquiry as a hallmark of a student learning experience at Sydney, and research-enriched learning and teaching (RELT) and community-engaged learning and teaching (CELT) experiences provide new opportunities for designing engaging, effective curricula and assessments. These signature learning experiences also offer new possibilities for defining pathways and degree ‘identity’ for students. The curriculum renewal process should explicitly support faculties and divisions in identifying and developing the opportunities RELT and CELT offers in their contexts.

As requested, this report to the CCPC committee focuses on:
1. The processes used to achieve curriculum renewal in the faculty
2. How the curriculum renewal process engaged staff and students in the faculty
3. What data the curriculum renewal process has drawn on
4. How Engaged Enquiry using RELT is embedded in the curriculum and co-curriculum to foster the development of graduate attributes
5. Any recommendations for curriculum development in the faculty that have resulted.
Introduction

In this report, a series of focussed and related initiatives to evolve the teaching programs of the Faculty of Science by embedding engaged enquiry through research-enriched learning and teaching are described.

The strategies employed through each initiative are designed to synergistically work together and support each other. Each initiative has also sought to engage academic and professional staff from within the Faculty, from allied disciplines and from co-curricula centres such as the Library, ITL and eLearning.

In each initiative, the emphasis has been on enabling all students to learn in this way and to ensure that the experience of every student is enhanced irrespective of the pathway that is chosen. They thus complement the existing Talented Students Program. After a brief overview of our programs and a rationale for the curriculum renewal, the following interrelated initiatives are described:

1. Embedding core foundation skills in first year units of study 5
2. Embedding inquiry laboratory experiences in first year units of study 8
3. Mapping graduate attribute development across multiple pathways and majors 10
4. Moving towards threshold learning outcomes 13
5. Identifying duplication and maximising strengths in the Division of Natural Sciences 15
6. Encouraging innovation and capacity building in research enriched learning and teaching 16
7. Using student evaluation data to measure student perception of research enriched learning and teaching 17

In each of these sections, an overview of each initiative is given followed by a description of how the curriculum renewal process engaged staff and students and the data used to inform and evaluate it. Where appropriate, recommendations for future developments are then reported.
Brief background to the Faculty of Science programs

The Faculty of Science offers 3 generalist science degrees:

- Bachelor of Science (BSc) – the ‘flagship’ degree available in a number of flavours including Advanced and Advanced Mathematics. Around 800 new students commence the BSc each year.
- Bachelor of Medical Science (BMedSc) – a degree covering the enabling sciences as well as medical science. Around 300 new students commence the BMedSc each year.
- Bachelor of Liberal Arts and Science (BLAS) – a degree that enables students to study at high levels in both arts and science and that is co-taught between the Faculty of Science and the Faculty of Arts and Social Sciences. Around 400 new students commence the BLAS each year.

The Faculty’s strategic plan recognises research as a major driver in its reputation and its ability to attract and engage the best students. Those teaching are themselves almost always actively involved in research and strive to embed current research ideas and practice into the curriculum. Science students naturally spend a considerable amount of their time in laboratories. The ‘Talented Student Program’ (TSP) is a highly sought after and popular way for high achieving students to undertake research. Honours continues to be seen as the capstone experience and involves embedding students directly in the research environment and culture of research groups in the Faculty.

Each of these degrees offer a wide range of majors from Science and from the School of Medical Science and a extensive number of pathways and options for students to follow even in first year. Embedding and evaluation of research enriched learning and teaching experiences for all students, irrespective of unit choices and pathway, is therefore complex and involves working with many disciplinary approaches. The BSc has no core units.

Students from every other faculty also take our units of study. In allied disciplines such as the health sciences and engineering, content knowledge is important and our units are integral to and service their programs. For others, science units are taken out of interest.

This report covers recent curriculum renewal work that seeks to ensure that all students in the Faculty’s programs have research enriched learning and teaching experiences in non-TSP units of study within the 3 year BSc, BMedSc and BLAS degrees. Although TSP and Honours are the most direct research enriched experiences available, they are thus not included in this report.
How Engaged Enquiry using RELT is embedded in the curriculum and co-curriculum to foster the development of graduate attributes

Engaged enquiry is a central value for the Strategic Plan 2011-2015. Research-enriched learning and teaching (RELT) is the most natural pedagogy for undergraduate science disciplines to embed enquiry in a research-intensive and focussed institution such as the Faculty of Science. We seek to develop scientists who will become national and international research leaders. Alongside development of content knowledge and skills, we seek to develop inquiring scholars who approach research with a strong understanding of and commitment to the scientific method.

Students commencing university study now come from a wide variety of educational and cultural backgrounds, and their preparedness for academic-level study can vary significantly. To flourish in a research-intensive university and to be ready to undertake research-enriched activities, this wide range of students need the ability to conduct self-directed, independent study in large classes, often whilst juggling university and part-time employment. To enable research-enriched learning to occur in the context of a larger and changing student body, it is vital that academic skills are developed in first year courses. Such development needs to be independent of a student’s unit choices.

Advances in technology are fundamentally changing the way that students learn and the places where learning takes place. Our curriculum needs to evolve and develop to take advantage of these developments and to ensure that current and future students are actively engaged. A curriculum, which is content heavy and is delivered didactically, is not suitable for many of today’s learners or relevant for their future employment and roles. Enquiry, guided through the lens of the scientific method, can be used to ensure ongoing engagement and relevance of laboratory and classroom teaching.

Laboratory work is very expensive to deliver, requiring considerable infrastructure as well as consumables and personnel. Laboratory work that is primarily instructor or recipe driven with the aim of reproducing known results is not only unengaging. It is not authentic of the way that researchers work. The cost pressures and the availability of video and simulations have led to suggestions for laboratory work to be reduced or replaced, particularly in service units. We strongly believe in the value of the laboratory experience.

Much future scientific progress is likely to occur through interdisciplinary teams that build on the strengths of the historical disciplines as well as at the boundaries between. To ensure the sustainability of our programs and to maximise opportunities for students in cross-disciplinary research, shared teaching models, which draw on expertise in the natural sciences from across the University, need to be developed.

The pressure to renew our curriculum and embed research-enriched experiences is not just led by University drivers or by the changes in technology and learning styles. One of the three strands of the new school ‘Australian Curriculum: Science’ is ‘Science Inquiry Skills’. Students who commence university from high school will thus soon already have experienced an enquiry-focussed approach to science for us to build on. At the tertiary level, the Learning and Teaching Academic Standards project has published threshold standards for what constitutes a science degree. These also explicitly identify inquiry and problem solving and a coherent understanding of the scientific method as central threshold learning outcomes for Bachelor degrees in Science. These standards are likely to become those used by TEQSA as well as by the professional bodies in Science.
1. Embedding core foundation skills in first year units of study

Overview of initiative

As noted above, our commencing students now come from a wide variety of educational and cultural backgrounds. They begin their studies with a range of academic skills and previous exposure to laboratory work. To engage fully and effectively in research-enriched activities requires students to have certain foundation skills. For example, students asked to read and analyse research literature who do not have basic understanding of academic honesty or referencing methods in higher education are being set up to negligently plagiarise.

The BSc and BMedSc degrees do not have units of study devoted to the development of academic skills. Further, the BSc and BMedSc degrees do not have any core units of study to serve as foundation courses. Evidence from USE evaluations and more anecdotal feedback from coordinators of intermediate and senior units of study strongly suggested that development of academic skills in our first year subjects was patchy. Given the subject choices available, students could have experienced little or no skill development or might encounter duplicate or even contradictory activities. Because of the size of the student cohorts and unit choices available, the assumption that academic skill development is “someone else’s business” is perhaps inevitable.

How the curriculum renewal process engaged staff and students

The ‘Sydney Scientist’ project, funded through a TIES grant, sought to identify academic skill gaps and to develop a framework for incorporating the development of key foundation skills across first year. The project team included the Associate Dean (Learning and Teaching), a Director of First Year Studies from one of the largest Schools in the Faculty and the Acting Manager, Library Service, Sciences and Technology. The key skills needing to be targeted in semester 1 of first year were identified through:

- mapping of current practice across all first year units of study,
- surveys of incoming students,
- student and first year coordinator focus groups and
- discussions with Faculty Liaison Librarians and eLearning.

The following were identified as key to the development of threshold academic skills to enable research-enriched learning and ultimately lead to relevant graduate attributes:

- plagiarism and academic honesty,
- understanding of what constitutes a scholarly resource, and
- searching, finding and reading the primary literature.

The research stage of the project also led to the following consensus for how the curriculum should be renewed to strengthen these skills:

- to engage students and lead to meaningful uptake, skill development should be embedded in the disciplines not as standalone activities or in a foundation unit,
- a consistent approach should be used at first year irrespective of small differences in disciplinary styles,
- development of academic skills is a shared responsibility of all units in a generalist degree such as the BSc,
- associated activities should be valuable to each discipline to ensure ongoing engagement,
- threshold skill development should be independent of the unit choices,
- workload for teaching staff should be minimised and
- duplication and additional workload for students should be minimised.
Each of the academic skills listed above were then embedded in key tasks in semester 1 in the units offered by the Schools of Biological Sciences, Chemistry, Physics and Psychology. The nature of the choices available for BSc, BMedSc and BLAS students means that this covered all new students in both degrees. In each unit, the Library’s ‘iResearch’ information skills modules were embedded in the curricula as part of assessments or in other compulsory tasks.

The iResearch modules are short, fully online scenario based courses available via the Library’s website. Students are awarded a certificate of completion and this is re-used across multiple units of study, thus avoiding duplication of work and ensuring consistency of approach identified as issues in the research stage of the project. Staff are provided with completion data electronically so that their workload is minimised too.

The usefulness of the iResearch modules is directly evaluated through an survey at the end of each. Evaluations by both staff and students is overwhelming positive. Other faculties now use the certificate of completion system, introduced through the fairly unique faculty – library collaboration in this project. For example, around 12000 certificates have been issued for the ‘plagiarism and academic honesty’ module by mid 2013.

The introduction of these threshold skill modules into our curricula has enabled further RELT activities to be introduced into first year courses. For example:

- the ‘plagiarism and academic honesty’ module is used as a starting point for discussions on scientific ethics in Biological Sciences, Chemistry and Physics,
- this module is also now used as the starting point for academic writing tutorials in Psychology,
- the ‘scholarly vs non-scholarly resources’ module is used as a starting point for the extended research dissertation in Biological Sciences and
- this module and the ‘finding journal articles using databases’ module are used as starting points for the research literature assignment in Chemistry.

This curriculum renewal work has been disseminated through a number of routes:

- internal workshops for first year coordinators in Science,
- presentations at other faculty learning and teaching workshops,
- presentation at the First Year Experience Working Group in Sydney,
- presentations at the Sydney Teaching Colloquium and
- papers at science education, first year experience and library conferences.

Data the curriculum renewal process has drawn on

Figure 1 shows the improvement in the USE responses to Q3 (graduate attributes) since this curriculum change was introduced in 2011. Given that responses to this question have historically proved hard to shift for our first year courses, the sustained improvement is pleasing. The change is no doubt due to a number of improvements of which the academic skills improvement intervention was the just most deliberate.

On the SCEQ for first year students, the changes in the generic skills scale are shown in Table 1. The improvements are agree with the USE although the response rate is relatively small.

Table 1. Percentage changes in SCEQ scores on the generic skills scale between 2009 and 2011.

<table>
<thead>
<tr>
<th>Degree</th>
<th>Degree average</th>
<th>Broad agreement</th>
<th>Agreement</th>
<th>Disagreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSc</td>
<td>+10.4</td>
<td>+5</td>
<td>+12</td>
<td>-5</td>
</tr>
<tr>
<td>BMedSc</td>
<td>+12.9</td>
<td>+9</td>
<td>+4</td>
<td>-9</td>
</tr>
</tbody>
</table>
Figure 1. Changes in USE Q3 (“This unit of study helped me develop valuable graduate attributes”) for first year units involved with the academic skill development review in 2011 – 2013.

Recommendations for curriculum development in the faculty

The model of developing foundation information skills through embedded tasks in multiple first year units of study with a common database has proven highly effective way in both the Faculty of Science (and now beyond). This could be extended in a number of ways, including:

- the development and recording of other key foundation attributes for research enriched learning, including writing and communication and laboratory skills, and
- the interfacing of the certificate database with student record systems to automatically generate student portfolios for both students and second year coordinators.
2. Embedding inquiry laboratory experiences in first year units of study

Overview of initiative

In our experimental units of study, students spend around a half of their face-to-face time in laboratories. Traditionally, these sessions have been mostly ‘recipe’ driven with students repeating key and sometimes historically important experiments to replicate and illustrate core theoretical concepts and to develop basic experimental skills. The key drivers for a shift towards a more inquiry-focused laboratory curriculum are:

- a desire, expressed through internal, national and international projects, to make the laboratory experience more authentic to the research activity of professional scientists,
- a parallel desire to excite and engage students and enhance progression rates in to scientific careers, including research and teaching,
- pressures to justify the time and expense of laboratory work, especially given the availability of excellent computer simulations and video and
- the introduction of inquiry as a thread in the high school ‘Australian Curriculum: Science’.

At a national level, academic scientists have agreed on the ‘Threshold Learning Outcomes for Science’, which formalise the importance of inquiry through the design and planning of investigations built around the scientific method.

The first year laboratory programs in Biological Sciences (BIOL1001, BIOL1901, BIOL1002 and BIOL1902 in 2012) and in Chemistry (all CHEM1 units in 2011) have been completely replaced by new programs with inquiry at their centre. The programs in Molecular Bioscience (MBLG1001 and MGLG1901) and Physics (all PHYS1 units) have been substantially changed in this way too. In these programs, students now have research-enriched and full scientific research experiences including:

- gathering, synthesising and critically evaluating information from a range of source,
- designing and planning an investigation,
- selecting and applying practical and/or theoretical techniques or tools in order to conduct an investigation and
- collecting, recording, interpreting and drawing conclusions from scientific data.

How the curriculum renewal process engaged staff and students

In Biological Sciences and Chemistry, the complete renewal of the laboratory courses was undertaken over a number of years through:

- allocation of resources and staff time, including use of institutional grants,
- whole School discussions involving all academic and research-focused staff and discussions with technical and professional staff including lengthy consultations with teaching laboratory service rooms.

Writing new inquiry experiments, or sliding existing experiments from the literature or other institutions towards inquiry can be a lengthy process. Many aspects must be considered, including:

- health and safety
- limitations of infrastructure and the cost of re-equipping current laboratories
- availability and costs of equipment and consumables
- availability and skills of technical staff, supervisors and demonstrators and
- suitability of tasks for the range and number of students who will be performing them.

With inquiry based experiments, these issues are compounded by the desire to introduce flexibility and more open investigations. As a result, experiments are trialled by staff and by
students with both formal surveys and informal focus group discussion. For the Chemistry experiments, for example, each experiment was trialled at least 3 times by student groups leading to extensive modifications.

Data the curriculum renewal process has drawn on

The evaluation of individual experiments, including an assessment of the amount of inquiry they entail, as well as whole has also been made using the ‘Advancing Science by Enhancing Learning in the Laboratory’ (ASELL) process. The ASELL process involves the practical and educational benefits of experiments being assessed through review by academic peers and students across Australia in national workshops.

Evaluation process thus include:

- Surveys of individual experiments, including items related to effectiveness of the inquiry elements, using our own and ASELL surveys,
- ASELL workshops and trials and
- USE and ASELL surveys for whole laboratory programs once in place.

Figure 2 shows the change in the USE responses to Q10. This is a faculty chosen item and relates to both tutorial and laboratory class. The major changes to the Chemistry laboratory curriculum were introduced in 2011 whilst those in Biological Sciences were introduced in 2012. For Chemistry, the percentage dissatisfaction was higher in 2011 than in 2010 but improved substantially in 2012, reflecting the need to bed down such large curriculum changes. Even with careful preparation and trialling, rolling out to classes of 2000+ is never straightforward.

![Figure 2. Changes in USE Q10 (“Tutorial classes and/or laboratory classes were worthwhile”) for semester 1 and semester 2 first year units with laboratory classes in 2008 – 2013.](image)

Recommendations for curriculum development in the faculty

The initiatives described above show how inquiry-based experiences can be introduced in large first year units. Renewal of our laboratory programs to engage students in research-enriched activities is key to progression into Honours and beyond. Focus on third year and capstone experiences is required and this may require better data and tools for evaluating practice in each major.
3. Mapping graduate attribute development across multiple pathways and majors

Overview of initiative

As noted above, the BSc degree has many pathways leading to a wide range of general and specialised majors. Given the rapidly expanding field of knowledge in science and the emergence of new disciplinary and cross-disciplinary fields, there has been a tendency for our curricula to become ‘content heavy’. Development of graduate attributes in the 3 year degree program has often taken a back seat, with the Honours year seen as the capstone experience in the degree. Research-enriched learning experiences are assumed to occur but it has been hard to ensure that development of the related graduate attributes truly does occur irrespective of the pathway.

How the curriculum renewal process engaged staff and students

Re-framing the science degree in terms of engaged enquiry requires an initial first step of mapping the curriculum across all of the pathways. In order to do this, the ‘Sydney Scientist’ unit of study template application was written in 2010-2012. This online application was designed to assist coordinators with the construction of unit of study outlines, which comply with the requirements of the assessment policy, and can be embedded as objects in the learning management system. In the context of this report, completion of the unit outline required coordinators to give:

- a list of learning outcomes with details of how the knowledge is assessed and
- the links between these learning outcomes and those of the program and the University’s graduate attributes.

Although such information was available in many units of study, it was not universally so. Requiring that this information is available for all units of study in a consistent and electronic format has many advantages for both staff and students. For students, the curriculum can be mapped out at any point of their study and the links between each assessment and the program goals is consistent and transparent. Similarly for staff, the role of each unit as a component within a program is evident as is mutual responsibility for graduate attribute development.

When completing the outline, the coordinator is walked through the following tasks:

- write learning outcomes for the unit of study,
- describe each assessment task including an indication of the learning outcomes that they address,
- indicate which of the contextualised graduate attributes are developed in the unit and at which level and
- link the graduate attributes to the learning outcomes.

With this data held electronically, it is possible to link directly between the assessment of a learning outcome in a unit to the development of a graduate attribute at the program level, and vice versa. This information is available for each unit of study and for collections of units, such as all first year units or those that comprise a major. Figure 3 shows an extract from a first year unit outline, illustrating the alignment between the unit learning outcomes and the graduate attributes. This has renewed focus on graduate attributes at the unit level and, most importantly, has required to coordinators to align and justify their assessments with both unit and program goals. Learning outcomes that are not assessed or assessments that are not aligned with learning outcomes and graduate attributes are rapidly identified.
Figure 3. Extract from CHEM1001 unit outline showing alignment between unit level learning outcomes, assessment tasks and graduate attributes. Clicking on the dots gives the user more information on the particular learning outcome.
For students, graduate attributes are given a new prominence by being explicitly aligned with learning outcomes and assessments. As shown in Figure 3, each assessment is linked to the unit level learning outcomes. Clicking on the links (the dots in Figure 3) gives a description on the aligned graduate attributes. This information is also central to that stored in the associated electronic assessment calendar which incoming students sync with their personal calendars in O-week.

Data the curriculum renewal process has drawn on

The application allows staff (and students) to assemble several units of study and construct a graduate attribute map across, for example, a particular major or a collection of units. Such data provides a view of what is taught. This will inform the conversations in the next phase of the process to answer the questions: why is it taught, how is it taught and is it learnt through our assessments?

Figure 1 in Appendix 1 shows the current map for a one of the combinations of units leading to a Chemistry major. As in the unit level map, gaps become obvious. For example, in this case, no unit of study in the major develops the information level attribute B4 (“Consider the economic, legal, social, ethical and cultural issues in the gathering and use of information.”) or E3 (“Demonstrate empathy with, and sensitivity towards, another’s situation, feelings and motivation.”). Research and inquiry though is a strong focus of the program. Evidence for how the graduate attribute is actually developed and assessed can be obtained by clicking on the links (the dots in the figure) to drill down to the unit level learning outcomes and their assessment.

Figure 2 in Appendix 1 shows the current map for first year units. This size and complexity of the map illustrates the task involved in ensuring a consistent and assured pathway for all students irrespective of their unit choices. As noted above, the original version of this map was used by the Sydney Scientist team, in collaboration with the first year coordinators, to identify holes in threshold skill level development.

There are a number of issues associated with attempting to accurately gather the data required for this project, including a number that are clear from the maps in Appendix 1:

- 100% compliance with the process is difficult to achieve given the large number of coordinators involved,
- coordinators have to re-focused from a discipline centred approach to a program level one,
- some coordinators see the process as just another box ticking exercise and
- calibration of what constitutes graduate attribute development and at what level this is done between coordinators is required.

These issues have not been fully resolved. In part, at least, they form necessary steps in a curriculum renewal process that focuses on program level goals and graduate attributes and replaces a traditional emphasis disciplinary and even on individual preferences of topics.

Recommendations for curriculum development in the faculty

The mapping process has been highly successful in engaging coordinators with considering the learning outcomes of their units and constructively aligning their assessments. The program and year level information now available can be used to inform discussions between coordinators and catalyse renewal at these levels. That this can be achieved has been demonstrated by the Faculty-wide ‘Embedding core foundation skills in first year units’ initiative described above which brought together a team of coordinators and co-curricula support.
4. Moving towards threshold learning outcomes

Overview of initiative

At the national level, the Faculty has been heavily engaged in the ALTC Learning and Teaching Academic Standards (LTAS) project. The Australian Council of the Deans of Science (ACDS) strongly supports and has endorsed Science Threshold Learning Outcomes (TLOs) nationally. The TLOs define the *minimum* learning outcomes a pass graduate must achieve at the end of a three year BSc. These include discipline specific knowledge and skills (including generic skills). In many ways, the threshold standards form a more natural language for science academics to work with than graduate attributes although the two approaches are closely aligned. As the TLOs have been agreed nationally, it appears highly likely at the point of writing that they will become the basis for the accepted standards used by TEQSA. The approach and the statements also closely align with those from European Tuning Project and UK Quality Assurance Agency.

The TLOs for Science cover the enabling and cross-disciplinary sciences in the Faculty including the mathematical and earth sciences but excluding Psychology. The graduate achievements in Psychology are closely aligned with strict accreditation requirements. The TLOs seek to describe what a BSc is and what BSc graduates can do. This encompasses both a body of knowledge and the process of discovery that is unique to the science.

The TLOs shift the focus from inputs to outcomes. For example, the Royal Australian Chemical Institute (RACI) has accredited laboratory work in Chemistry majors through hours spent in the laboratory. The TLOs replace this with a minimum expectation of skills and proven problem solving ability. Although much harder to assess and requiring fundamental reviews of our teaching and assessment, this approach is much more useful in rewarding and engaging students for participating in and staff for shifting to research-enriched approaches.

A number of the TLOs encompass research-focused outcomes most obviously in the “Inquiry and Problem Solving” section, which requires that each student passing the BSc can:

3. Critically analyse and solve scientific problems by:
   3.1 gathering, synthesising and critically evaluating information from a range of source,
   3.2 designing and planning an investigation,
   3.3 selecting and applying practical and/or theoretical techniques or tools in order to conduct an investigation and
   3.4 collecting, accurately recording, interpreting and drawing conclusions from scientific data.

How the curriculum renewal process engaged staff and students

The development of the overarching Science TLOs was carried out through national fora led by ALTC Discipline Scholars. The next stages of this process involve adapting the Science statements to the disciplinary contexts and their implementation across the sector:

- The national discipline networks in Chemistry (ChemNet), Mathematics (AMSLTN), Biomedical Science (CUBEnet), Physics (PEN) and Biological Sciences (VIBEnet) are currently writing detailed learning outcomes for the majors and
- The ACDS Teaching and Learning Centre has formed a working party to oversee implementation and to spread good practice through guides and exemplars.

The Faculty of Science is heavily involved in both of these initiatives. Being discipline led they are likely to be highly influential in the structure of the research-enriched learning and teaching approach in our curriculum. Running parallel to development of a common national curriculum skeleton is the new focus on benchmarking of approaches and depth.
The Science TLOs and the emerging disciplinary statements will be strong drivers of curriculum change in the next few years. Alongside the mapping of graduate attribute development in our curriculum discussed above, we have now begun an analogous exercise for the TLOs. Coordinators can map their unit level learning outcomes to the program level threshold learning outcomes. Figure 4 illustrates this for the same unit shown in Figure 3.

![Figure 4](image.png)

**Figure 4. Extract from CHEM1001 unit outline showing alignment between unit and program level learning outcomes. Clicking on the dots gives the user more information on the particular learning outcome.**

**Data the curriculum renewal process has drawn on**

As with graduate attributes, staff and students can request a map across a number of units of study. Figure 3 in Appendix 1 illustrates this for a typical combination of first year units. By clicking on the links (the dots in the map), information gives information on the learning outcome and how it is assessed. Thus, an audit of how each TLO is addressed and assessed can be obtained by drilling down from the program level for each major.

The TLOs articulate the minimum standards for students to achieve in our curriculum. Each student must master each. This is fundamentally different to our present approach where a student can achieve an overall pass by excelling in one area whilst failing in another. This will require a substantial shift in the way in which the curriculum in our programs is shaped and assessed. In particular, the introduction or renewal of capstone experiences to address all of the TLOs are likely to be a focus as the route to ensure that each criterion is demonstrated.

**Recommendations for curriculum development in the faculty**

Work at the national level by the discipline networks, the ACDS and TEQSA will direct both the speed and much of the way in which the TLOs will be implemented. At a local level, the focus will be on using the mapping process to inform conversations within the disciplines but also across our programs to reduce disciplinary silos. Much of this will concern assessment and the need to benchmark our standards using devices such as the QVS or those developed by the disciplines.
5. Identifying duplication and maximising strengths in the Division of Natural Sciences

Overview of initiative

To ensure that our science graduates are engaged enquirers capable of meeting the challenges of the 21st Century, the focus of our programs are being sharpened so that they maximise opportunities for inter-disciplinary study, draw on expertise across the institution and are efficiently delivered and so sustainable. It is clearly important to align both our overall curriculum and those of each unit of study with external imperatives such as the needs and expertise of others in the University for whom we provide service teaching. The allied disciplines in the Division of Natural of Sciences are particularly important in this regard.

How the curriculum renewal process engaged staff and students

Through Division and Faculty retreats and the work of the Learning and Teaching Committees, these initiatives are already beginning to reduce overlap. For example, BIOL1 units are now co-taught with staff from the Faculty of Veterinary Sciences and a CHEM1 unit will be co-taught with staff from the Faculty of Agriculture and Environment in semester 2 of 2013. This strategy will develop as shared teaching models become established and better understood. As well as providing possible ways to increasing efficiency of delivery, such partnerships have the potential to offer rich context and applied research perspective to the enabling sciences.

A new process has been initiated in the Faculty of Science for changes to existing units of study and before the introduction of new units of study. This process also includes units from the School of Medical Sciences taken by BSc and BMedSc students. Proposers now first complete an expression of interest form based on the CCPC ‘Curriculum Renewal/Review Proposal’ form. Prior to discussion at the Undergraduate Studies Committee, this is discussed with the Associate Dean (Academic) and the Associate Dean (Learning and Teaching). In conjunction with the Dean, possible issues including cost, overlap and duplication of resources are identified and, if required, working parties are set up to ensure all interested groups can contribute. The EOI process also ensures that new or changed units align with the CCPC priority areas, including embedding of engaged enquiry through research-enriched learning and teaching experiences and the development of graduate attributes. This process has proved highly successful, particularly in identifying duplication and for ensuring that the response to the University Strategic Plan has not led to a large growth in units of study.

Data the curriculum renewal process has drawn on

All decisions on changes to existing units of study and the development of new units include an analysis of current and future student enrolments and staffing. A number of quality assurance and improvement measures have been introduced through the SEG Compact process, Processes have been introduced to ensure that all units of study in the Faculty of Science and science units within the School of Medical Science are now regularly evaluated. Each School is now sent a detailed summary of USE data each semester which identifies strengths and weakness and includes a comparison with overall Faculty performance and performance by year group. Strategies for improvement on poorly performing units are developed through discussions between the coordinator and Associate Dean.

Recommendations for curriculum development in the faculty

Increased integration of facilities and physical location of staff and experience with teaching and financial models which encourage co-teaching will assist in further amalgamation of units of study. The identification of the defining outcomes of each major should be used to renew subject choices and develop capstone experiences.
6. Encouraging innovation and capacity building in research enriched learning and teaching

Overview of initiative

To encourage and reward a RELT focus for learning and teaching initiatives, the Faculty of Science Learning and Teaching Fellowship was introduced and awarded for the first time in 2013. This award provides an individual or team funds for resources and for teaching leadership and development activities over 3 years to develop strategic, high profile and sustainable RELT projects. In 2013, the Fellowship was awarded to a team from the School of Molecular Bioscience to develop online tutorial “webinar” support for discussing experimental results and processes in molecular biology and biochemistry.

How the curriculum renewal process engaged staff and students

The leaders of this project disseminate the results from their innovation and from their leadership activities through Faculty of Science seminars and mentoring. The awards are open to academic staff and teams comprise teaching and research academics and postgraduate research students.

Informal ‘teaching tips seminars’ have been introduced as monthly events for Faculty staff to complement the more structured annual Learning and Teaching Forum. In 2012-13, these events have included presentations and staff discussions with Les Kirkup, an OLT National Fellow, on his inquiry-orientated learning in science project and internal talks by learning and teaching leaders and young staff on RELT topics. Students are also invited to these events and a number have included student panels. A peer observation and review scheme has been introduced for new teachers who take the ITL ‘Principles and Practice’ program. The associated evaluation documents for this scheme include an item on effectiveness of active enquiry learning in the classrooms.

Data the curriculum renewal process has drawn on

Rolls at seminars are used to measure attendance and to ensure that a variety of staff attend, beyond the teaching innovators. Since being introduced in 2012, 7 short teaching seminars, 2 Faculty forum and 3 longer teaching events have been held with around 20 regular internal academics attending and over 60 attending more than once. The events are also regularly attended by staff from other faculties, ITL and eLearning.

Recommendations for curriculum development in the faculty

In the curriculum renewal described here, a recurring theme has been the need to build teams within and between Schools to build on its successes by closing gaps in graduate attribute development and ensure development of the foundation skills development and research-enriched experiences in first year through to inquiry-based capstone experiences in third year. This requires leaderships and capacity in each School with appropriate evaluation and reward structures.
Using student evaluation data to measure student perception of research enriched learning and teaching

Data the curriculum renewal process has drawn on

Student evaluation data can be used to understand student perception of our engaged enquiry research-enriched teaching, to measure improvements in it and to calibrate staff understanding of how planned teaching activities actually relate and translate to RELT experiences.

As described above, the USE items Q3 (“This unit of study helped me develop valuable graduate attributes”) and Q10 (“Tutorial classes and/or laboratory classes were worthwhile”) are linked to graduate attribute development and to RELT activities. Whilst they are useful for identifying strongly positive or negative issues, these items do not delve deeply into students’ experiences. Q3 suffers from a lack of awareness amongst many students about graduate attributes, particularly at first year level and Q10 clearly conflates tutorials and laboratory work and does not directly address research enriched experimental work.

The SCEQ, however, does, however provide a rich source of data for both graduate attribute development and on how students perceive the research-enriched experience and balance of our programs. Appendix 2 lists the SCEQ items from the 2011 version of the survey that could be used to develop a RELT scale. Many of these are naturally also applicable to the graduate attributes scale and this is also indicated. Others relate more obviously to learning and teaching experiences from students’ studies rather than their own learning outcomes.

Unfortunately, insufficient responses were recorded to allow a useful breakdown of the data into each major. With more responses, it seems possible that studies of individual courses could be pursued. To illustrate the responses on RELT experiences, Figure 5 shows the percentage agreement on Q11 (“My degree course has stimulated my enthusiasm for further learning”), Q30 (“I feel my learning benefits from being in contact with active researchers”), Q36 (“My degree course is developing my capacity for research and inquiry”) and Q40 (“My degree course encourages me to be an active enquiring learner”). Detailed numerical data is included in Appendix 3.

Recommendations for curriculum development in the faculty

For all of these measures, the indications are that students have reasonably good RELT experiences but that more work is needed to embed activities that highlight the enquiry nature of real science. The lowest scores are for Q30 suggesting that many students are not benefiting from the Sydney model of academics who teach and are active researchers. The changes in students’ perception from first to third year are perhaps not as large as might have been expected, especially given the decreasing size of the classes and the associated increase in staff – student contact. The data from 2007, 2009 and 2011 is fairly consistent with only moderate overall gains and can serve as a benchmark for future comparison.

Richer evaluation data is needed to pinpoint areas of strengths and weaknesses and to identify how successful curriculum changes have been. The SCEQ provides relevant and good questions on RELT and graduate attributes but response rates mean that currently available data does not allow a breakdown by major to be meaningful. A more directed survey, perhaps using the SCEQ items, but delivered in class may be needed to provide such information.
Figure 5. Percentage agreement on SCEQ items (a) Q11, (b) Q30, (c) Q36 and (d) Q40 related to RELT experiences from 2007-2011
Conclusions

Overview

In this report, a number of mutually enhancing initiatives have been described that have attempted to embed and enable research-enriched learning and teaching in the programs of the Faculty of Science. Given the nature of the Faculty and the maturity of these programs, the curriculum renewal process has focussed on:

- mapping and evolving our current courses rather than a revolution and
- ensuring that all students benefit from and are able to learn from a research-enriched curriculum, irrespective of their pathway in the degree or incoming skills.

How the curriculum renewal process engaged staff and students

Involvement of academic, research and technical staff, across the Faculty and from co-curricula centres, as well as students has been crucial to the successes. Understanding our current programs through the collection of information on the many pathways and offerings of the Faculty is crucial to forming and informing discussion groups of program and unit coordinators and key staff, as we shift the focus from disciplinary to program level outcomes for students.

Capacity building for RELT expertise and understanding in our teachers is key to the ongoing success of the renewal process. The impact of shared teaching models within the Division and the use of new technologies are rapidly change the nature of what and how we teach.

Data the curriculum renewal process has drawn on

Evaluation of the curriculum renewal has been possible through use of USE and SCEQ RELT and graduate attribute items.

Recommendations for curriculum development in the faculty

Considerable success, especially at first year, has been achieved. Because the strategies employed through each initiative have been deliberately designed to synergistically work together and support each other, these improvements have been larger than could have been achieved in isolation. Within our large and diverse programs, a coherent focus on graduate attribute development has been possible. This renewal process can now inform ongoing developments within each major to enable all students to learn through research-enriched engaged enquiry irrespective of their pathway in our degrees. The ‘Sydney Scientist’ unit outline template and curriculum mapping tool has been invaluable in this work.

External pressures, including TEQSA and the national shift to threshold learning outcomes, are helping to drive this shift and may require a more fundamental change in our curriculum and assessment, perhaps with the introduction of capstone RELT experiences across each major and inter-disciplinary benchmarking.
Appendix 1. Examples of curriculum maps.

Figure 1. Current graduate attribute map for the units making up a Chemistry major. The different colour dots represent the level of attainment of the attribute. Clicking on one of the dots gives information, such as that shown at the bottom, about the aligned unit level learning outcomes and assessments.
Figure 2. Current graduate attribute map for first year units.
Figure 3. Current threshold learning outcome map for a typical combination of first year units. The different colour dots represent the level of attainment of the learning outcome. Clicking on one of the dots gives information, such as that shown at the bottom, about the aligned unit level learning outcomes and assessments.
Appendix 2. SCEQ items that measure students’ perceptions of graduate attribute development and RELT experiences.

<table>
<thead>
<tr>
<th>item</th>
<th>Question</th>
<th>GA</th>
<th>RELT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>I found my studies intellectually stimulating</td>
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<td></td>
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<tr>
<td>Q6</td>
<td>The degree course has helped me develop my ability to work as a team member</td>
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<tr>
<td>Q9</td>
<td>The degree course has sharpened my analytic skills</td>
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<td></td>
</tr>
<tr>
<td>Q11</td>
<td>My degree course has stimulated my enthusiasm for further learning</td>
<td></td>
<td></td>
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<tr>
<td>Q18</td>
<td>The degree course has developed my problem-solving skills</td>
<td></td>
<td></td>
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<tr>
<td>Q21</td>
<td>The teaching staff work hard to make their subjects interesting</td>
<td></td>
<td></td>
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<tr>
<td>Q22</td>
<td>The degree course has improved my skills in written communication</td>
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<td></td>
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<tr>
<td>Q23</td>
<td>My degree course has helped me to develop the ability to plan my own work</td>
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<td></td>
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<tr>
<td>Q26</td>
<td>To do well in this degree all you really need is a good memory*</td>
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<tr>
<td>Q30</td>
<td>I feel my learning benefits from being in contact with active researchers</td>
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<tr>
<td>Q36</td>
<td>My degree course is developing my capacity for research and inquiry</td>
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<td></td>
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<tr>
<td>Q37</td>
<td>My degree course is encouraging my development of relevant, ethical, social and professional perspectives</td>
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<tr>
<td>Q39</td>
<td>My degree course is developing my ability to use oral, written, and/or visual communication</td>
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<tr>
<td>Q40</td>
<td>My degree course encourages me to be an active enquiring learner</td>
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<tr>
<td>Q42</td>
<td>My degree course is developing my ability to use information effectively</td>
<td></td>
<td></td>
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<tr>
<td>Q48</td>
<td>My degree course is fostering my personal and intellectual independence</td>
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</table>

* Reverse item: a low score on this item is indicative of an engaging experience.
Appendix 3. SCEQ percentage agreement (broad agreement) for Science units for 2007 – 2011. The scores obtained for each year group are shown as well as the overall score.

<table>
<thead>
<tr>
<th>Year</th>
<th>Group</th>
<th>Q1</th>
<th>Q5</th>
<th>Q9</th>
<th>Q10</th>
<th>Q11</th>
<th>Q18</th>
<th>Q21</th>
<th>Q22</th>
<th>Q23</th>
<th>Q26</th>
<th>Q30</th>
<th>Q36</th>
<th>Q37</th>
<th>Q39</th>
<th>Q40*</th>
<th>Q42</th>
<th>Q48</th>
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<tr>
<td>2011</td>
<td>Year 1</td>
<td>87</td>
<td>52</td>
<td>80</td>
<td>63</td>
<td>75</td>
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<td>Year 2</td>
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<td>58</td>
<td>77</td>
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<td>Year 3</td>
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<td>58</td>
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<td>75</td>
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| 2009 | Year 1 | 88 | 55 | 79 | 62 | 76 | 72 | 69 | 65 | 71 | 23 | 63 | 79 | 72 | 73 | 76 | 76 |
|      |       | (97) | (83) | (97) | (91) | (93) | (95) | (93) | (87) | (92) | (47) | (87) | (96) | (93) | (94) | (97) | (95) | (95) |
|      | Year 2 | 82 | 43 | 69 | 47 | 72 | 61 | 68 | 51 | 64 | 24 | 53 | 68 | 68 | 60 | 67 | 70 |
|      |       | (75) | (87) | (94) | (87) | (93) | (94) | (91) | (81) | (91) | (47) | (83) | (94) | (91) | (90) | (97) | (93) | (93) |
|      | Year 3 | 83 | 51 | 75 | 58 | 67 | 69 | 66 | 71 | 25 | 61 | 75 | 71 | 73 | 73 | 73 |
|      |       | (97) | (85) | (97) | (86) | (88) | (93) | (93) | (82) | (90) | (51) | (86) | (94) | (93) | (96) | (93) | (93) | (97) |
|      | Overall | 94 | 67 | 85 | 69 | 81 | 81 | 70 | 69 | 75 | 25 | 70 | 86 | 77 | 83 | 81 | 80 |
|      |       | (99) | (91) | (98) | (95) | (95) | (97) | (97) | (93) | (94) | (52) | (88) | (97) | (96) | (96) | (98) | (98) | (96) |

| 2007 | Year 1 | 86 | 56 | 74 | 60 | 69 | 69 | 60 | 61 | 69 | 28 | 59 | 78 | 66 | 77 | 77 | 70 |
|      |       | (97) | (87) | (94) | (90) | (91) | (94) | (89) | (87) | (92) | (51) | (89) | (94) | (90) | (97) | (98) | (97) | (95) |
|      | Year 2 | 83 | 57 | 65 | 51 | 56 | 61 | 47 | 59 | 33 | 51 | 70 | 61 | 67 | 68 | 64 |
|      |       | (96) | (86) | (90) | (85) | (88) | (91) | (88) | (81) | (87) | (61) | (88) | (93) | (89) | (97) | (96) | (97) | (94) |
|      | Year 3 | 87 | 64 | 74 | 64 | 70 | 69 | 58 | 62 | 69 | 25 | 55 | 76 | 68 | 80 | 82 | 74 |
|      |       | (98) | (86) | (96) | (93) | (92) | (94) | (88) | (91) | (93) | (46) | (91) | (95) | (93) | (98) | (98) | (98) | (96) |
|      | Overall | 88 | 98 | 78 | 61 | 70 | 73 | 64 | 71 | 76 | 29 | 66 | 81 | 73 | 87 | 76 | 69 |
|      |       | (96) | (94) | (96) | (89) | (88) | (95) | (90) | (88) | (93) | (52) | (89) | (94) | (89) | (94) | (98) | (98) | (92) |

* Q40 changed in 2011. The previous question is not relevant for the present report.