

# Teaching Research - Evaluation and Assessment Strategies for Undergraduate Research Experiences (TREASURE)

Final Report 2014

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## List of acronyms used

ALTC	Australian Teaching and Learning Council
ANU	The Australian National University
AQF	Australian Qualifications Framework
ASC	Advanced Studies Course (ANU)
ASP	Advanced Science Project (UWS)
ATAR	Australian Tertiary Admissions Rank
GPA	Grade Point Average
GSM	Global Social Movements (UC course)
HEI	Higher Education Institution
ILO	Intended Learning Outcome
LMS	Learning Management System
MOI	Methods of Inquiry (UC course)
MOOC	Massive Open Online Course
OLT	Office for Learning and Teaching
PQF	Prompt Question Framework
TEQSA	Tertiary Education Quality Standards Agency
UC	University of Canberra
URE	Undergraduate Research Experience
URSSA	Undergraduate Research Student Self-Assessment
UWS	University of Western Sydney

## Executive summary

Research-led education is seen as beneficial to both students, through enhancing generic skills and introducing them to disciplinary culture and practices, and to institutions, in better integrating research and teaching and attracting high quality students. One aspect of the rise of research-led education is the inclusion of more undergraduate research experiences (UREs) as part of the undergraduate degree. While UREs have a long history, they have traditionally been a voluntary and not-for-credit experience, for example through vacation scholarships, or available within the degree to a small proportion of later year students. The current focus on research-led education has led to increasing numbers of students undertaking assessed UREs as course components of regular and elite, research-focussed degrees. Smaller research experiences may also be embedded within conventional coursework. The rise of these experiences has rarely been accompanied by serious consideration of how learning gains might be achieved, fostered and assessed, with the assumption being made that research experiences are inherently worthwhile. The focus of the TREASURE project was to examine what students learn during research experiences and how this learning occurs. This information could then be used to reconsider scaffolding and assessment of UREs.

The specific aims of the project were to:

- develop reflective tools which will make the objects and processes of learning in student research experiences more explicit to both the student and the supervising academic, and
- develop more evidence-based methods of assessment for UREs, which better align with the purposes of including UREs in the curriculum, and which in turn lead to clearer strategies for evaluating URE effectiveness.

During the course of the project, we sought input into intended learning outcomes for UREs through interviews with URE supervisors and course convenors and by running workshops. We used the information gained to develop prompt questions for a structured reflective journal (the Prompt Question Frameworks, implemented as online Learning Logbooks). These were designed to prompt students to reflect on particular aspects of their learning and experiences while undertaking research. Students responded to questions at approximately fortnightly intervals so that we could observe their development over time. Learning Logbooks were implemented in 19 courses across the three participating institutions with 330 students participating over three semesters. We initially tested the Prompt Question Framework concept in science but subsequently expanded to include arts and social science courses. Participating students were enrolled in both standard and elite research-based degrees. The three semesters were treated as three action research cycles, allowing us to refine and develop possible Prompt Question Framework approaches based on intended learning outcomes and feedback from students and staff.

Students engaged well with the Learning Logbooks, resulting in the Learning Logbooks of participants forming a rich resource for analysis of student learning. To develop an evidence base for what students learn, the barriers they encounter and the value of Learning Logbooks to students and staff, we have taken a phenomenographic approach to the analysis of Learning Logbook entries, interviews with staff both before and after participation, and feedback from students (online, focus groups or interviews). We have also collected data on the level of engagement by students and which questions they chose to answer.

The Learning Logbooks demonstrate that formal assessment in most UREs assesses only a small part of the learning that occurs. Actual learning encompasses not just disciplinary knowledge, but also a sense of self as a researcher, an understanding of the nature of

research, and the development and valuing of professional and generic skills. However, only a small proportion of Learning Logbooks demonstrate the high level understanding of the nature of research desired by most supervisors (although this could be because some students do not report on the full extent of their learning). The more sophisticated responses we observed reveal that 'understanding research' is a complex construct consisting of a range of attitudes and ways of thinking as much as mastery of skills and knowledge. This suggests that simple diagnostic tools to assess learning about research are likely to miss the very learning that is most valued by researchers. Our conclusion is that there is considerable value in listening to the student voice and we have suggested ways in which Learning Logbooks can be used to contribute to the assessment and evaluation of UREs.

The deliverables from the TREASURE project include:

- The reflective tools developed: the Prompt Question Framework approach.
- A framework for intended learning outcomes for UREs.
- A set of guides for students, URE supervisors and staff wanting to implement the Prompt Question Framework.
- A series of case studies on specific aspects of student learning and expectations about research.
- A body of data on student learning and opinions about research which we are using for ongoing analysis.
- A refereed book chapter, three non-refereed articles and several conference abstracts.

These resources are available in the accompanying resources handbook and on the TREASURE website: <[treasure.edu.au/project/](http://treasure.edu.au/project/)>.

The Learning Logbooks show that learning in UREs is highly variable and is dependent on the nature of the project, the expectations and attitudes of the student and the role of the supervisor. While this is partly reflective of the nature of authentic research, we believe that better preparation for research experiences by both students and supervisors could enhance the learning that occurs and hence the value of UREs and other research experiences in the curriculum. Our recommendations to achieve this are:

- That UREs be seen as teaching and learning activities rather than extensions of a supervisor's research activities. This will require better scaffolding for the design of projects and the way in which the activities undertaken lead to desired learning outcomes.
- That the Prompt Question Framework approach be incorporated more widely into research experiences as a low stakes assessment item.
- That a whole curriculum approach to learning about research is taken resulting in scaffolding of learning about research and development of research skills early in the degree that better prepares students for the reality of a research project.

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# Chapter 1: Introduction

The following report describes the planning, processes and outcomes of the OLT-funded project, *Teaching Research – Evaluation and Assessment Strategies for Undergraduate Research Experiences (TREASURE)*.

This project aimed to improve both:

- the learning experiences and outcomes for undergraduate students engaging in research activities, and
- the visibility of this learning to both academics and students.

As universities across the sector seek to enhance their research profiles, there has been growing impetus behind moves to better integrate the teaching and research activities of higher education institutions, often leading to curriculum development initiatives that engage students directly in research activities as part of their assessed (graded) coursework.

While there is substantial evidence that students benefit from exposure to and engagement in research, initiatives that engage undergraduates in research have rarely been accompanied by careful consideration of how learning gains might be identified and assessed in ways that allow for grading to be commensurate with that of traditional coursework. This has been true particularly for individuals undertaking extended research projects (henceforth referred to as Undergraduate Research Experiences or UREs). UREs have tended in the past to be seen primarily as an opportunity for students to experience research rather than as a course with intended learning outcomes. They may function as “tasters” for Honours – one-off experiences that help both potential Honours students and supervisors make up their minds whether research is the right choice before committing to it. In addition, they have typically formed only a small fraction of the degree (one unit’s worth out of a total of 24) or are undertaken as extra-curricular activities such as vacation scholarships. The lack of rigour, clarity and equity around assessment and grading of UREs has attracted little attention, with any concerns raised being viewed as a small sacrifice that is unlikely to significantly perturb the student’s GPA and easily outweighed by the benefits of a research experience.

The TREASURE project aimed to bring more clarity to the kinds of learning that might be going on when undergraduate students engage in research and in doing so to suggest ways in which supervisors, project unit convenors and institutions might approach assessment in ways that better align with that learning. The project built on ideas from previous Australian Learning and Teaching Council (ALTC)-supported projects (Brew 2010; Willison et al. 2007)) and from research undertaken by the two project leaders at their home institution where the introduction of research-immersive elite degree programs had led to a significant increase in the number of research projects undertaken by undergraduate students.

The project involved staff and students at three contrasting institutions. The institutions differed in many ways including: staff and student profiles; disciplinary mixes; policy and management structures; aspirational and actual institutional cultures; and identity and role within a local community. Yet each had its own special reasons for promoting undergraduate engagement with research.

The Australian National University [ANU] (home institution for the two project leaders and the project manager) is a research intensive university that prizes its role as the national university. It is a member of the International Alliance of Research Universities as well as Australia’s Group of Eight. Historically, it has housed a high proportion of research-only academics, and has a significant focus on training the academic researchers of the future. It is elitist in its outlook and intake, with relatively high ATAR requirements for entry into most of its degree programs. It offers several restricted entry, research-influenced undergraduate

programs such as the Bachelor of Philosophy (PhB) – ATAR 99+; Bachelor of Science Advanced (BSc (Adv)) – ATAR 95+; and a variety of other direct-entry Honours degrees, typically with ATAR cut-offs around 95 or higher. Currently, the lowest ATAR cut-off for any of its ordinary degree programs is 80. It is a relatively small, single campus university situated in the centre of Canberra with a high proportion of students drawn from the region and from white-collar families.

The University of Western Sydney [UWS] (home to team members Gill and Ross) is a large, multi-campus institution that serves the suburbs of western Sydney and much of western regional NSW. It was a member of the now-disbanded New Generation Universities grouping, and now describes itself as a research-led university ([www.linkedin.com/edu/university-of-western-sydney-10254](http://www.linkedin.com/edu/university-of-western-sydney-10254)). As it seeks to strengthen its national and international research profile, academic staff are encouraged to find ways to bring their research into their teaching. It has a strong commitment to serving and enhancing the intellectual and economic life of its local area. While it offers restricted entry programs in Arts, Business and Commerce, Law and the Sciences with ATAR cut-offs in the 90s, ATAR requirements for its ordinary degrees are typically around 65-70. A large proportion of its student body are first-in-family and drawn from regions dominated by low SES groups.

The University of Canberra [UC] (home to team members Roberts and Åkerlind) is a non-aligned university with a strong emphasis on providing a “professional preparation for a professional future.” It positions itself as the capital’s university and seeks to build strong relationships with the Australian Capital Territory (ACT) government, local education, community and health organisations, local sporting bodies etc. It adopted Research-Led Education as one of its five Signature Educational Themes, focusing on the ways in which experience research and developing research-related skills can contribute to the development of generic skills such as critical and analytical thinking. Although a non-negligible fraction of its student body is comprised of international students (mainly from the Asia-Pacific region), the majority of the student cohort is drawn from the local ACT area. It offers a small number of high ATAR requirement programs (e.g. Physiotherapy – ATAR 93+; Law and combined programs – ATAR 90; direct entry Honours Psychology – ATAR 86+), the majority of its programs have ATAR requirements around 70. Many of its staff are dual professionals with backgrounds in industry or the professions before entering academia.

Undergraduate students in each of these institutions are increasingly being offered opportunities to engage in research. The contexts for this engagement, however, vary widely, from immersive, apprentice-style individual projects to structured experiences of selected aspects of the research process embedded in conventional coursework. The project team thus had the opportunity to examine and enhance the learning occurring in a wide range of contexts.

The TREASURE project grew out of the team’s belief that reflective writing could be used to both prompt and reveal critical analysis and metacognition about the nature of research and about learning itself. We hoped that allowing students’ space to engage in such reflection would produce an enhanced evidence base on which to assess student performance and with which to inform future research project/activity design and supervision. Because the majority of the existing literature on UREs (and the project leaders’ own prior work) focused on (and hence provides some understanding of) apprentice-style projects in the sciences, the TREASURE project started with its own focus on such contexts. The team’s intentions to expand the focus to other contexts in subsequent stages meant that regular reflection, informed by careful, critical analysis of the project’s progress to date, was required on the part of the team throughout the project. It was thus essential that formative evaluation was conducted as an embedded component of the project activities and processes. Discussion of our ongoing evaluation strategies and activities is therefore included as an integrated element of each chapter.

The report is structured as follows:

Chapter 2 provides more context for the project, describing some of the policy and pedagogical drivers leading to increased use of research experiences in undergraduate degrees. It also positions the project within existing work and gives a rationale for our choices.

Chapter 3 gives details of the development, implementation and evaluation of reflective tools to enhance learning (the Prompt Question Framework and Learning Logbooks). It also reflects on the successes and difficulties encountered.

Chapter 4 highlights the value of our approach for making student learning visible.

Chapter 5 summarises impact and implications for assessment and curriculum renewal.

Chapter 6 includes lists of project deliverables and dissemination activities.

Chapter 7 presents a summative evaluation using a Theory of Change framework.

Many of the outcome documents from the TREASURE project are presented in the accompanying resources handbook and on the website. These include guides to implementation, resources, case studies and examples of analysis of student learning from logbooks. They are identified in this report as 'nuggets from the TREASURE trove'.

## Chapter 2: Why we need to go down into the mine and look for treasure

### Global context: the impact of policy and institutional drivers

Over the last few decades, the higher education sector in many countries, including Australia, has undergone significant change. These changes include higher participation rates, an increasingly managerial culture of quality assurance and tensions between teaching and research activities in an increasingly competitive research environment. One development associated with quality assurance is the Australian Qualifications Framework (AQF), which outlines standards required for the accreditation of different levels of tertiary qualification (Australian Qualifications Framework Council 2013). This document stresses the development and acquisition of generic research-based and inquiry skills at both undergraduate and graduate coursework levels. At the same time, changes within society including the shift to the knowledge economy, increased globalisation and mobility, and the complexity and technological dependence of social and economic issues are resulting in demand for graduates with well-developed interpersonal and communication skills, analytical thinking and problem-solving abilities. For example, surveys by Graduate Outlook Australia (Graduate Careers Australia 2013) consistently find that interpersonal and communication skills are the most important selection criterion for graduate recruitment.

These two drivers, coming from both the higher education sector and graduate employers have led to an increasing focus on the development, during their degrees, of students' generic skills. Universities seek to both distinguish their offerings from those of their competitors, and market their degrees as providing strong employability skills, through statements of graduate attributes and commitments to the development of critical and analytical thinking, communication skills, problem-solving abilities, professionalism and social responsibility, for example. While this focus at the level of university management and policy is almost universal, there has been less consideration given to approaches to teaching generic skills and evaluating their acquisition. Teaching staff vary in their attitudes from those who value of explicit instruction for generic skills, to those who argue that students acquire them simply as a consequence of undertaking a degree or prior schooling (Barrie 2007). There are also arguments about whether generic skills are best taught within the disciplinary context or more widely, for example, using service courses for large numbers of students early in the degree (eg Jones 2009).

A potential solution to meet external requirements for generic skill development, as well as integrating students into the culture and ways of thinking of their discipline, is through authentic research experiences. This recommendation is consistent with those of the widely read Boyer Commission Report (Strum Kenny 1998) which encouraged universities to offer all undergraduates the opportunity to engage in or experience research and this view is reinforced by the AQF. Subsequent reports into science teaching and learning in several countries have further supported the widespread inclusion of research experiences in undergraduate degrees, for example, Vision and Change in Biology Education (AAAS 2011). What is rarely mentioned in these reports is the need to assess and document learning outcomes, consistent with the requirements of such frameworks as the AQF.

Another factor in the increasingly "massified" market of higher education providers is that having undergraduates working with high-profile research academics is seen as a promising marketing strategy. This practice allows more research-intensive institutions to claim that they provide a distinctive education by introducing undergraduates early to research and developing both generic skills and their understanding of the research process. This view also developed from the Boyer Commission Report which focused on the advantages for undergraduates if research-intensive institutions to capitalised on their research excellence to improve degree programs.

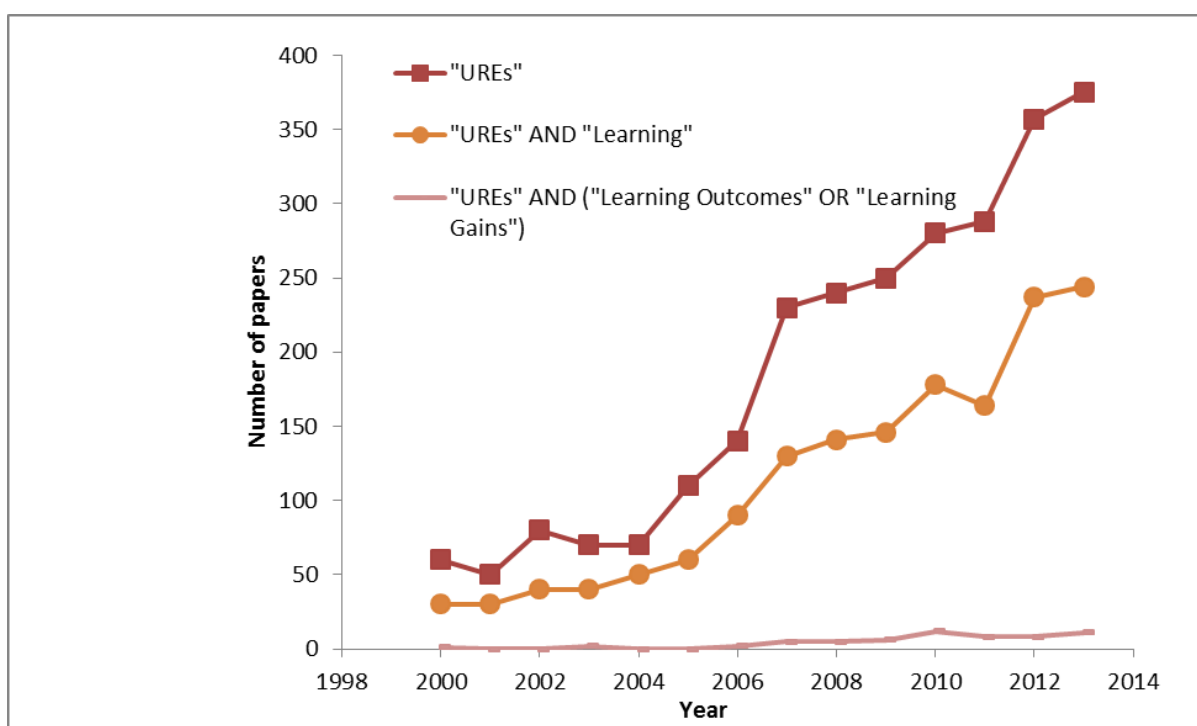
In response to all these factors, undergraduate research experiences are becoming more common across the sector. A number of Australian universities have introduced elite, research-based degrees aimed at top school leavers. These degrees include one or more undergraduate research experiences which are assessed, contribute to meeting degree requirements and substitute for a normal lecture course. These degrees often exist in parallel with opportunities for research projects courses already available to a wider range of students. Where a research project replaces a conventional course, students and academics might justifiably hope that identifiable learning outcomes will be achieved. Brew (Brew 2010) notes that although ungraded research experiences such as summer projects could be seen as a mechanism to integrate research and teaching, they usually fall outside the standard curriculum. The situation for research experiences that fall within degree programs is quite different; in this case, the projects are clearly within the curriculum and therefore should be designed with specific learning outcomes and aligned assessment.

It is well documented that research experiences have a very positive motivational role for undergraduates (Laursen et al. 2010; Lopatto 2007; Russell et al. 2007) and may be linked to progression to further research; a concern with the rise of graded research experiences is that this perception appears to take precedence over consideration of learning outcomes. A previous OLT report focusing on undergraduate research experiences outside the curriculum noted, 'The primary aim of the programs is to maintain and grow a pipeline of undergraduates progressing into Honours and research higher degree programs. The learning value of such programs is not emphasized or evaluated' (Brew 2010). Unfortunately, even in the context of research experiences that do contribute to a student's degree, some supervisors still see them as a mechanism for recruitment or to 'test' the suitability of a student for further research (Wilson et al. 2012). Academics who are used to supervising projects in summer research programs or who are completely unused to project supervision may need significant levels of support in designing appropriate learning outcomes and in ensuring that project activities, grading criteria and grading decisions are aligned with these. Because of their location within the research activities of the university, and their focus on current problems or existing research programs, each individual research experience tends to be unique. Thus they are unlikely to receive the kind of careful cycles of curriculum design that may occur in established, repeated units of coursework.

## Why it's time to get the mining gear out and go underground in search of precious gems

Much of the existing research into learning from UREs has taken place in the context of unassessed projects, for example those done as summer scholarships. The implications for learning that follow from the incorporation of such experiences into degree programs have rarely been considered or examined. The data shown in Figure 1 provide a graphic illustration of this. The data shown in red and orange indicate the number of works published per year since 1998, yielded by a search using Google Scholar on the key words "Undergraduate Research Experiences" and the Boolean AND of "Undergraduate Research Experiences" and "Learning" (search performed in December, 2013). Although such numbers are indicative rather than definitive, the data suggest steadily increasing rates of publication around these topics, in line with our expectations given the increasing frequency with which research experiences form part of the undergraduate curriculum. The data shown in pink are the results of a similar search but with the search terms the Boolean AND of "Undergraduate Research Experiences" and either of "Learning Outcomes" or "Learning Gains". While also showing in increasing trend, the overall numbers of publications combining mention of both UREs and learning framed in terms of outcomes or gains (i.e. using language typical of discussions of design and assessment of learning) form only a tiny proportion of the publications in this area. (It might also be usefully pointed out that a significant fraction of the publications included in this sample were generated by the project leaders.)

**Figure 1: Papers published on UREs, learning and learning outcomes**



The issues raised above and the data in Figure 1 suggest that it is timely to examine what learning occurs in assessed UREs, if it is being assessed effectively and how well UREs contribute to their stated aims, in particular, developing generic and problem solving skills, critical thinking and an understanding of the research process. As well as introducing a relatively uncontrolled element into the student's curriculum, UREs that operate on the apprenticeship model are costly in terms of staff time and therefore it is even more important to evaluate their function in enhancing learning of desirable capabilities and attributes.

Competing models of research learning may be more controlled, less labour-intensive for staff and equally effective in developing students' skills and capabilities. For example, a current OLT project, 'Developing and resourcing academics to help students conduct and communicate undergraduate research on a large scale' addresses the development of large scale research experiences in which groups of students are mentored to contribute to a research project within a normal course. While such a model may not provide all the advantages (or costs!) of a one-on-one experience, it can be effective in developing students' understanding of research and associated generic skills (Auchincloss et al. 2014). Thus, a continued focus on apprentice-style UREs may need to be justified in terms of both enhanced learning and cost effectiveness in comparison to viable alternatives.

Proponents of UREs claim that they enhance students' critical thinking and problem-solving skills and better prepare them for future research, whether in an academic context or as lifelong learners. The authentic nature of the research experience, and the fact that many operate on an apprenticeship model where the student works with an experienced supervisor, is thought to develop students' skills and abilities as researchers. However, the evidence suggests that while UREs have strong motivational benefits and do promote some understanding of scientific practice, students much more rarely report gaining higher order research skills such as identifying research questions and formulating hypotheses (Howitt et al. 2010; Hunter et al. 2006; Kardash 2000; Laursen et al. 2010; Lopatto 2004; Russell et al. 2007; Seymour et al. 2004). Students value the authenticity of the experience and the opportunity to become involved in 'real' research as opposed to undergraduate practical experiences in science, for example. The opportunity to interact with researchers was also

appreciated by students. A rigorous evaluation of summer students at four liberal arts colleges found that the major benefits to students, reported by both students and staff, related to an awareness of research and professional (Hunter et al. 2006; Seymour et al. 2004). Although benefits were categorised as 'thinking and working like a scientist' and 'becoming a scientist,' few students developed an awareness of the provisional nature of scientific knowledge and an understanding of how to formulate research questions.

The project leaders' prior work showed very similar benefits to students enrolled in an elite, research-intensive degree that included multiple research experiences. While it might have been expected that multiple research experiences would have increased the level of higher order thinking demonstrated, this was not the case (Howitt et al. 2010). Instead, the major additional reported gains related to time management and organisation. This is likely to be due to the degree structure, where students need to contact supervisors, organise their research projects and then balance project work against the demands of their normal coursework.

While UREs are often seen as valuable learning experiences and an important part of research-led education, the assessment structure of such experiences often focuses both staff attention and students' conceptions of what constitutes successful learning on the outputs, with students usually assessed through a formal written report in the style of a research paper. The student may therefore see their learning largely in terms of discipline-specific skills and content, with success or failure being measured by the results obtained. This focus can be exacerbated by both student and supervisor expectations about what kind of learning opportunities can occur during a URE (Wilson et al. 2013; Wilson et al. 2012). Students who are unfamiliar with research may have expectations relating to learning additional content, for example. The learning that they identify will therefore focus on content and research achievements. Our prior research suggests that students see little value in projects where the results are largely negative (Howitt et al. 2010); however, learning to deal with problems that arise during research and coping with negative results is an essential part of the learning that prepares students to both do and understand other research.

The distinction between outcomes and the process of research was also made by Peter Medawar in his essay, 'Is the scientific paper a fraud?' (Medawar 1963). He argued that the formal structure of a paper conceals the thought processes that led to the research and conclusions and thus presents a misleading view of scientific research. While the structure of a scientific paper can be justified on the grounds that its purpose is to communicate the outcome of research as clearly and succinctly as possible, it is less obvious that this is the sole purpose of a research report by an undergraduate student. In the latter case, experiencing the process of research is an important aspect of the learning that takes place. Learning how to communicate a research result in the most effective and concise way possible is clearly a valuable experience. However this may also be achieved through the preparation of, for example, formal reports following ordinary undergraduate practicals carried out in traditional teaching labs. We would argue that the special (and resource-intensive) experience of research offers other, more powerful, developmental learning opportunities, which are not captured in a formal report.

In addition to misalignment of assessment and significant learning, there are also potential problems regarding URE design to facilitate this learning. Indeed, it is rare that staff or students explicitly consider how research skills are developed during a project; there is an implicit assumption that students will learn how to do research by doing research, but doing implies knowing what/how to do, and so a student who is unaware of the nature of research may remain so despite participating in a research project. Our prior research suggested that if students perceive research-training as the acquisition of facts and disciplinary content knowledge, and are left unaware of the role of higher-order critical thinking skills, then it is less likely that they will be aware of or take advantage of opportunities to develop such skills and ways of thinking during UREs (Wilson et al. 2013). This reinforces earlier studies showing that there is a need to make such goals explicit to students if they are to benefit



fully (Schwartz et al. 2004; Thoermer and Sodian 2002). Thus the evidence suggests that both students and supervisors may need more support to take advantage of the learning opportunities offered by the process of research, by separating learning about and through the process from the quality of the research outcomes.

## Existing frameworks for evaluating research skills

There have been many previous attempts to assess the development of skills and understanding of research. We discuss only a few examples here, including those that are particularly relevant to the TREASURE project.

A previous ALTC grant resulted in the Research Skills Development Framework (<https://www.adelaide.edu.au/rsd/>) which allows teachers and students to evaluate the skills developed by particular assessment tasks. Like TREASURE, the aim was to reveal development of research skills but the framework focuses on activities within normal coursework rather than UREs. It does not assess development of wider understandings, for example, the nature of science and research processes. However, it does provide a useful summary of the generic skills associated with research that students might be expected to develop during their degree programs. Use of the framework in assessment enables teachers and university management to demonstrate that teaching and learning activities and student outcomes are developing students' generic skills.

The Researcher Development Framework (<https://www.vitae.ac.uk/researchers-professional-development/about-the-vitae-researcher-development-framework>) is similar in that it allows researchers, from students to professionals to map their skill base onto the framework to identify strengths and areas for improvement. It is more explicitly focussed on professional development and therefore includes a broader range of skills and abilities such as leadership and public engagement, in addition to those more traditionally focused on research such as research methods and critical thinking. However, it could also be used in the same way as the Research Skills Development Framework to map learning outcomes to research skills.

The Undergraduate Research Student Self-Assessment (URSSA) survey has been specifically developed to assess the gains in skills, understanding of research and confidence that result from participation in science UREs (<http://www.colorado.edu/eer/research/undergradtools.html>). This survey consists mostly of Likert scale statements, with some space for open-ended comments. The items were developed after an extensive study involving interviews with both students and supervisors of UREs and are based on gains reported by students during interviews (Laursen et al. 2010). It is comprehensive, research-focussed and can be used as a pre- and post-test to assess outcomes from UREs.

Other OLT projects have examined final year capstone or honours projects in a range of disciplines, but usually with the aim of assessing the effectiveness of such projects in meeting specific objectives within the discipline. While this often includes the development of research skills and understanding, explicit understanding of learning about research and fostering such learning has not usually been a major goal.

## The value of reflection: why we decided to learn from our students

Reflection is now a common term in the higher education sector. In a general sense reflection is understood as a form of thinking that relates to re-examining of experiences and situations, with some intent of seeking to learn and improve based on that analysis. However, the concept in practice is far more complex, precisely because it has divergent uses and applications across a range of disciplines and contexts. Here, we briefly review some of the background to the use of reflection in education and then consider its value in the context of undergraduate research.

The theoretical underpinnings of reflection in the educational context largely derive from the research of John Dewey and Donald Schön. Dewey's research concerned theories of knowledge. He saw knowledge creation as a process of intelligent inquiry based on interaction with our environment and identified four core modes of thought - belief, imagination, reflection and stream of consciousness. He theorised that reflection had a key function in sustaining continuity in learning through deepening, relating and making connections between one experience and the next (Dewey in Rodgers 2002, p.845). His work is based on a holistic view of reflection as a process.

Schön's (1983) interest in reflection centred on professional knowledge and its development. He saw a schism between knowing and doing which he saw as a potential gap between technical-rational knowledge learnt as theory during training and the reality of real-life practice where theory can often be inadequate in dealing with the messy, ill-defined problems that arise. He theorised that professionals employ 'theory in use' as a form of tacit knowledge, rarely articulated, in actual practice situations. He distinguished between reflection-in-action as an 'in process dimension of reflecting' and 'reflection-on-action' as a process of review that occurs after an event.

Boud (1995, p.19) sees reflection in this context as 'a generic term for those intellectual and affective activities in which individuals engage to explore their experiences in order to lead to new understandings and appreciations.' In this sense he sees reflection extending beyond the logic and rationality which engages the cognitive domain to include the metacognitive and affective areas of learning as well.

In an educational context reflection is a more formal and structured activity than informal settings in which an individual might consciously or spontaneously reflect by themselves. In the formal context, reflection is underpinned by a pedagogical intention to assist learning in specific dimensions. It requires that the student communicate what they are reflecting on and that this reflection might be assessed, read and commented on by others. The majority of the literature on reflection and reflective writing is geared towards either teaching it or developing it as a professional practice disposition. This is indicative of the fields in higher education that have embraced reflection as a component of professional learning including disciplines such as teacher education, health sciences, law and finance and economics.

While undertaking research might equally well be seen as professional practice, reflection has been used much less frequently in this context, especially in the sciences. Its value in developing students' understanding of the nature of science in the classroom context, however, has been well recognised (Deng et al. 2011). The experience of the project leaders with using reflection in another science course (Howitt and Wilson 2014, Yucel 2013) suggested that while science students did show some nervousness over the use and assessment of reflective writing, they could learn to use reflection effectively. This course addresses the nature of science through reading, discussion and reflection. Analysis of assessment items from this course shows that reflection supports students to challenge and develop their existing conceptions of research (Howitt and Wilson 2014). This led us to believe that reflection will also be useful in the context of an extended research project, particularly in relation to Schön's views of surfacing tacit knowledge in applying theory to practice by using 'reflection-on-action'.

There is consensus in the educational literature that reflection involves a complex set of higher order thinking processes that are associated with turning experience into learning. Reflection can assist students to:

- think about what, why and how learning takes place;
- order and clarify their thoughts to make sense of what is being learned and locate it within an individual framework;
- provide evidence of thinking through articulating either verbally or in writing their responses;

- encourage independent learning, which is usually more meaningful for learners;
- move beyond specific content knowledge to use and develop a bank of thinking skills; and
- find a 'voice' to express thoughts which leads to increased confidence and self-awareness.

Reflective journals thus have the potential to contribute to both promoting learning and making this learning visible to instructors. Such journals are used in a variety of contexts, often contributing to assessment and can relate to a program of study, work, fieldwork professional placement or a research project experience. In these contexts, reflective journals can assist students to translate and bridge current knowledge and skills to new, unfamiliar learning situations - through assisting them to integrate theoretical and practical aspects of learning; to cope with messy information and ideas and to address ill-defined problems where solutions are not straightforward. Moon has a nice phrase here as she refers to them personal 'thought holders' over time for students (Moon 2006).

Simply keeping a journal does not necessarily promote reflection. A useful distinction is made by Fink ((Fink 2003)p 16) between substantive writing and reflective writing. He sees substantive writing as focussing on a topic that the writer is seeking to present information about and their ideas associated with it. In contrast, reflective writing focuses on the writer's experience itself, and their attempts to identify the significance and meaning of it. This entails metacognitive engagement with the student's own learning and developing an awareness of themselves as learners. Keefe (1992 p. 123) fleshes this out by distinguishing reflective journal writing from other forms of writing by:

- focussing on ongoing issues over time;
- developing criticality in thinking processes;
- encouraging deep learning through reflection;
- building personal understanding through relating what students are experiencing to what they already know; and
- encouraging metacognition.

Although the use of learning journals is widely promoted and there is diverse on-the-ground usage, it is not always clear what research evidence might be used to demonstrate the value of reflection. In particular, White, Fook and Gardener (2006) point to a relative lack of empirical research on the effectiveness of reflection, the outcomes of reflection and the different methods and processes of reflection. In part this stems from some of the difficulties associated with researching higher order thinking skills, in which multiple thinking processes orchestrate and intersect. Much of the available research on reflection in education provides only partial views of the efficacy of reflection in discrete contexts, which makes it difficult to compare and generalise reported gains. In a recent review of the literature on reflective journals, O'Connell and Dymont (O'Connell and Dymont 2011)) report that the research is as much about issues and challenges in using reflective journals as it is about the benefits. However, they suggest that the evidence of potential and actual problems with reflective writing and its assessment is often ignored by practitioners. Mis-use, or over-prescriptive use of reflection can also create problems, negating any potential benefits to students (Boud and Walker 1998).

These considerations indicate that introduction of reflective journals needs to be carefully considered from a number of angles. Setting a reflective writing journal as a learning activity does not guarantee reflective engagement by students. Additionally, Moon (2006) suggests that the journal needs to be based on tasks that encourage reflection. She recommends tasks that are driven by questions with no clear-cut answers, thought-ordering, evaluative, challenging, ill-structured, 'messy' or based on real-life situations, integrating new learning into previous learning, all of which suggests that reflective journals could be ideal for research experiences.

In addition to the type of task engaged in, performance is contingent on a range of factors that are needed to scaffold engagement. These are the pedagogic drivers that shape the learning experience, and include:

- the type of reflection being set as a learning activity
- the focus of reflection
- support provided for reflection
- assessment and motivational incentives.

In designing these activities, Boud (2001) reminds us that all learning is built on prior experience and that we need to be aware of the pre-existing disposition of the student towards reflection and any previous experience or perceptions that student have of reflection. The conditions under which journal writing take place also have a profound effect on what writers produce and how they engage in reflection (Boud and Walker 1998). Some of these conditional factors include students' perceptions of control, vulnerability, trust, privacy, value, incentive, authenticity, time, importance and worth of the activity.

Undergraduate research experiences are seen as providing a context in which students can assume more responsibility for their own learning and performance. The one-to-one nature of the student/supervisor relationship, engagement in authentic activities and the greater level of independence spur both motivation and a sense of responsibility and accountability to their research colleagues. There is potential for UREs to provide various levels of challenge to students in terms of self-organisation, making independent decisions and exercising personal judgement. Coping with these challenges is a significant component of learning in UREs (Howitt et al. 2010). Reflection could assist the student to deconstruct an experience by considering what has happened and why and thus help them to adjust to the unfamiliar demands of undertaking research.

Reflection can be completely free or can be structured by providing prompts to direct reflection to particular aspects of what the student does. Often these structures take the form of prompt questions, designed to help students identify the important features of their learning and help them make sense of their experience. This structured form of questioning encourages student investigation and independent learning, helping students move away from the passive recording of knowledge and events and into the realm of enquiry and dealing with complex situations. A simple mechanism to achieve this in the context of UREs is for students to respond to prompt questions about their project and their learning regularly. Such responses could document what the student does, their understanding of the rationale for their research, their feelings about their research as well as any problems or issues encountered, for example. Such an approach values the student voice, allowing the student to report on the progress and learning in the context of their unique research project. Previously, similar approaches – where students respond to prompt questions - have been found to be successful in making students more aware of their learning and encouraging communication between students and supervisors (Audet et al. 1996; Campbell and Lom 2006).

## What the TREASURE project hoped to add: the Prompt Question Framework

We hoped to achieve our aims of both enhancing learning and making learning visible to students and supervisors by developing:

- reflective tools which make the objects and processes of learning in student research experiences more explicit to both the student and the supervising academic, and
- more evidence-based methods of assessment for UREs, which better align with the purposes of including UREs in the curriculum and which in turn lead to clearer strategies for evaluating URE effectiveness.

It was hoped that by adding a reflective assessment component that focused on learning about the research process and that was less formal than the final project report, both students and supervisors may more easily recognize the wider range of learning that takes place. Our view is that much of the valuable learning in a URE occurs as the student struggles to come to terms with the reality of research and its inherent uncertainty and that it is appropriate to recognise this in the assessment of the URE. In addition, students who are encouraged to reflect regularly on their own learning and on the nature of the research they are engaged in are more likely to realise higher order gains from their research experiences.

To reveal the 'invisible learning' that occurs, we aimed to develop a scaffold that would prompt students to reflect on their research activities and learning. We felt that it was important that students reflect regularly throughout the project so that they created a record of any progression in their learning, in contrast to the final report which usually focuses on the final achievements and minimizes the process of discovery. Their reflections may also be useful for supervisors to recognise the achievement of learning outcomes and to improve student's awareness of the nature of and transferability of research processes in which they are engaged. We felt it was important to provide a structure for the reflective process and our approach to this was to develop prompt questions to direct students' thinking to particular areas of their experience. This led to the development of the Prompt Question Framework (PQF), which is described in the next chapter.

In terms of the pedagogic drivers for assessed reflective writing listed in the previous section, our initial position was:

- the type of reflection being set as a learning activity – reflective journals linked to research experiences undertaken as part of the normal curriculum
- the focus of reflection – students' attention was directed to specific aspects of their research experience by prompt questions supplied by the project team
- support provided for reflection – reflection was structured by the requirement to answer prompt questions, with a brief written introduction on the value of reflection being provided. We also hoped that supervisors would respond to student's reflections.
- assessment and motivational incentives – we tested a range of different models as part of the project.

In contrast to the existing approaches to evaluating research skills and learning described above, the TREASURE project values the student voice. By asking students to reflect on the progress of their research, we are enabling students to use their own words and the unique contexts of their projects to help recognise learning. The use of an ongoing journal, where students record their thoughts at multiple points during the semester rather than a summative assessment at the end of the experience, may be more effective in assessing changes in conceptions of research and learning over time, ultimately leading to the development of interventions that can enhance learning.

Our approach of reflective journals using the Prompt Question Framework thus has three unique features:

- it allows the student their own voice,
- it is context-dependent, revealing learning during specific incidents and experiences, rather than relying on the student to extract generic understandings or skills,
- it can show the development of learning over time, allowing the identification of critical incidents and barriers to learning.

## Chapter 3: Going down the mine

This chapter describes the development of the Prompt Question Framework (PQF) approach and implementing it in the context of Learning Logbooks. As described in the previous chapter, the purpose of the PQF was to give some structure to reflective journals by directing students' attention to aspects of their learning, their research and the skills they were developing. A key factor in the development of the PQF was therefore an understanding of desired learning outcomes from UREs and other research experiences. While some learning outcomes span disciplinary boundaries, for example generic skills, others might be more specific in relating to ways of thinking and practicing within a particular discipline. We therefore chose to focus on one discipline initially and then expand into others in the later phases of the TREASURE project.

The project was initially trialled in science UREs because both project leaders have backgrounds in science research and teaching. Starting in science resulted in some challenges relating to lack of familiarity with reflective writing and required some adjustment to the original project aims. For example, some academic staff in science are unfamiliar with reflection and hesitant about its use. This suggested that we needed to modify our initial strategy in two ways:

1. To undertake a preliminary scoping exercise to gain more information about staff and student attitudes to reflective writing. This would enable us to identify, and respond to, barriers perceived by staff in using reflective writing and to develop an evidence base on what students valued and found problematic in reflection.
2. We re-named our proposed reflective journals 'Learning Logbooks'. This removed the focus on reflection and instead directed attention to the learning that students undertook. As our interviews with supervisors demonstrated, most were aware of, and encouraged, a much wider range of learning than was actually assessed. By emphasising that the purpose of the writing activities introduced into UREs by TREASURE was to reveal and enhance this desired learning, rather than explicitly emphasising the development of reflective practitioners, we hoped to persuade more participants of the value of these activities.

We recognised the need to involve project supervisor and unit convenor views in the development of the PQF. In previous research, the project leaders had surveyed science academics about their intentions when supervising UREs (Wilson et al. 2012). Although indicating an occasionally alarming lack of thought around precisely what students might learn through their projects, these surveys also suggested to the project team that individual interviews, in which follow-up questions allow for deeper probing and clarification, and in which supervisors might be forced to confront the idea of projects as learning experiences, might be a more productive way to unearth intended learning outcomes.

After an initial formative evaluation around our own project design, we thus adjusted our initial plan to allow for an additional opening phase. Ultimately, the project consisted of the four phases set out in Table 1.

**Table 1: Phases of the TREASURE project**

Phase	Activities
1: Prospecting	Scoping exercise (interviews with supervisors and students about reflection and learning outcomes for UREs), development of the Prompt Question Framework and set-up of Learning Logbooks through <i>edublogs</i>

2. Exploratory dig	Trial of Learning Logbooks in UREs in science at two of the participating institutions (ANU and UWS)
3. Full-scale mining operation	Review and refinement of the PQF in science and other disciplines; extension of Learning Logbooks to arts and social sciences
4. Working with the raw materials	Development of resources for academic developers, project convenors, supervisors and students in UREs, grounded in the rich mine of data provided by the TREASURE Learning Logbooks

## Phase 1: Prospecting

### Interviews with URE supervisors and students

In the first phase of the project, we interviewed a range of staff from different science disciplines about their perceptions of the benefits and intended learning outcomes of UREs, their beliefs about what skills and attributes are characteristic of good researchers in their field, and how or, indeed whether, these learning outcomes and characteristics were assessed in UREs in their institution (Appendix 1). Questions about reflection addressed familiarity with it as an assessment item and opinions about its value and limitations. Staff participating in a biology course that used reflective writing as an assessment component were also interviewed about their experiences and perceptions of the course and its assessment.

Interview data were used to develop an initial framework describing intended learning outcomes, using a thematic analysis to breakdown the intentions described by academics into various categories (Table 2).

**Table 2: Intended learning outcomes for URE students**

<b>Intended outcomes for student: initial analysis</b>
<b>Disciplinary/technical skills/knowledge</b> Students should: <ul style="list-style-type: none"> <li>• Acquire technical skills (equipment, computational etc)</li> <li>• Acquire methodological skills (data literacy, statistics, applying disciplinary approaches)</li> <li>• Apply theoretical/methodological knowledge/skills</li> <li>• Acquire/develop scientific/professional communication skills</li> <li>• Acquire project management skills (time management, organization, prioritization, self-discipline)</li> <li>• Develop mastery/complete learning (move towards disciplinary expert status)</li> </ul>
<b>Engaging in/understanding process of research</b> Students should learn how to: <ul style="list-style-type: none"> <li>• Analyse and interpret data</li> <li>• Come up with a question</li> <li>• Turn a question into a research question</li> <li>• Design an approach to answering a research question; make it feasible (conceptualisation to academically defensible method)</li> <li>• Attack a complex problem – experience the kind of strategies that aren't possible in simple, set-piece problems</li> </ul>

<ul style="list-style-type: none"> <li>• Understand what constitutes relevant data/evidence</li> <li>• Understand how data are generated</li> <li>• Make inferences, drawing conclusions</li> <li>• Understand how the whole process fits together</li> </ul>
<p><b>Ways of thinking</b></p> <p>Students should develop a variety of ways/habits of thinking:</p> <ul style="list-style-type: none"> <li>• Independent thinking</li> <li>• Creativity, originality</li> <li>• Awareness that creativity can be connected to a logical process</li> <li>• A conceptual (as opposed to procedural) approach – marriage of creativity and independence</li> <li>• Critical thinking, externally directed (data, the work of others)</li> <li>• Critical thinking, internally directed (tracking own thinking, reflection)</li> <li>• Deep thinking</li> <li>• A habit of looking for patterns – generalizing</li> <li>• The habit/desire/intention to integrate learning from multiple/disparate sources/courses</li> <li>• The attitude that a body of knowledge is something that can be built on/used to achieve something new, not just something that should be absorbed</li> </ul>
<p><b>Sense of self as scientist</b></p> <p>Students should:</p> <ul style="list-style-type: none"> <li>• Have a sense of ownership, control</li> <li>• Cope with being stuck, with things not working; persevere/persist</li> <li>• Become (temporarily) part of community</li> <li>• Experience what it is like to have expertise</li> <li>• Develop confidence in own capacity to do research</li> <li>• Develop informed enthusiasm for field/discipline</li> </ul>

The interviews also confirmed our views on the mismatch between skills, abilities and learning valued by supervisors and usual assessment, with most supervisors agreeing that the assessment did not value the same qualities that they felt defined a good student. Supervisors' views on both learning outcomes and reflection were used to draft the PQF and in the development of workshops that were run later in the project.

Students who had completed a first-year course on the nature of science run by the project leaders (Yucel 2013) were also interviewed (Appendix 2). The majority of the assessment for this unit was based on reflective writing, with 40percent derived from fortnightly reflections around prompt materials during the course and an additional 20percent based on an explicitly integrative final reflection. The students in this course were drawn from across the science disciplines offered at ANU, with a bias towards the biosciences. None of the students had prior experience of reflective writing in undergraduate coursework, and the unit convenors had made the decision not to provide explicit training around such writing, but rather to provide a single resource on reflective writing and help students' to develop over the semester through individual, focused feedback. Interviews with these students took place 6-18 months after completion of the unit. Amongst other things, we were interested to find out if early training in reflective writing impacted on their subsequent approach to study. Typically, it appeared from what the students said that they were indeed



continuing to reflect and take a more critical approach to their studies in science. Some students described deliberately attempting to set aside time and mental space to do so, whereas others claimed not to have continued the practice while describing approaches that were inherently reflective and critical – in these cases, it appeared that they did not recognise their own thinking as reflective when it wasn't being committed to paper and given the title reflective writing. Comments on the value of reflective writing in the original unit included:

*...it helped solidify what I was thinking ... having to articulate my ideas ... really helped me develop them*

*Sometimes when I'm thinking about my own opinion I find it hard to understand how anyone could think differently ... [reflecting on] the group discussion made me realise how much broader the possibilities were than what I could see*

*I could ... reassemble what it was I was trying to say and put it into the right words, in the right order, the way I wanted to say it*

*I'm more aware of possible bias and how research might work, it definitely enhanced my critical thinking ability*

These excerpts were used in workshops with supervisors and convenors to demonstrate that even science students do indeed find reflection useful for their learning.

### Developing the mining infrastructure: the Prompt Question Framework (PQF)

The initial phase led to the development of a workshop for URE convenors and supervisors in which we provided context for the TREASURE project by showing them some of our findings and interview results. We aimed to prompt them to think about ways in which evidence for the extended learning outcomes for UREs could be gained. We suggested that it might be useful for students to respond to questions about what they were doing and learning. Initially, we used the supervisor interviews and our own experiences to develop a preliminary set of questions. This was used as a stimulus for discussion in workshops with requests for discussion and feedback. During the workshops, we worked with URE supervisors from science disciplines to use these ideas to develop and refine the set of prompt questions to help students think about not just what they are doing, but why they are doing it; what they are learning (particularly from the problems they encounter and the way they go about solving them); and how what they are learning links to their learning in other contexts. The questions are intended to scaffold student thinking about the nature of research and their developing disciplinary awareness and problem-solving skills.

The questions presented and developed in the workshops were intended for use during the student's project. We developed separate sets of initial and final questions to ask students about their reasons for doing a URE, their ideas about research and the skills needed for research, with initial questions focusing on expectations and final questions on whether their expectations had been met and what students thought they had gained from the experience (Table 3).

Following the workshops, suggestions for new questions or re-wording of existing questions were discussed by the project team, resulting in the development of the PQF for the initial phase of trials. The workshops, as well as personal contacts, were used to recruit supervisors and unit convenors to participate in the pilot implementation of TREASURE learning Logbooks. As the first trials took place in science courses, the questions were developed for use in science UREs and the initial workshop was restricted to science audiences and run only at the ANU.

**Table 3: The Prompt Question Framework used in the pilot phase of TREASURE**

The Prompt Question Framework used in the pilot phase of TREASURE
<p><b>First post questions:</b></p> <ul style="list-style-type: none"> <li>• Why have you chosen to do a research project and what are you expecting to get out of it?</li> <li>• Have you undertaken a research project previously? Describe it.</li> <li>• What are you expecting to be different in this research project experience from your normal coursework?</li> </ul>
<p><b>Regular questions:</b></p> <ul style="list-style-type: none"> <li>• What did you do on your project over the last fortnight?</li> <li>• Have you made progress in the last fortnight? <ul style="list-style-type: none"> <li>◦ If so, what allowed you to make progress?</li> <li>◦ What kind of activities did you engage in that helped you make progress?</li> </ul> </li> <li>• Did you encounter any problems or obstacles? <ul style="list-style-type: none"> <li>◦ If so, what made them problems?</li> <li>◦ How did you go about solving them?</li> <li>◦ What would have helped you overcome them?</li> </ul> </li> <li>• What might you have done differently if you had known what you know now, two weeks ago?</li> <li>• Has your research question changed? If so, how?</li> <li>• How have the recent activities that you undertook this week helped you address your research question?</li> <li>• Can you see any connections between your research activities and your other studies?</li> <li>• Can you see ways in which you could apply what you have learned this week to other activities, in or out of university?</li> <li>• Has this fortnight's activities raised any questions you would like to discuss with your supervisor? If so, list them.</li> <li>• What have you learned about your project topic, science and research, or your own learning?</li> </ul>
<p><b>Last post questions:</b></p> <ul style="list-style-type: none"> <li>• Has your research project/unit met your expectations? Why/why not?</li> <li>• What have you learned from undertaking this research project/unit?</li> <li>• Would you do another research project/unit if you had the opportunity? Why/why not?</li> </ul>

In later phases of the project, we ran similar workshops (Appendix 3 and Chapter 6) that were open to all disciplines and were repeated at UC and UWS. Workshops were also run at two conferences (ACSME 2012 and ComScie 2013). Attendees were specifically requested to consider whether the questions were appropriate for their discipline and whether extra questions should be included. Further cycles of evaluation of workshop suggestions and comments on questions led to changes to the PQF for each semester that the project ran. In addition, the later workshops included examples of student learning demonstrated in Learning Logbooks. These examples were used to contribute to the evidence base showing that reflection in general, and the PQF specifically, could prompt students to consider a wide range of issues, many corresponding to the different learning outcomes put forward by staff.

## Developing the mining infrastructure: Learning Logbooks and associated resources

To make a wider range of learning outcomes visible to both students and supervisors, TREASURE uses Learning Logbooks (online reflective journals), where students reflect on their projects in response to prompt questions. We set up a Learning Logbook as a private blog for each student, with their supervisor, the course convenor and the project team also having access. Our aim was for students to post responses to questions regularly, with the logbooks providing an opportunity for students to think reflectively about their projects by going beyond the day-to-day focus on the immediacies of research.

Our preferred model (based on experiences throughout the project) is for students to do five posts during a semester-long project, answering about three questions in each post, and with the posts contributing a small amount to assessment (typically 1 percent per post just for doing each of the five posts). Two of the posts are directed towards the initial and final questions, with the other three posts giving students a choice of questions from the PQF. Students could also think of, and answer, their own questions. The questions can be used in different ways to meet different course goals and structures, including full semester UREs and embedded research components in lecture courses. While most are quite generic, they can be tailored to meet particular course requirements and learning outcomes. Course convenors who participated were given the option of adding or modifying questions to suit the requirements for their particular course and learning outcomes. Often, the project team contributed one or two extra or modified questions after discussion with convenors. More structure could also be provided by restricting choice of questions so that students respond on particular issues at key points throughout their projects; this strategy was used in one course that contained an embedded research component. In two courses, a final reflection piece asking students to evaluate their learning during the semester was also included as part of the assessment. This appeared to be effective in prompting students to look back at their own development over the semester and therefore is a useful addition to Learning Logbooks.

Although supervisors of UREs were given access to their student's Learning Logbooks, very few logged on and read the Logbooks during semester. Many supervisors felt that they already communicated well with their student and did not need an extra means of communication. It is also possible that we should have provided more support and encouragement to supervisors to do this as supervisors were unfamiliar with both the purpose of Learning Logbooks and use of the blog platform. To ensure that all supervisors were provided with an easy way of reading their student's logbook prior to final grading, the complete set of logbook entries by each student was emailed to their supervisor at the end of semester. While this did not allow supervisors to respond in a timely fashion, most did read the logbooks, with some reporting that they provided a different perspective on the student's learning or perceptions of the URE. Course convenors were more engaged with the Learning Logbooks, with some using them to monitor student progress or to identify potential problems during the semester; however, one issue encountered was that convenors had limited time and with large classes, it was not possible to respond to individual students about their logbooks. Convenors did report that logbooks could be useful to identify common difficulties and provide a timely response to the class as a whole.

## Choosing a technology platform to pilot Learning Logbooks

In any cross-institutional project such as TREASURE there are inherent challenges when seeking to implement an online student-centred journal as an assessed course activity. In the case of TREASURE, the project needed to develop and implement an online reflective journal to use across three institutions, over a two year period in diverse course contexts.

After overviewing the information technology facilities and protocols at the participating institutions, we decided that negotiating across institutional Learning Management Systems and processes to deliver online journals for participating course was cumbersome in terms of time and inherent dependencies. Each of the partner institutions had their own stand-alone Learning Management System, configured to their institutional needs. In Moodle (used by at least one of the participating institutions) at that time, there was no provision for individual student logbooks within a course framework; rather students could create a personal blog focussed on their own educational journey and interests. Since then there has been increasing provision for external plugins to enable linking to other blog systems, but at the pilot commencement stage of TREASURE, it appeared that blogging platforms might be able to better deliver on project needs.

TREASURE was seeking a secure online blog based system, with a service orientated to higher education provision. We wanted a system that encompassed the three partner institutions and that did not need a huge amount of technical knowledge to use. A platform that allowed us to manage student blog accounts and privacy settings, that could map against our own project domain name and finally that supported customised themes and layout.

Through purchasing an *edublogs* campus edition license the project was able to:

- immediately commence using a robust and secure blog platform;
- speedily realise example online journals to test and develop for first round pilot implementation;
- filter specific domains to allow student signup for their own logbooks, and staff access to specific student logbooks from each partner institution;
- set up backend access to the administration area of *edublogs* campus for the project team to share and resource various functions;
- implement a robust template-based design to generate course-based logbooks and attendant resources while still enabling student to personalize them;
- readily respond to student queries and issues from system generated alerts;
- harvest data from consenting student logbooks for project research; and
- utilise timely Australian-based *edublogs* support to assist in a smooth rollout, maintenance and further development of the Learning Logbooks for each pilot round.

We developed Learning Logbook guides that provided some information about TREASURE and gave detailed instructions for using Learning Logbooks within *edublogs* set-up. The guide was tailored to each course, providing assessment deadlines and other relevant, course-specific information. If the PQF had been modified for a particular course, the modified version was included in both the guide and the *edublogs* template for that course. The guide was available online and where possible was emailed to all participating students and supervisors. The guide and online template also provided information on the project ethics approval and a request for consent from all students participating. The full guides can be found on the TREASURE project website. Common to all guides, however, was some explanation and advice regarding engagement with the logbook as a reflective activity. These elements included the purpose of Learning Logbooks, how logbooks might benefit student learning, challenges in making regular logbook entries, and advice about logbooks and writing. A sample guide is included in the accompanying resources handbook.

The TREASURE team was responsible for setting up course templates and individual blogs in *edublogs*, providing Learning Logbook guides, sending information and reminders to students and staff about participation, responding to student queries about using Learning Logbooks and compiling posts to provide feedback to supervisors and convenors at the end of semester. This workload would need to revert to course convenors and/or supervisors or be handled the institutional level to ensure sustainability after the lifetime of the TREASURE project.

## Phases 2 and 3: Exploratory dig and full-scale mining operations

### Implementation of Learning Logbooks

Throughout the project, over 330 Learning Logbooks were set up in a range of courses across the three participating institutions. Participating courses covered different disciplines, full semester projects or embedded research experiences, group and individual projects, students in elite and standard degree programs. Details of the units that implemented learning Logbooks in Phases 2 and 3 of the project are provided in the table below.

Learning Logbooks were implemented over three consecutive semesters and in summer and winter projects. One course participated five times (all three semesters and over summer and winter) and two participated twice.

<b>Table 4: Courses participating in the TREASURE project</b>								
<b>Unit</b>	<b>Level</b>	<b>Semester</b>	<b>Total enrolment</b>	<b>No. active logbooks</b>	<b>Gender F/M</b>	<b>Assessment</b>	<b>Elite program</b>	<b>Style of URE</b>
<b><i>TREASURE Phase 2: trialling Learning Logbooks in science units</i></b>								
<b><i>ANU</i></b>								
BIOL3208 Special Topics	3	S2/2012	22	18 (79 percent)	12/6	Required 5 percent + final reflection as component of Project report	N	Individual, apprenticeship
BIOL3209 Special Topics	3	S2/2012	2	2 (100 percent)	1/1	Required 5 percent + final reflection as component of Project report	N	Individual, apprenticeship
ENVS3016	3	S2/2012	21	4 (19 percent)	4/0	Voluntary, not assessed	N	Individual, independent / apprenticeship
PHYS/ CHEM Special Topics	3	S2/2012	10	5 (50 percent)	2/3	Various (required upkeep or voluntary)	N	Individual, apprenticeship
Advanced Studies Courses	1-3	Summer 2012-13	11	6 (55 percent)	4/2	Supervisor/students voluntary, 5 percent	PhB (Science)	Individual, apprenticeship
<b><i>UWS</i></b>								
Mammalian Cell Biology 300408	3	S2/2012	26	10 (38 percent)	8/2	Voluntary, not assessed	N	Individual, embedded, scaffolded
Aquatic Ecology 300465	3	S2/2012	61	54 (89 percent)	37/17	Required 20 posts (10 percent) + an integrated reflection (10 percent)	N	Individual and group, embedded, scaffolded
Phase 2 totals:			153	99 (65 percent)	68/31			
<b><i>TREASURE Phase 3: repeat Learning Logbooks in science units, roll-out to other disciplines</i></b>								
<b><i>ANU</i></b>								
Advanced Studies Courses	1-3	S1/2013	22	9 (41 percent)	4/5	Either voluntary or 5 percent for upkeep	PhB (Science)	Individual, apprenticeship
BIOL3208	3	S1/2013	11	11 (100 percent)	5/6	Required 5 percent + final reflection as component of Project report	N	Individual, apprenticeship

BIOL3209	3	S1/2013	1	1 (100 percent)	1/0	Required 5 percent + final reflection as component of Project report	N	Individual, apprenticeship
ARTS1102	1	S1/2013	19	17 (89 percent)	10/7	Bonus 5 percent, on top of course assessment	PhB (Arts)	Group, embedded, scaffolded
BIOL3208	3	S2/2013	12	12 (100 percent)	7/5	Required 5 percent + final reflection as component of Project report	N	Individual, apprenticeship
BIOL3209	3	S2/2013	1	1 (100 percent)	1/0	Required 5 percent + final reflection as component of Project report	N	Individual, apprenticeship
EMSC3050	3	S2/2013	4	4 (100 percent)	2/2	Required 5 percent	N	Individual, independent / apprenticeship
SCOM3003	3	S2/2013	3	3 (100 percent)	3/0	Required 5 percent	N	Individual, independent / apprenticeship
<b>UWS</b>								
AS Project A: 300937	2	S2/2013	40	35 (88 percent)	16/19	Required 5 posts (5)percent	Advanced Science	Individual, apprenticeship, scaffolded
300465 Aquatic Ecology	3	S2/2013	53	51 (96 percent)	33/18	Required 5 posts + an integrated reflection (20 percent)	N	Individual and group, embedded, scaffolded
<b>UC</b>								
Methods of Inquiry 8192	2	S2/2013	9	9 (100 percent)	8/1	Required, 5 posts 5 percent	N	Group, embedded, scaffolded
Global Social Movements 8168	3	S2/2013	81	78 (96 percent)	52/26	Required, 5 posts 5 percent	N	Individual, embedded, scaffolded
Phase 3 totals			256	231 (90 percent)	142/89			
<b>Project totals</b>			<b>409</b>	<b>330 (81 percent)</b>	<b>210/120</b>			

The implementation phases of the project followed three action research cycles, as Learning Logbooks were implemented over three consecutive semesters from Semester 2, 2012 to the end of 2013 (with a small number of additional summer and winter students). At the completion of each cycle, the project team evaluated the experience in each course, based on preliminary analysis of the Learning Logbooks and feedback from students, supervisors and course convenors. This led to changes to the PQF and the advice provided to course convenors, supervisors and students about participation and expectations for the next cycle.

Each cycle commenced with discussion with course convenors to ensure common aims and understandings, decisions on assessment value and dates for posts, and development of modified PQF, *edublogs* template and Learning Logbook guide specific to each course. To evaluate the experience of using Learning Logbooks, we sought feedback from participating students and staff at the end of each semester. Semi-structured interviews (Appendix 4) were used to obtain supervisor and convenor feedback. Student feedback (Appendix 5) was sought through a mix of focus groups, online surveys through *edublogs* and interviews. One difficulty with obtaining student feedback was that this needed to be at the end of semester after completion of the URE and students were either doing exams or on holidays, leading to low response rates.

### Exploratory dig

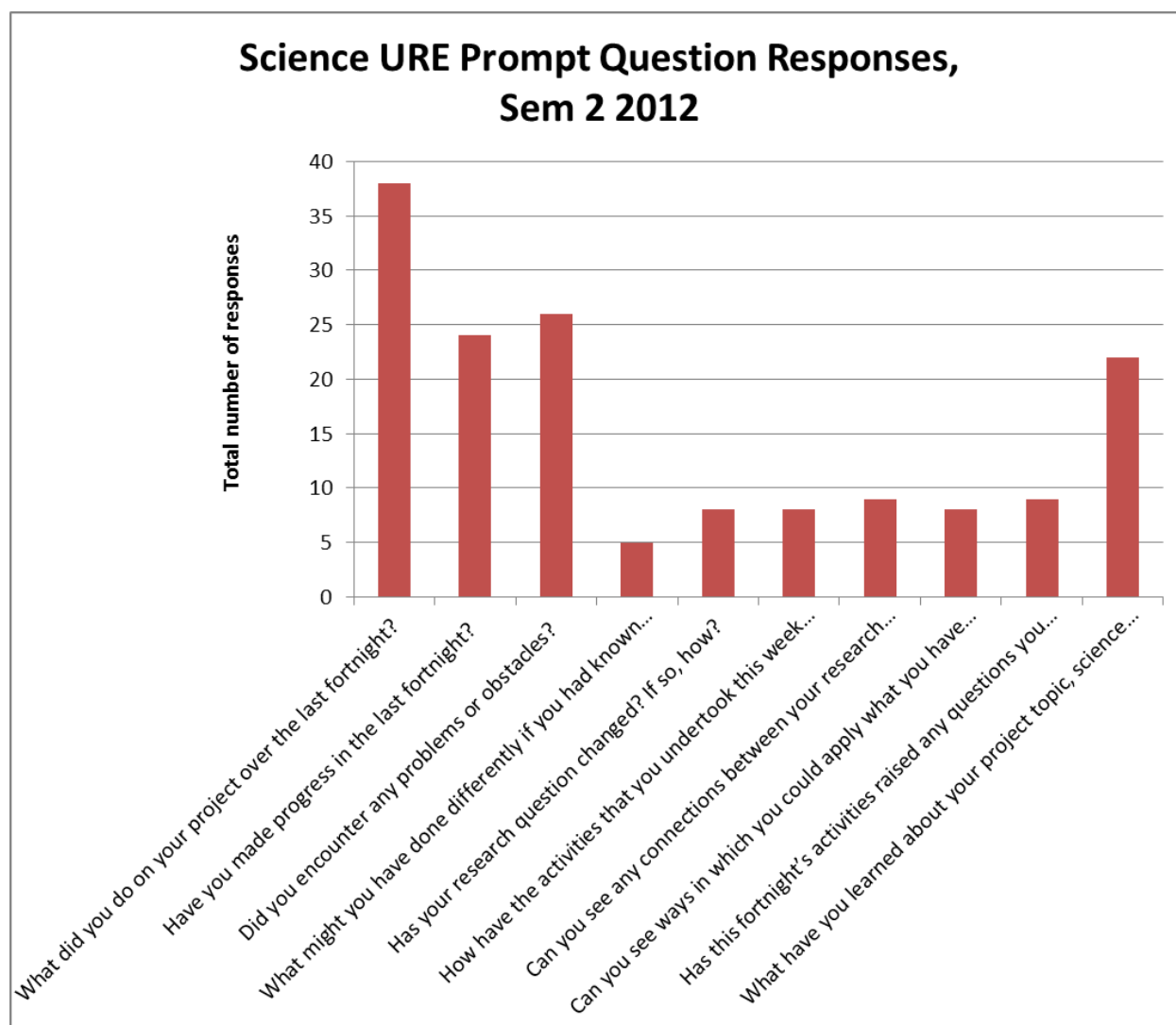
In Semester 2, 2012, trials were restricted to science courses (two at UWS and three at ANU). The PQF was the same for all courses, although two courses were lecture courses with embedded research components and the remaining three were full semester UREs. The courses had different participation and assessment requirements, as detailed below:

- BIOL3208 (ANU) – URE, 5 posts over the semester worth 5percent, final reflection included as part of major report but not separately assessed
- ENVS3050 (ANU) – URE, 5 posts over the semester, voluntary participation
- A small sample of elite degree and final year BSc Special Research Topic student research projects in physics and chemistry (ANU) – URE, 5 posts over the semester, voluntary participation
- Mammalian Cell Biology (UWS) – embedded research component, 5 posts over the semester, voluntary participation
- Aquatic Ecology (UWS) – embedded research component, 20 posts over the semester worth 10percent, final reflection worth 10percent, quality of posts and final reflection assessed.

The experiences with these courses led to the development of our preferred model of implementation, 5 posts over the semester worth 5percent simply for doing the posts, with deadlines set for each post. We recommended this model to subsequent participants (although not all adopted it). We found that when the posts were voluntary, participation rates were low and fell over the semester. The small incentive provided by 1percent per post seems to be sufficient to encourage most students to participate fully (with many writing substantial posts). The quality of posts was not assessed because many participants were concerned about the validity of assessing reflective writing and this would also have substantially added to workloads. Twenty posts was found to be too many, with our preference being for students to answer three questions within each post. This allowed students to consider different aspects of their project but was not so onerous that the task was completed without thought. Deadlines for each post were important so that the logbook recorded the development of the student's project and their thinking about the project over the semester, rather than a student completing all posts at the end. A final integrated reflection, in which students were encouraged to discuss and evaluate what they had learned from participating in research, was valuable but not all convenors were willing or able to make substantial changes to assessment.



**Figure 2: Prompt question responses in science UREs (first cycle)**



The first cycle of Learning Logbook implementation was also important in providing feedback on the effectiveness of the PQF. Figure 2 shows number of responses for each question provided by students engaged in individual, apprenticeship-style UREs in science. While some questions were answered more frequently than others, all were used, suggesting that the questions were appropriate in at least some contexts.

It is evident from the graph that the question “What did you do on your project ...?” was the most popular. The project team had decided to include it as a gentle opener that would guide the students to focus on concrete examples of activities they had themselves undertaken, and initial analysis of the Learning Logbooks suggested that this question was, indeed, fulfilling this function. However in some case, it also seemed to be offering students who were less naturally reflective a way of avoiding critical analysis and instead providing a highly procedural account of their activities. At this point, the team considered whether to remove this question from the next cycle of Logbook implementation in Phase 3 of the project. The initial decision was made to keep it in order to acquire more data on which to base a judgement.

In fact, one might consider the most popular questions to be the two directly related to project progress (or lack of it) – that is, the second and third questions in the chart. Taken together, they represent around one third of the questions chosen to respond to at some

point during semester. The initial form of the PQF did, thus, appear to be successfully directing students' attention towards factors that enhanced or impeded their progress. In many cases, students responding to these questions described their own responses to the situations they found themselves in.

Perhaps surprisingly, the third most popular prompt question was that concerning what students identified themselves as having learned. This strongly suggested that the Learning Logbooks were successfully revealing (and perhaps prompting) metacognition, and might help students to better recognise higher order learning outcomes over the course of their project.

However, the questions had been designed with full semester, immersive, apprentice-style UREs in mind and some were not appropriate, or not understood, by students doing smaller embedded research component within courses. This suggested to us the need to tailor the PQF towards each course; only minor modifications were made with many standard questions included for almost all courses. These modifications ensured that the PQF better aligned with course learning outcomes and helped students focus on specific aspects of their learning, for example in courses involving group research projects we included a question about the nature of collaboration. Refinement of the PQF was also addressed through workshops with a wider range of staff as outlined above, as well as through discussion with participating course convenors.

## Full-scale mining operations

The second and third semesters of the TREASURE project saw implementation expanded to include students enrolled in elite research-based degree programs in arts and sciences at ANU and UWS, courses in social sciences at UC and continued participation in science at ANU and UWS.

Following the first and second cycles of reflection and formative evaluation around the framing of the prompt questions, the PQF was revised in response to our assessment of their value, and adapted for different contexts.

**Table 5: The Prompt Question Framework for science UREs**

<b>PQF for immersive, apprenticeship style UREs in science</b>
<p><b>First post questions:</b></p> <ul style="list-style-type: none"> <li>• Why have you chosen to do a research project and what are you expecting to get out of it?</li> <li>• Have you undertaken a research project previously? Describe it.</li> <li>• What are you expecting to be different in this research project experience from your normal coursework?</li> <li>• What skills do you think you need to be a good researcher?</li> </ul>
<b>Adaptation for second cycle of Learning Logbook implementation</b>
<ul style="list-style-type: none"> <li>• What did you do on your research project/activity since your last post?</li> <li>• Have you made any progress since your last post?</li> <li>• Did you encounter any problems or obstacles? <ul style="list-style-type: none"> <li>○ If so, what made them problems?</li> <li>○ How did you go about solving them?</li> <li>○ What would have helped you overcome them?</li> </ul> </li> <li>• What might you have done differently if you had known what you know now, a few weeks ago?</li> <li>• Has the focus of your research project/activity changed? If so, how?</li> <li>• How have your recent activities helped you address your research project/activity?</li> <li>• Can you see any connections between your course/project activities and your other studies?</li> </ul>

- Can you see ways in which you could apply what you have learned to date to other activities, in or out of university?
- Have your recent activities raised any questions you would like to discuss with your supervisor/course convenor? If so, list them.
- What have you learned about your research topic, science and research, or your own learning?
- How do you see the research environment you have been working in?

#### **Adaptation for third cycle of Learning Logbook implementation**

- How have your recent activities helped you address your research question?
- Have you made progress in the last fortnight?
  - If so, what allowed you to make progress?
  - What kind of activities did you engage in that helped you make progress?
- Problems and obstacles are a normal part of research. Did you encounter any?
  - If so, what made them problems?
  - How did you go about solving them?
  - What would have helped you overcome them?
- What might you have done differently if you had known two weeks ago what you know now?
- Has your research question changed? If so, why, and what has it changed to?
- Have you found/learned anything unexpected? Explain.
- Has anything you've learned shifted the focus or aims of your project? How?
- How confident are you in drawing any conclusions from your observations or results? Why?
- How have you chosen the approach or methods that you are using for your project?
- What are the connections between your research activities and your other studies?
- Can you see ways in which you could apply what you have learned to other activities, in or out of university? How?
- What have you learned about your project topic, science or research more generally?
- What have you learned about yourself from doing this project?
- Has your view of what research is changed from your project experience? Explain how.
- Has this fortnight's activities raised any questions you would like to discuss with your supervisor? If so, list them.

#### **Last post questions:**

- Has your research project/unit met your expectations? Why/why not?
- What have you learned from undertaking this research project/unit?
- Would you do another research project/unit if you had the opportunity? Why/why not?
- What skills do you think you have developed or strengthened through your research project?

New or changed questions highlighted

As is evident from the final cycle of PQF revision for apprentice-style UREs (Table 5), the project team ultimately decided to remove the question, "What have you done...?" as it did indeed seem to be encouraging (or at least giving an excuse for) a procedural approach to the logbook. Other revisions were made to the bank of prompt questions to help probe the student's own sense of contribution/ownership, for example the addition of the question about how the student has chosen the approach or methods they are using. Data on the number of time each question was used demonstrated that all questions were useful and that students answered a range of questions across their posts.

The other two units in which the original prompt questions had been trialled both adopted a very different approach to URE provision to the individual, apprentice-style approach generally found in the ANU units. The UWS unit Aquatic Ecology, led by one of the project team (PR), took a much more structured approach to engaging students in research-like activities as part of their overall experience of participating in a series of field trips. In the first cycle of the implementation of Learning Logbooks for this unit, students largely ignored the PQF. For the second cycle of implementation in this unit (in Semester 2 of 2013), a tailored, specially-designed PQF was provided (Table 6). This framework focused on specific

aspects of the field-based research, and on issues that the convenor wanted to highlight such as the collaborative nature of research and the challenges in conducting field research in a rigorous, replicable manner.

**Table 6: The Prompt Question Framework for an embedded URE (Aquatic Ecology)**

<b>PQF for embedded, scaffolded UREs (Aquatic Ecology) – adaptation for second cycle of Learning Logbook implementation</b>
<ul style="list-style-type: none"> <li>• Did you prepare for your field studies research? If so how?</li> <li>• What did you actually do on the field trip?</li> <li>• Did you encounter any problems or challenges during your field trip?</li> <li>• What follow-up or further activity have you undertaken from the field trip?</li> <li>• What might you have done differently if you had known what you know now, prior to undertaking your field trip?</li> <li>• What have you learnt about data analysis and interpretation?</li> <li>• Has your field report changed at all doing the process of writing it up?? If so, how?</li> <li>• Did the field research raise any questions, or make you think about aspects of science research methods at all?</li> <li>• In hindsight what might you have done differently if you had known what you know now, prior to undertaking your field trip?</li> <li>• What progress have you made make in terms of data collection, analysis and interpretation? Explain.</li> <li>• During the field trips did you have any second thoughts about experimental design and sampling procedures used in your field work?</li> <li>• What are you learning about collaboration in research?</li> <li>• Can you identify any factors that could have improved the rigor and quality of your field samples and the data generated from them?</li> <li>• What are the connections between your field research activities and your other studies, in or out of university?</li> </ul>

These questions proved to be much easier for students to respond to than the original framework, with all questions eliciting some response from each student.

The first non-science unit to implement learning logbooks was the course ARTS1101, a compulsory first-semester, first-year unit in the ANU's elite PhB (Arts) program. This unit introduces students who are at the start of a research-intensive degree to research methods in the arts and humanities disciplines. The PQF developed for this unit (in collaboration with the unit convenor) is given in Table 7.

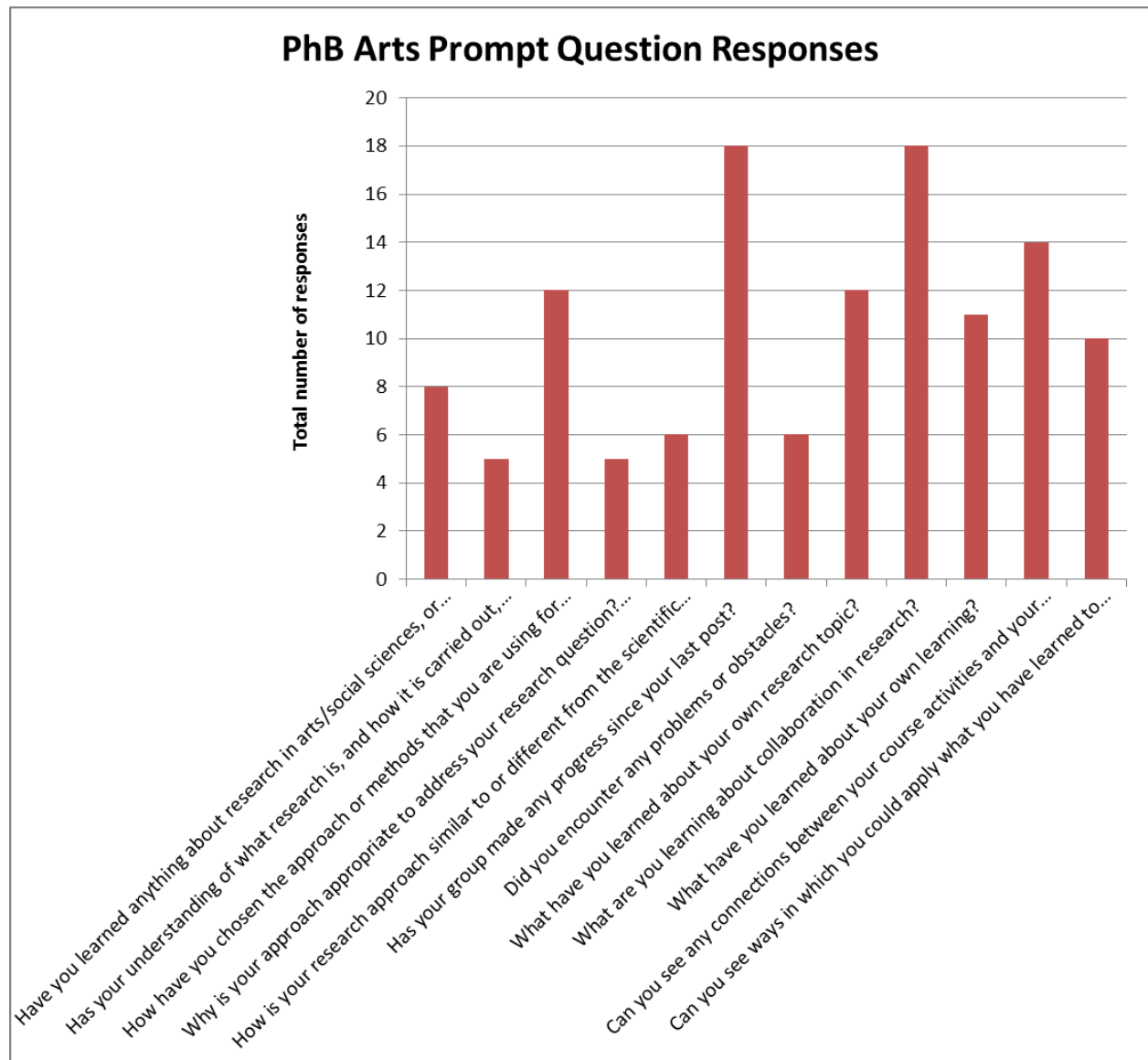
**Table 7: The prompt question framework used for PhB Arts nature of research course**

<b>PQF for PhB (Arts) course about the nature of research (only one implementation cycle)</b>
<ul style="list-style-type: none"> <li>• Have you learned anything about research in arts/social sciences, or research more generally, since your last post?</li> <li>• Has your understanding of what research is, and how it is carried out, changed? If so, in what way, and what made it change?</li> <li>• How have you chosen the approach or methods that you are using for your project?</li> <li>• Why is your approach appropriate to address your research question? Could you have chosen an alternative?</li> <li>• How is your research approach similar to or different from the scientific method?</li> <li>• Has your group made any progress since your last post? <ul style="list-style-type: none"> <li>○ If so, what allowed you to make progress?</li> <li>○ What kind of activities did you engage in that helped you make progress?</li> </ul> </li> <li>• Did you encounter any problems or obstacles? <ul style="list-style-type: none"> <li>○ If so, what made them problems?</li> <li>○ How did you go about solving them?</li> <li>○ What would have helped you overcome them?</li> </ul> </li> </ul>

- What have you learned about your own research topic?
- What are you learning about collaboration in research?
- What have you learned about your own learning?
- Can you see any connections between your course activities and your other studies?
- Can you see ways in which you could apply what you have learned to date to other activities, in or out of university?

Figure 3 shows the number of times each of these questions was selected to respond to in the students' Learning Logbooks. Although, as with immersive UREs in science, the question addressing whether progress had been made was among the most popular, only a small number of students directly addressed the question about obstacles or problems. In general, most of the questions appear to have been appropriate. The additional question about collaboration was also popular, with answers covering both the benefits and challenges of collaboration. This indicates that including such a question successfully directs student attention to desired aspects of a course.

**Figure 3: Prompt Question Responses in PhB Arts nature of research course**



The final set of units in which learning Logbooks were implemented in Phase 3 were two Social Sciences units at the University of Canberra. Both of these embedded research activities in conventional coursework, using small, independent projects to engage students in the real research practices of their disciplines without the overhead of providing one-to-one supervision. The prompt questions developed for these units (again, in collaboration with the unit convenors) are shown in Table 8. One of the key differences between these and the PQF used in the context of apprentice-style projects in the sciences is the question inviting students to explicitly consider and evaluate alternative approaches to those they have been using. This question was introduced because the Learning Logbooks from the science projects suggested that directing students' thinking towards envisioning and evaluating alternatives to current practice is a potentially highly powerful way of enhancing their critical thinking skills.

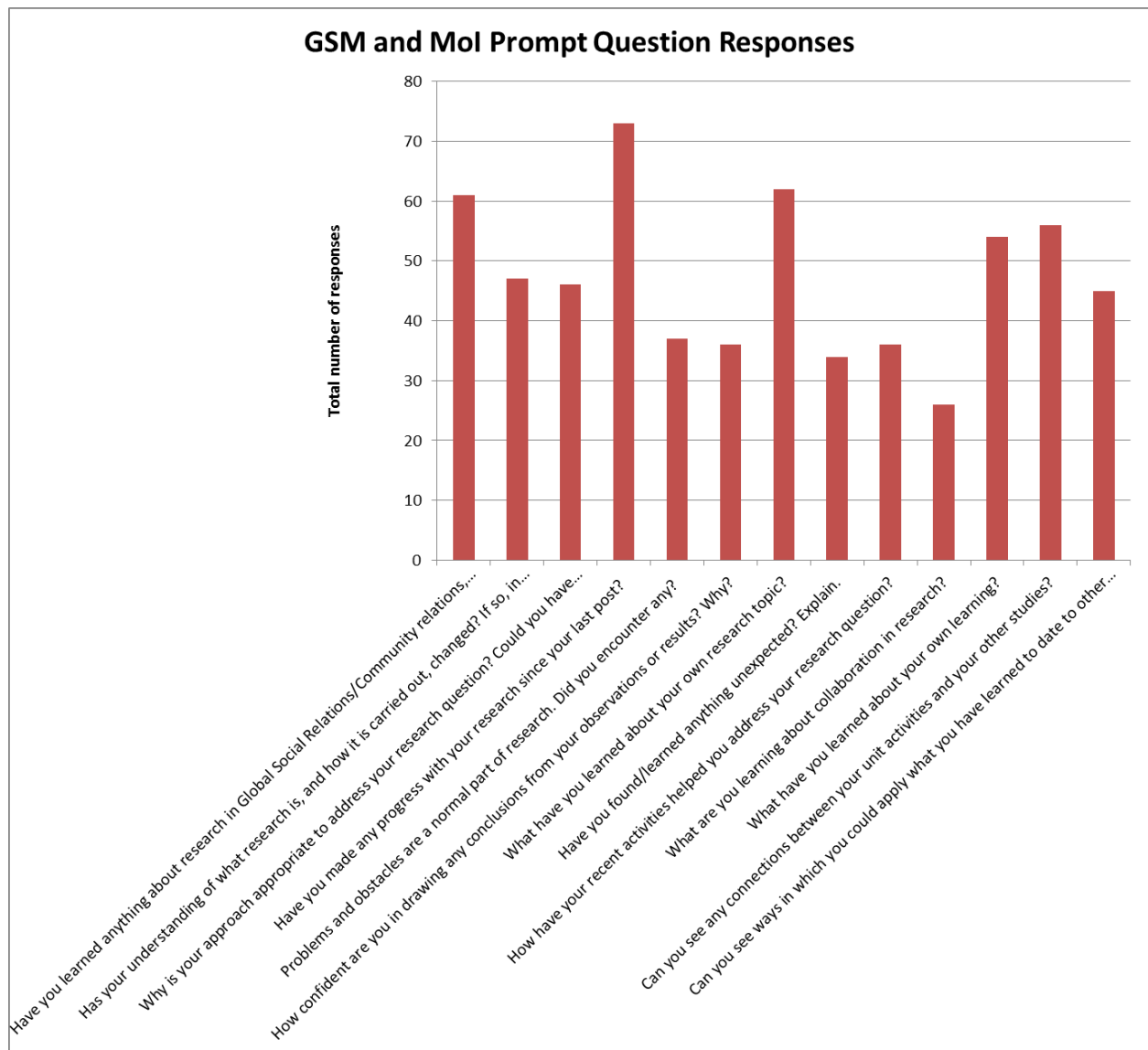
**Table 8: The prompt question framework for embedded research projects in social sciences**

<b>PQF for embedded, scaffolded research projects in social science (one cycle of implementation only)</b>
<ul style="list-style-type: none"> <li>• Have you learned anything about research in Global Social Relations/Community relations, or research more generally, since your last post?</li> <li>• Has your understanding of what research is, and how it is carried out, changed? If so, in what way, and what made it change?</li> <li>• Why is your approach appropriate to address your research question? Could you have chosen an alternative?</li> <li>• Have you made any progress with your research since your last post?</li> <li>• Problems and obstacles are a normal part of research. Did you encounter any?</li> <li>• How confident are you in drawing any conclusions from your observations or results? Why?</li> <li>• What have you learned about your own research topic?</li> <li>• Have you found/learned anything unexpected? Explain.</li> <li>• How have your recent activities helped you address your research question?</li> <li>• What are you learning about collaboration in research?</li> <li>• What have you learned about your own learning?</li> <li>• Can you see any connections between your unit activities and your other studies?</li> <li>• Can you see ways in which you could apply what you have learned to date to other activities, in or out of university?</li> </ul>

The number of times each question was selected for a response during the course of the semester is shown in Figure 4. As is evident from this Figure, all questions in this PQF adaptation appear to have been appropriate, and were successful in eliciting responses from students.

The data presented in this chapter demonstrates that the PQF we have developed is a useful addition to the assessment of a research-based course, either in URE form or as a scaffolded and embedded smaller research experience and across a range of disciplines. All questions generated responses from at least some students and individual students commonly answered different questions in each of their posts. Across the entire set of logbooks, 23percent of students included an answer to the same question in each of their three posts (ie one of their three questions was common in each post). This also suggests that students found the diverse range of questions relevant and were able to use them to discuss different aspects of their experience. It is important to note, however, that questions be carefully considered to ensure that they are appropriate for the context of a particular course. Additional course-specific questions can also be included if desired.

**Figure 4: Prompt Question Responses in embedded research projects in the social sciences**



## Resources

The nuggets below can be found in the accompanying resources handbook.

**Table 9: Chapter 3 nuggets**

### A nugget from the TREASURE trove: sample student guide to using Learning Logbooks

This nugget is an example of the guide we provided to students at the start of semester. It introduces the idea and potential value of the Learning Logbook, includes the Prompt Question Framework and assessment information as well as instructions on how to use the *edublogs* site.

### A nugget from the TREASURE trove: case study of a biology URE course

This nugget describes a case study of the involvement of one course in the TREASURE project. This course participated in all three cycles of TREASURE implementation and the team worked closely with the convenor to ensure that logbook implementation was successful. The nugget discusses evolution of the PQF within this course as well as lessons learned.



## Chapter 4: Finding treasure: gemstones and precious metals

One major goal of the TREASURE project was to improve the effectiveness of units and courses that use assessed undergraduate research experiences to improve students' understandings of the nature and practice of research and to foster generic and research skills. In doing this, the project aimed to contribute to the OLT priority areas of *promotion and assessment of student learning* through the improved visibility of student learning and *curriculum renewal* through the provision of better strategies for supervision and assessment. We aimed to:

- develop reflective tools which will make the objects and processes of learning in student research experiences more explicit to both the student and the supervising academic, and
- develop more evidence-based methods of assessment for UREs, which better align with the purposes of including UREs in the curriculum, and which in turn lead to clearer strategies for evaluating URE effectiveness.

The previous chapter described the design and implementation of our reflective tools, the Learning Logbooks and the PQF. In this chapter we continue to address the first of these goals by providing evidence that the Learning Logbooks do demonstrate student learning about the nature of research and help students identify the development of generic skills. Most of this evidence is presented as case studies – nuggets – addressing particular aspects of learning and these are available in the accompanying resources handbook and on our website. Here we provide an overview of how the Learning Logbooks contribute to the promotion of student learning. Implications for assessment and impact on curriculum renewal are addressed in Chapter 5.

The Learning Logbooks were highly effective in revealing students' thinking and learning. As discussed in the previous chapter, supervisors have a much broader range of learning outcomes for UREs than is assessed by the most common formal assessment methods. We can find evidence in the logbooks, considered collectively across the range of projects included, that most of these broader learning outcomes can be met by research experiences. In addition, they reveal the emotional and personal development experienced by students, something that is not present in conventional assessment. The Learning Logbooks, therefore, play a valuable role in helping both students and supervisors to see that the 'invisible learning' does occur. In fact, it would be fair to say that they significantly exceeded our expectations in this respect. In many cases, they:

- provided evidence of students thinking critically, independently and creatively
- showed students developing interpersonal skills and confidence
- revealed deepening understanding of the underlying purpose and meaning behind professional habits and approaches (such as keeping a lab notebooks or rigorous adherence to safety procedures in the lab)
- demonstrated increasingly fluent acquisition of disciplinary discourse(s)

The Learning Logbooks revealed a great deal more than simply learning outcomes that might be assessed. They also showed the emotional load that projects put on students, such as:

- significant levels of commitment and desire, a sense of ownership, and responsibility both to a team and to the progression of the research itself
- the tendency of the usually unconfident student (unconfident due to the unfamiliar environment and requirements of research) to internalize failure

- the overhanging fear of not finishing – of failing to produce an output – due to e.g. technical problems or other delays outside of their control.

To examine the nature of student learning and thinking in more depth, the project leaders are analysing Learning Logbooks, student interviews and focus group transcripts. Because we sought to identify qualitatively different ways of understanding and experiencing research as elements of a coursework degree, our approach was informed by the methods and underpinning theories of phenomenography. Phenomenography is a methodology explicitly designed to distinguish between more and less sophisticated ways of understanding or experiencing the same concept (Åkerlind 2005; Marton and Booth 1997). While this analysis is still incomplete, it is already allowing us to illustrate different types of learning and to identify different levels of sophistication in the way staff and students engage with learning about research. Staff interviews conducted before and after projects supervised are also being examined to further understand the ways in which staff experience and engage with undergraduate research.

One significant outcome from this project is the mapping of excerpts from Learning Logbooks of science URE students to the intended learning outcomes described in the previous chapter (Table 2). We have done this to develop an evidence base showing that students have achieved particular learning outcomes or are at least starting to develop in the appropriate direction. This type of analysis could be used:

- as evidence to support the value of UREs as learning activities within the curriculum,
- to develop scaffolding or interventions where students commonly report difficulties associated with particular learning outcomes,
- as a rubric where a particular student's learning can be compared to different levels of achievement, which could feed into assessment of UREs.

Here we show one example but the complete analysis is available in the accompanying resources handbook and on our website. The learning outcome used in this example is the development of project management skills. Quotes from three different students are shown to illustrate different levels of achievement: excellent, good and needing intervention.

*"I have gained a much deeper appreciation for the amount of time and effort that goes into collecting and analysing data. I have learned the importance of setting deadlines for finishing tasks, such as data analysis, and sticking to these deadlines (or changing my expectations in order to be able to meet realistic targets)."*

This comment illustrates an excellent mastery of one of the demands of project management, reflecting the need to be both organised and realistic. It differs from those in the 'good' category in that this student has recognised the need for flexible, responsive planning and expectations.

*"Hard work and a lot of time spent searching. When searching for subjects is unsuccessful, I re-focus on the literature to establish the baseline of what is known about vocal mimicry and what functional explanations have been proposed to explain it. This helps me establish my introduction for my report and what questions might be answered by our study. And stops me from getting depressed that I cannot find enough birds ... when one avenue fails, re-focus on something that I can get on with in the meantime."*

This comment has been categorised as good because the student understands that it is fruitless to continue with an unproductive activity and diverts his attention elsewhere rather than simply giving up. He does not, however, address the need to eventually solve the problem encountered.

*"I am not naturally good at doing small amounts of work regularly, over a sustained period of time. What I did with this analysis part of the project was essentially to wait until I was nervous that I was running out of time, and would be receiving an email from [my supervisor] at any stage, and then spent 2 days and nights combing the data in depth."*

While we know that students often work like this, explicit discussion and the development of intermediate goals and reporting could help this student manage his workload.

For every learning outcome we have examined, we see a range in the degree to which it has been mastered by different students. The logbooks, therefore, are proving effective in demonstrating not only a greater range of learning outcomes than a formal report, but also in distinguishing levels of sophistication. They have the potential to provide a valuable mechanism for assessing the development of a student's understanding of research and development of generic skills during a research project.

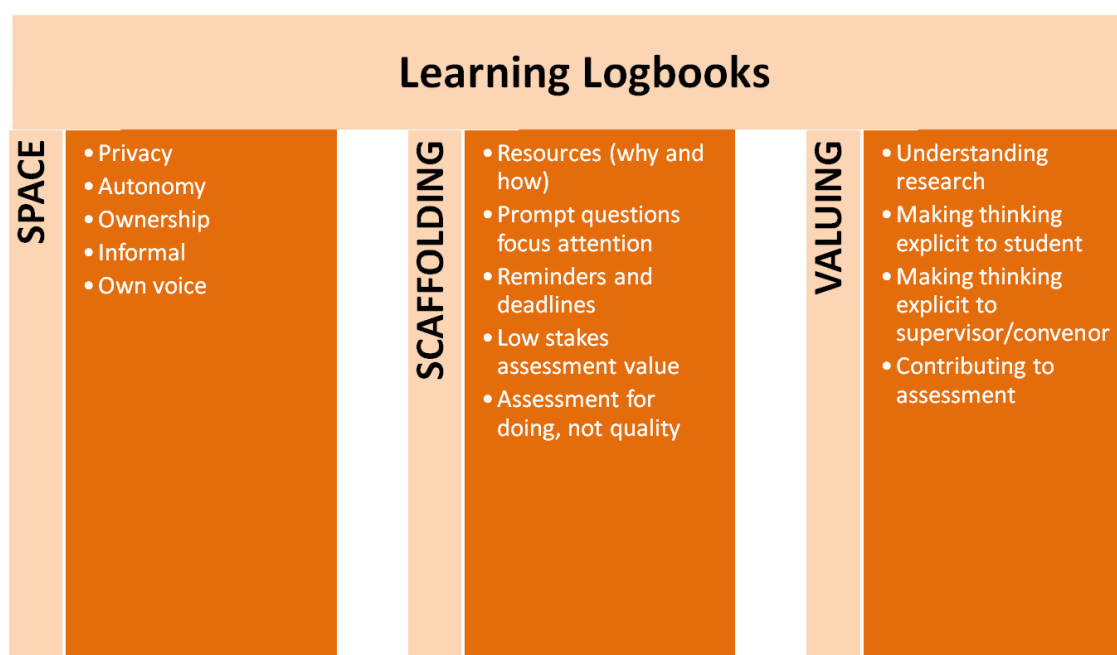
## Factors important for the success of Learning Logbooks

Our ability to use Learning Logbooks to examine learning and develop new ways of framing learning outcomes was dependent on the richness and detail that students provided in writing about their experiences. It was striking that the majority of students did appear to use the logbooks as we intended; ie as a place to reflect on their learning and for honest self-assessment. Ideally, a reflective journal would provide a space, place, and time for students to surface and attend to thoughts and to distil meaning out of experiences. As discussed in Chapter 2, reflective assessment is not automatically successful and appears to be quite sensitive to the context, including purpose, assessment, structure and perceived value. Although we tested some different models for the structure of the PQF and its assessment (Chapter 3), we settled quite quickly on our preferred model of 5 posts per semester with 3 questions answered in each post, assessment for completing the posts but no assessment of their quality, and supervisor/convenor access to the Learning Logbooks. Posts ranged from one sentence to several pages in extreme cases but averaged 1-2 paragraphs.

We felt that the Learning Logbooks were much more successful than we anticipated in drawing out students' experiences. The experience of the project leaders in reflective assessment in another course was that it was important to provide detailed feedback on students' responses. In the TREASURE project there were no mechanisms for formal feedback although supervisors could have responded and students knew that they were participating in a research project. Despite this low level of responsiveness, it was common to see students writing about both successes and failures, describing the progress of their project and reflecting on their own role, achievements and learning. This suggests that many students engaged deeply and thoughtfully with their logbooks. Not all did this, however, and the biggest problem we encountered in use of Learning Logbooks was that not all students showed evidence of reflection, with some posts remained largely descriptive.

In the final phase of the project, we reflected on factors that may have contributed to the success of Learning Logbooks. We drew on students' comments in their logbooks and feedback, supervisor and convenor interviews and our own observations and data analysis. The factors we identified as important are summarised in Figure 5. Further implementation of Learning Logbooks will rely on recognition of the importance of these factors to support student learning most effectively.

**Figure 5: Factors important for student use of Learning Logbooks**



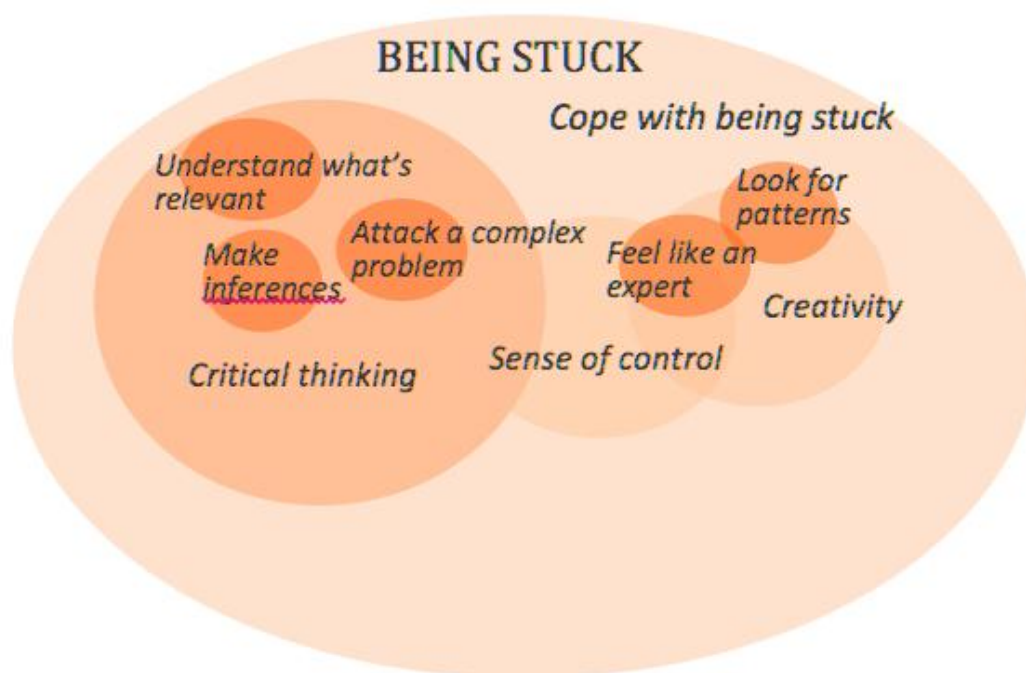
## An alternative way of framing learning outcomes

One thing we have learned in carrying out this project is that we should spend much more time listening to what the students are telling us, both intentionally and unintentionally. This can help us better grasp what is important about the special circumstances of UREs in terms of contributions to learning both about and how to do research.

Equally importantly, by listening to the students reflect on their ongoing experiences, our sense of the learning outcomes themselves changes.

In the process of undertaking the mapping of intended learning outcomes exercise illustrated above, it became obvious that many of the intended learning outcomes identified by supervisors were, when embodied in concrete examples of students' thinking and writing, deeply intertwined. For example, the personal attributes and skills required to "cope with being stuck" include an ability to think critically about the nature of the problem, its possible causes, and its likely implications; a sense of control and confidence in one's capacity to proceed; and creativity in looking for solutions. In turn, an ability to think critically about the problem might include considering the complexity of the problem, trouble-shooting, reflecting on aspects of experimental design, understanding what constitutes relevant data and how they are or might be generated, making inferences and judgments and so on; a sense of control is likely to arise when one has understood the problem and has confidence in one's own expertise; and creativity in looking for solutions is also linked to being able to draw on existing knowledge and expertise. Thus rather than looking for indications of each learning outcome separately (as is the case in existing diagnostic assessment tools discussed in Chapter 2), we might better conceptualise the learning outcomes as sometimes overlapping, sometimes nested and sometimes hierarchical, but always connected by the concrete experience of the project itself, as shown schematically in Figure 6.

**Figure 6: Coping with being “stuck”: relevant learning outcomes**



Ultimately this led to an alternative way of framing the intended learning as elements of a *learning process* as well as *outcomes*. This recognises the complexity of research, and therefore the complexity of what students need to learn, as well as including dispositions or ways of thinking that encompass the emotional and confidence aspects of a research experience. It is evident from our data that both students and supervisors recognise this complexity, even if the assessment of research experiences usually does not. It is also evident that the development of generic skills and professional practice (or often the recognition by students that their skills are inadequate) is deeply embedded in the reality of the research experience. As the Learning Logbooks richly illustrate, thinking (whether deep, creative, independent, etc) is always *about* something.

We have re-framed intended learning outcomes by considering them in terms of what students need to think about and the way in which this thinking links to each learning outcome (Table 10). The key to this lies in the contents of each of our initial categories of learning outcomes (Table 1 in Chapter 3). The first two categories (“developing disciplinary/technical skills/knowledge” and “engaging in/understanding the research process”) mainly describe activities that supervisors want students to engage in or gain experience of. The third category, “ways of thinking,” lists ways of thinking that can be applied during these activities. The fourth category, “sense of self as a scientist”, is partly composed of dispositions that students need to develop in order to successfully engage in the activities of a researcher – the sense of responsibility that comes with ownership, the confidence that comes with control, a disposition to persevere in the face of obstacles, a belief that one’s activities have value – and partly about socialisation into the research community (it is only by experiencing oneself as an “expert” that one can feel one is a valid member of the expert community). Table 10 shows a possible way of reframing the intended learning to better allow the relationships between these different types of learning outcome to be drawn out.

**Table 10: A framework for linking learning outcomes, activities and ways of thinking in undergraduate research**

Activity for student to engage in	Related ways of thinking and dispositions
<b>Developing disciplinary/technical skills/knowledge</b>	
Acquire project management skills (time management, organization, prioritization, self-discipline)	<p>Critical thinking about, e.g.:</p> <ul style="list-style-type: none"> <li>• data, methods, possible outcomes</li> <li>• own dispositions and habitual work patterns</li> </ul> <p>Creative thinking about, e.g.:</p> <ul style="list-style-type: none"> <li>• data management / organisation</li> <li>• Conceptual thinking to keep the bigger picture in mind</li> </ul> <p>Self-discipline and persistence</p>
Develop mastery/complete learning (move towards disciplinary expert status)	<p>Critical thinking about, e.g.:</p> <ul style="list-style-type: none"> <li>• The impact/consequences of following or not following procedures/protocols</li> <li>• The development of the disciplinary knowledge base</li> </ul> <p>Perseverance, persistence Curiosity (for motivation to persevere)</p>
<b>Engaging in/understanding process of research</b>	
<p>Understanding that research requires asking a question</p> <ul style="list-style-type: none"> <li>• Coming up with a question</li> <li>• Turning a question into a research question</li> <li>• Designing an approach to answering a question</li> </ul>	<p>Independent thinking</p> <p>Critical thinking about, e.g.:</p> <ul style="list-style-type: none"> <li>• evidence, methods, data interpretation and the interaction between them</li> <li>• previously published work</li> </ul> <p>Creative thinking, e.g.:</p> <ul style="list-style-type: none"> <li>• to identify new areas of focus</li> <li>• to design new methods or approaches</li> </ul> <p>Curiosity The habit/desire/intention to integrate learning Seeing knowledge as something to build on or used to achieve something new Desire to bring forward the disciplinary community's knowledge</p>

Attack a complex problem – experience the kind of strategies that aren’t possible in simple, set-piece problems	<p>Critical thinking aimed at, e.g.:</p> <ul style="list-style-type: none"> <li>• trouble-shooting</li> <li>• own practice</li> <li>• Independent thinking</li> </ul> <p>Creative thinking (generating solutions)  A habit of looking for patterns  A sense of ownership, control  Perseverance/persistence  Desire to bring forward the community’s knowledge  Willingness to learn from others in the community  Sense of expertise  Confidence in own capacity</p>
<p>Understanding how the whole process fits together</p> <ul style="list-style-type: none"> <li>• Understanding what constitutes relevant data/evidence</li> <li>• Understanding how data are generated</li> <li>• Making inferences, drawing conclusions</li> </ul>	<p>Critical thinking aimed at, e.g.:</p> <ul style="list-style-type: none"> <li>• data and methods</li> <li>• inferences made by oneself and others</li> <li>• alternatives hypotheses</li> <li>• uncertainty and the status of assumed (disciplinary) knowledge</li> </ul> <p>A habit of looking for patterns  The habit/desire/intention to integrate learning  Willingness to learn from others in the community  Sense of expertise  Confidence in own capacity</p>

Each Learning Logbook offers the chance to examine how these activities, ways of thinking and dispositions are brought together by individual students, in the unique circumstances offered by their specific projects. Although each project experience is unique, the Learning Logbooks highlight both that there are some common *classes* of experience, and how those experiences invoke development of (or experience of) particular thinking. For example, students typically experienced both patterns of routine, problem-free work and periods of difficulty. One might expect different affordances for thinking and learning in different circumstances, with periods of difficulty more likely to require a tight focus on the problem at hand, while routine work might provide space for reflection and critical thought about the bigger picture of the discipline/research process. Each type of work also offers different opportunities to integrate and generalise. It’s important to remember that these types of thinking may not happen spontaneously, and so active discussion between students and supervisors around the evaluation of alternatives, integration and generalisation will be beneficial.

## Resources

The Learning Logbooks have provided a rich body of evidence to suggest that deep and complex learning is occurring in both embedded and apprentice-style research experiences. Because the Learning Logbooks from arts and social sciences courses have only been available to the project team for a limited time at the time of writing this report, the focus here is inevitably on the sciences, since we have had time to perform more sophisticated analyses and develop richer resources on the basis of these data. The results of further analysis and new resources will be made available via the project website in due course.

The following table briefly describes nuggets that throw light on different aspects student learning and experiences in research projects. In addition to the very wide-ranging analysis of ways in which the Learning Logbooks provide evidence for learning outcomes described above, we have focussed on a number of specific areas that have attracted our interest. These nuggets can be found in the associated resources handbook and on our website.

**Table 11: Chapter 4 nuggets**



### **A nugget from the TREASURE trove: revealing evidence for intended learning outcomes in science UREs**

Intended learning outcomes from UREs were identified from supervisor interviews (Chapter 3). This nugget describes an analysis of logbook posts from science URE students to identify instances where students achieved these learning outcomes to a greater or lesser degree. Each learning outcome is illustrated by quotes from logbooks to demonstrate the way in which the learning outcome can be recognised. We were able to find evidence for all of the wide range of learning outcomes desired, although not all outcomes were evident in all logbooks. It was also possible to find evidence for different levels of sophistication in demonstrating each outcome, as a first step in developing mechanisms for supervisor intervention to enhance learning.

### **A nugget from the TREASURE trove: making critical thinking visible**

Critical thinking is a key component of problem solving and analysis and we would expect that research experiences might provide opportunities to develop such skills. This nugget focusses on science UREs and identifies the types of critical thinking students demonstrate. Critical thinking can be directed at a range of different aspects of research and the Learning Logbooks demonstrate breadth in application as well as different degrees of criticality.

### **A nugget from the TREASURE trove: revealing that research is inherently collaborative**

The collaborative nature of science appears to come as a surprise to many students, with many Learning Logbooks describing the value of interactions with supervisors, colleagues and peers as something the student had not anticipated. This nugget illustrates the different ways that students experienced collaboration, or the lack of it, during their URE.

### **A nugget from the TREASURE trove: science students' expectations for a URE**

This nugget describes an analysis of answers to the first post questions. These aimed to elicit students' initial thoughts about what research is and their reasons for including a research experience in their degree. Expectations can have significant effects on the learning that takes place and what is seen as important within the research experience so understanding expectations can assist in better scaffolding of learning.

### **A nugget from the TREASURE trove: a cross-disciplinary comparison of the skills students perceive are needed for research**

Analysis of answers to an initial question about the skills needed for research has helped us understand student perceptions of research. Perhaps surprisingly, different disciplines show more commonalities than differences. There is a widespread perception that research requires little more than good organisation. This nugget explores the conceptions of research implied by the skills perceived as necessary and examines differences between the sciences and humanities in the areas of context, bias and communication.

### A nugget from the TREASURE trove: helping students learn

This nugget examines some of the literature on whether reflective journals such as Learning Logbooks can help students learn. Learning Logbooks and feedback from students who used them are examined to see what students say about their learning and the role of the logbooks.

## Chapter 5: Impact and implications

This chapter addresses the second of our two original aims, which was to develop more evidence-based methods of assessment for UREs, which better align with the purposes of including UREs in the curriculum, and which in turn could lead to clearer strategies for evaluating URE effectiveness. We also report on the possibilities for longer term curriculum renewal.

### Implications for assessment of UREs and other research experiences

As described in previous chapters, the TREASURE team developed reflective tools designed to make the objects and processes of learning in student research experiences more explicit to both the student and the supervising academic. Our starting point was the recognition that most existing URE assessment is very poorly aligned with the intended learning outcomes expressed by supervisors and course convenors (Chapter 2). Assessment usually focuses on formal reporting according to disciplinary conventions but this does not assess the more valuable learning where students grapple with the processes and practice of research.

Our major conclusion about assessment from the project is that Learning Logbooks are an excellent formative assessment tool with value to students, supervisors and course convenors, as illustrated in the previous chapter and resources handbook. We would recommend that they be used widely in assessed research experiences, following the model used here. However, we have reservations about using Learning Logbooks or similar approaches for summative assessment – where the quality of posts is assessed - and about the possibility of using our data to develop simple diagnostic tools to assess learning about research. Two reasons for this have emerged from the analysis of Learning Logbooks:

- Research projects are inherently variable, meaning that students, especially those in UREs, will meet some learning outcomes but may not have the opportunity to meet others. This cannot always be predicted at the outset of the project.
- Complex learning outcomes, such as many of those desired by supervisors, cannot be easily identified because it is difficult to separate them from each other or from the context in which the learning occurs. Valuing the student voice, as a mechanism to report on learning, can provide an alternative approach.

These points are discussed below.

### The variability of research projects

Analysis of the 330 Learning Logbooks generated during the TREASURE project shows that the wide range of learning outcomes desired by supervisors can be met by research experiences. However, not all learning outcomes are met by all projects as the Learning Logbooks clearly show that there is very great variability between the research projects undertaken by students. This is especially true in UREs, which will be the focus of this discussion. However similar considerations may apply to embedded research projects depending on the nature of the project and the way it is scaffolded. Research itself is inherently variable since students in UREs are aiming to contribute to new discoveries and supervisors often cannot predict whether interesting results (or problems) will arise. The tension between giving students a genuinely new project, or something more predictable that would guarantee results was an issue raised by some supervisors in interviews; others seemed unaware that this might be a problem. We observed several cases in Learning Logbooks where the results obtained demonstrated that the approach chosen was not the most appropriate but the students usually did not have the time to repeat the investigation. Logbooks showed that there is also variability resulting from project design and nature (field

of research, eg highly technical or more accessible to a novice), supervisor/student interaction, research environment (e.g. student does an independent project or contributes a small part of a larger one) and random events (e.g. bad weather preventing field work, equipment failure), for example.

In addition to the inherent variability of research, there is also a significant time constraint on what a URE student can achieve. Of necessity, this results in a focus on some aspects of research at the expense of others. For example, in a project where the student encounters experimental difficulties early on, the major experience might be troubleshooting. In this case, we might expect the student to develop a good understanding of the way in which experiments are modified and optimized as a result of experience. We might also expect them to develop the ability to make judgments about what is or isn't important in the design of those experiments. However, the student may have much less experience with data analysis. By contrast, in a project where results are generated early and require complex analysis, the student might gain a good understanding of the parameters important for data analysis but have much less experience with experimental design. Such inherent variability in the nature of the experience leads to the conclusion that it is unrealistic to expect, and therefore assess, the full range of potential learning outcomes from any single project.

URE assessment almost always includes a formal report, structured similarly to a journal article and may include other components such as an oral or poster presentation, lab book or field journal and literature review. The formal report provides students with experience in mastering disciplinary writing conventions and therefore is an important component of their learning experience. However, the ease with which a report can be written varies with the success of the research project. Projects that generate genuinely new results consistent with the aims of the research are much easier to write up than those where difficulties are encountered, contributing further to inequity in UREs. Assessment criteria should be written to focus on the understanding of the process of research that the student demonstrates, rather than the results; in most participating courses this was the case but supervisors were not always aware of the assessment criteria (the latter was most common for elite degree projects). Furthermore, the structure of a formal report minimises the extent to which processes, rather than results, can be discussed. One option might be to assess reports arising from research participation as satisfying course requirements, rather than grading reports because of the variability in student experience. One supervisor interviewed suggested this for similar reasons.

## The value of the student voice in observing complex learning outcomes

The intended learning outcomes supervisors proposed for their students were wide-ranging and complex, from higher order thinking skills to attitudes to research. As we described in the previous chapter, many of these are manifested together as students address a complex problem or new experience during their research project which requires a combination of knowledge, skills and dispositions (see, for example, Figure 6). This feature is not addressed by existing frameworks for the assessment of research skills, which adopt a reductionist approach of isolating particular skills in tables or as Likert-style statements. Furthermore, the focus of assessment on a formal report may result in the student seeing their learning largely in terms of discipline-specific skills and content, with success or failure being measured by the project results rather than their learning about the process of research. This could inhibit developing an understanding of some of the more complex aspects of research; for example, students might see problems merely in terms delaying getting results rather than as an opportunity to develop problem-solving skills.

It is evident from the Learning Logbooks that student views are often highly context-dependent. Many Learning Logbooks show students addressing key issues in understanding the nature of research, for example, creativity in experimental design, subjectivity in data analysis and the interaction between data obtained and the questions asked. However, such learning is rarely expressed in the form seen in research skill assessment questionnaires;

instead students tend to use highly individual language, relating to the lived experience of their project. The value of Learning Logbooks is that they provide a window into student thought, allowing us to track the development of a better understanding of the nature of research in an authentic context.

We also see that students vary in their ability to generalize from their own experience to the broader disciplinary context. Analysis of Learning Logbooks suggests that it is the ability to recognise that multiple skills and abilities contribute to solving problems and the ability to generalise from personal experience to broader considerations about research that are the hallmarks of a more sophisticated understanding of research. Research, by its nature, requires an integrative approach and an important shift for students is recognising that an open-ended and ill-structured problem requires a different approach from a more formulaic type of problem-solving typified by much undergraduate assessment. The logbooks record this shift occurring in some students while also showing that many remain unaware of this aspect of research. By focussing on each skill separately, existing frameworks lack the depth to identify these more sophisticated understandings.

The student voice highlights another key feature of learning about research; the affective domain. Many logbooks record the emotional involvement of a student with their project. Students report on the highs and lows as their project progresses and for many we can observe increasing ownership and confidence as the logbook moves from reporting 'my supervisor told me to...' to 'I plan to ...' or 'I want to...'. It is also evident that students take pride in their achievements. Interestingly, both supervisors and students showed a high level of awareness of the affective domain. Our analysis of learning outcomes desired by supervisors included a category 'sense of self as a scientist' that covered this aspect (Table 1) and many students, in their initial posts, included personal attributes such as passion, curiosity and perseverance in their response to a question about the skills needed for research. In view of this concordance of views, it is surprising that the affective domain is largely neglected by existing frameworks for the assessment of research skills and learning (although questions on confidence in different abilities are included in URSSA).

A potential limitation to the value of the student voice (at least as used in this project) is that students demonstrate very different levels of engagement with the Learning Logbook. Some students' logbooks remained largely descriptive throughout their projects. They tended to choose those questions relating to what they had done and avoid the broader questions about learning. They also showed little evidence of higher order thought or the affective domain. However, in these cases we cannot be sure if the logbook is an accurate representation of the student's development; the student may have a sophisticated understanding of research but choose not to record this in the logbook. There is scope to address this in future by reconsidering assessment (should the quality of posts be assessed?), scaffolding (should students be given more guidance, support and feedback to develop reflective writing skills?) and the PQF (should some questions on particular areas of development be added and should some be compulsory?).

## Implications for curriculum renewal

### Undergraduate research project design

At the start of the TREASURE project, we hoped that the reflective tools developed (embodied by the PQF and Learning Logbooks) would encourage staff to approach the design of UREs through a curriculum framework in which the learning outcomes, learning processes and assessment methods were more explicit, evidence-based and aligned. Analysis of the logbooks is proving useful in developing an understanding of how students perceive research and how such experiences might be better structured to improve learning. We suggest two complementary directions for improvement in the integration and design of research experiences within the curriculum:

- Introducing greater scaffolding around research skills and the nature of research earlier in the degree so that students are better prepared for a capstone URE, and
- Assisting supervisors to see UREs as a teaching and learning, rather than research, activity and therefore designing projects that focus on a small set of learning outcomes and ensuring they support students to achieve them.

The Learning Logbooks make clear that students have a mix of realistic and unrealistic expectations for their research experiences, suggesting that many embark on their project with very little understanding of what research actually entails. This is despite the fact that all three institutions participating in the project describe their undergraduate programs as research-led. Similarly, supervisors vary in how much they consider the learning experience for the student in URE design, with some showing very little awareness of the need to design and scaffold the URE as a learning experience. Previous studies have highlighted the role of the supervisor in contributing to the student's perception of their research project and its value to them (Howitt et al. 2010; Laursen et al. 2010; Lopatto 2004; Russell et al. 2007). It is clear that there is scope to improve both student and supervisor preparation.

While none of the courses that participated in TREASURE was explicitly a capstone, many were third year courses undertaken by students with a desire to use the skills obtained during their degree or to obtain research experience and therefore they do fulfil some of the expectations for a capstone. Students' unrealistic expectations and subsequent surprise at some aspects of research suggest that universities could better scaffold research experiences so that students become aware of the nature of research earlier in their degree program. In particular, the logbooks show that many students believe that research is simply a matter of good organisation. It is ironic that the rise of UREs in the curriculum is often seen as a response to the Boyer Commission Report (Strum Kenny 1998), which in fact recommended a scaffolded approach to integrating research into the curriculum from first year onwards. If this is done, so that students are gradually introduced to more complex research experiences and gain expertise and understanding of the different aspects of research, then it may be appropriate to assess a wider range of learning outcomes in a capstone URE that builds on earlier learning. Scaffolding to introduce students to the nature of research was evident in the courses with embedded research components that participated in TREASURE. Courses of this nature might, therefore, be good preparation for UREs.

Instead of identifying the full range of learning outcomes UREs might provide (which we found supervisors did enthusiastically), we suggest that supervisors could instead be encouraged to focus on specific learning outcomes that a particular project might be expected to meet. While the variability of research means that the direction a project will take cannot be fully anticipated, supervisors could take into account the limited time available and design a project that focuses on one or more specific aspects of research. For this to be done effectively, supervisors will need scaffolding and training to assist them to think of research projects as a teaching and learning activity rather than as furthering their own research. We are not suggesting that UREs be too highly structured, as their authentic nature was one of the factors most appreciated by students. However, the nature of research means that it is easy for both the student and supervisor to focus on the results obtained, rather than on what the student is learning.

The alternative way of framing learning outcomes we have suggested in Chapter 4 (Table 10) may be useful to supervisors in designing effective projects and in improving their supervisory practice. The table could assist supervisors to see links between the activities undertaken by students and the type of learning and ways of thinking that develop. For example, a particularly important aspect of this could be to focus on the learning that arises when problems are encountered. The table could help both students and supervisors recognise and value learning that is not linked to obtaining results. Focussing on the type of thinking engaged in re-directs attention from the project outcomes (ie results) to learning outcomes. It would also be valuable for supervisors to re-consider learning outcomes and

their student's progress towards meeting them mid-way through the project. This could allow adjustment for any unanticipated problems or successes, recognition and valuing of where learning is occurring and timely interventions to support the student's learning. Such a model has previously been implemented in research projects at honours level (Heylings and Tariq 2001) and relies on supervisor feedback to the student on their reflections throughout the year. It is important to recognise that the most sophisticated thinking about research was evident in only some logbooks and therefore there is considerable potential for improvement. The Logbooks show that supervisors play an important role in directing and supporting their students' thinking.

A potential difficulty with this approach is that many supervisors may be reluctant to change, either because of their focus on research, which we have observed in our previous studies (Wilson et al. 2012) or because of their belief that they already supervise effectively. To take a more positive note, interviews with supervisors and convenors suggested that the introduction of Learning Logbooks is resulting in improvements to the supervisory practice of some participants. A number of supervisors who saw themselves as effective supervisors were, nevertheless, surprised at what the Learning Logbooks revealed about their student's thinking. These supervisors were prepared to consider ways in which they could have better supported their student as a result of reading the Learning Logbook. A further benefit from the TREASURE project was that interviews with supervisors provided them with an opportunity to discuss aspects of their teaching (in a research context) and assisted them to think of UREs in terms of learning outcomes. Thus, simply raising awareness of UREs as teaching and learning activities may at least start the process of change.

## Sustainability and ongoing use of Learning Logbooks

The TREASURE project achieved a high level of support from small numbers of participating staff, largely recruited through personal contacts and workshops. Workshop attendees and participants who used Learning Logbooks were supportive and enthusiastic about the project. Several had previously used, or wanted to use, reflection in assessment and found the guidance provided by the PQF and support from the TREASURE team valuable. The goals of the project, in terms of engagement with the three participating institutions were met, with the 330 Learning Logbooks being more than we anticipated (Appendix 3). We were able to show that Learning Logbooks can be useful across a range of disciplines and types of research experience (Chapter 4). On the whole, both staff and students were positive about the experience, suggesting that ongoing use of the PQF and Learning Logbooks will be valuable.

The biggest barrier we encountered to the sustainability of using Learning Logbooks was that the responsibility for setting up and managing Learning Logbooks reverts to course convenors or institutions at the end of the TREASURE project. Supervisors and convenors generally saw that the logbooks provided a different perspective on their students. Many supervisors and convenors in interviews were more open to the use of reflection than we had anticipated but were not prepared to implement reflective assessment themselves. This suggests that staff placed developing and implementing new approaches to teaching as a low priority, perhaps especially in the context of a research experience which they might see as more in line with their research interests than their teaching. This is indicative of the more general issue of the balance between research and teaching, with staff perceiving that directing their efforts towards research, rather than teaching, is more valuable to their careers.

We have produced practical guides to implementing the PQF and Learning Logbooks, as well as evidence of their value in the resources handbook and on our website. We recognise that the provision of resources is only one step in promoting change and is unlikely, by itself, to lead to significant implementation. A useful extension of the TREASURE project would be to explore and publicise other mechanisms for the integration of the PQF into assessment, for example, through existing e-portfolio platforms or as add-ons to existing assessment items. Our most successful strategy for sustainability has been in identifying and supporting

champions for the project. These have come about through existing personal contacts and workshops. As more champions are recruited, we expect this to have a ripple effect in raising awareness of the project outcomes and encouraging further implementation. We also expect to publish several papers arising from the analysis that we have reported in the nuggets.

We have had some successes with sustainability, with some continued use of Learning Logbooks in their current form and two extensions of the project from new adopters who are modifying the PQF to their own requirements. These are:

- Continued use of the PQF and Learning Logbooks in Biology Research Projects, Science Communication Research Projects and some ASC supervisors who can determine their own assessment for UREs at ANU and in Aquatic Ecology at UWS. We have obtained institutional support for maintaining and supporting the *edublogs* system until the end of 2014, with negotiations about further support to take place prior to 2015. Convenors of these courses are committed to continued use of Learning Logbooks.
- Some participants intend to continue to use the PQF and Learning Logbooks but are not currently teaching.
- A modified form of the PQF has been implemented at Griffith University in the School of Biomolecular and Physical Sciences Honours Program in 2014. A common response in workshops was that Learning Logbooks would be useful during the honours year and discussions with several honours convenors have taken place. This was not within the scope of the TREASURE project, which focussed on smaller undergraduate projects or embedded research components, but we have provided advice on the implementation of the PQF at Griffith and will also be involved in its evaluation. Students will answer PQF questions at regular intervals in first semester as a course requirement and will have the option to continue to respond in second semester. Dissemination of the results of this has the potential to impact on other honours programs where interest has been expressed.
- Questions from the PQF are currently being modified for incorporation into online courses under development by the College of Asia and the Pacific at ANU, including the recently launched 'Engaging Asia' MOOC (<https://www.edx.org/course/anux/anux-anu-india1x-engaging-india-1376#.U3RhwigXI89>). Although not all of these new courses are explicitly research experiences, students are expected to think deeply, adopt a research-oriented approach and make connections within the course content. It is hoped that responding to prompt questions will help direct their thinking and learning in the desired direction.

## Resources

The nuggets summarised in the following table range from practical guides on implementation of Learning Logbooks and better supervision to broader discussions relating to the inclusion of research experiences in the curriculum. The full nuggets can be found in the associated resources handbook and on our website.



**Table 12: Chapter 5 nuggets**

<p><b>A nugget from the TREASURE trove: guide for students using Learning Logbooks</b></p> <p>This guide was developed during the project to assist students understand the purpose of Learning Logbooks and use them effectively. It includes generic information such as a background to reflection and use of the <i>edublogs</i> platform, as well as course-specific information such as assessment and due dates. This guide was available on the blog website and was separately given to students at the beginning of their course.</p>
<p><b>A nugget from the TREASURE trove: guide for staff implementing Learning Logbooks</b></p> <p>This guide provides some background information for staff interested in implementing Learning Logbooks. It raises questions that need to be considered about purpose and implementation and provides information on the factors that drove our decisions and alternatives that may be appropriate in different situations.</p>
<p><b>A nugget from the TREASURE trove: advice on URE supervision</b></p> <p>Analysis of Learning Logbooks identified several common issues that cause difficulties for students. This nugget discusses these issues and provides examples from Learning Logbooks of effective supervision as well as instances where the student could benefit from better supervisor intervention. These are used to identify best practice in the areas identified.</p>
<p><b>A nugget from the TREASURE trove: value of Learning Logbooks to supervisors and convenors</b></p> <p>This nugget draws on interviews with URE supervisors and convenors of courses with embedded research components to examine their feedback on using Learning Logbooks. It highlights the value that they saw in having another window into their students' thinking but also identifies barriers to the effective use of Learning Logbooks.</p>
<p><b>A nugget from the TREASURE trove: assessment tools and the student voice</b></p> <p>One goal of the TREASURE project was to develop reflective learning and assessment tools to make learning from UREs more explicit to both staff and students. While simple assessment tools that cover a wider range of learning outcomes than typical URE assessment would be desirable, there are practical difficulties in such an approach because of the variability between projects and experiences. This nugget discusses the value of the student voice in revealing complex learning outcomes and the context-dependence of such learning. We suggest that a major advantage of the reflective approach is that it does reveal such complexity.</p>

# Chapter 6: Deliverables and Dissemination Events

## Deliverables

### Resources handbook

This project report is accompanied by a resources handbook that includes implementation guides, case studies and more detailed analysis of the findings than has been included here. Resources include:

#### Guides

- Prompt Question Framework (tested and evaluated through three action research cycles)
- Intended learning outcomes for UREs developed from supervisor interviews
- Sample guide for students using Learning Logbooks
- Guide for staff implementing Learning Logbooks
- Using Learning Logbooks to reveal intended learning outcomes in science UREs
- Advice on URE supervision
- Case study of using Learning Logbooks in a biology URE course
- Value of Learning Logbooks to convenors and supervisors

#### Case studies of aspects of student learning during research experiences

- Making critical thinking visible
- Revealing that research is inherently collaborative
- Science students' expectations for a URE
- A cross-disciplinary comparison of the skills students perceive are needed for research
- Helping students learn
- Assessment tools and the student voice

#### Website

[<treasure.edu.au/project/>](http://treasure.edu.au/project/)

#### Publications

Wilson AN, Howitt SM, Higgins DM and Roberts PJ (2014) Making Critical Thinking Visible in Undergraduates' Experiences of Scientific Research. Accepted as chapter in '*Handbook on Critical Thinking in Higher Education*', eds M. Davies and R. Barnett. Palgrave MacMillan.

Howitt SM and Wilson AN (2014) Revisiting 'Is the scientific paper a fraud?' *EMBO Reports*. 15: 481-484. <http://embor.embopress.org/content/15/5/481>

Howitt S, Wilson A and Higgins D (2013) The TREASURE project: enhancing student learning in undergraduate research experiences. *Undergraduate Research News Australia* 6: 5

Howitt S, Wilson A and Higgins D (2014) Revealing invisible learning in undergraduate research experiences. *Australian Biochemist*, forthcoming

Conference presentations are included in the table of dissemination events below.

## Dissemination activities

**Table 13: TREASURE dissemination activities**

Date	Activity	Purpose	Numbers
July 2012	ANU workshop doe Science Research supervisors of UREs	The workshop focussed on ILOs in UREs and consultation on the proposed Prompt Question Framework for use with Learning Logbooks in round 1 piloting at ANU.	9
July, 2012	Science ADEs workshop (lunch/planning day)	Build project awareness and engagement	10
5 June 2012	Workshop at ANU Science Education Colloquium	Raise awareness among potential project participants	40
September 2012	UWS Directors of Academic Programs Forum briefing on project	Build project awareness and engagement with management at UWS and engage in identifying possible participants for next stage.	10
27 September 2012	Ideas exchange session, <i>Standards and learning outcomes for undergraduate research projects</i> , for the Australian Conference on Science and Mathematics Education (ACSME)	Build project awareness and get some peer feedback on project premise and approaches	12
28 Nov 2012	Invited presentation in Education Symposium, <i>What do students learn in undergraduate research experiences?</i> , Bangkok, Thailand	Used to raise awareness and obtain feedback on the project	25

17 Dec 2012	Oxford Learning Institute Mini-conference, Oxford, UK	Briefing on project to raise awareness, obtain feedback on prompt questions and strengthen the ANU/ Oxford collaboration	15
14 Dec 2012	Society for Research in Higher Education annual conference, Newport, Wales	Presentation to raise awareness and obtain feedback on the project	40
11 April 2013	Teaching Forum Workshop at ANU	Cross campus, awareness raising, group of academics with an interest in education, about project and their feedback on Prompt Question Framework from a range of disciplinary perspectives.	27
17 May 2013	TREASURE Project workshop University of Canberra	Workshop for interested staff on project aims, and emerging information and a focus on participants' responses to Prompt Question Framework re disciplinary fitness and suggestions for incorporation.	13
17 July 2013	UWS Workshop	Workshop for interested staff on project aims, and emerging information and a focus on participants' responses to Prompt Question Framework re disciplinary fitness and suggestions for incorporation.	12
21 Sept 2013	ACSME, presentation, Canberra <i>Recognising the development of expert practice in undergraduate research: A TREASURE Project update</i>	TREASURE Project progress and emerging outcomes.	25

1 Oct 2013	<i>Learning about research: supporting learning in an undergraduate research project.</i> Symposium presentation at ComBio, Perth	Presentation to raise awareness and obtain feedback on the project	40
31 Oct 2013	<i>Evidencing student learning through reflective practice.</i> Invited workshop at ComScie 2013, Brisbane	Workshop on project aims, and emerging information and a focus on participants' responses to Prompt Question Framework.	22
5 Feb 2014	<i>Making the Development of Critical Thinking Visible in Undergraduates' Experiences of Research.</i> Oxford Learning Institute, University of Oxford, UK	Seminar to report on TREASURE project outcomes	15
14 July 2014	Workshop at STEM in Education, <i>Making Learning Visible in Undergraduate Research Experiences</i> , Vancouver, Canada	Presentation of project outcomes and enhancing participants awareness of learning in UREs	

## Chapter 7: Looking back through a Theory of Change lens

As well as the integrated formative evaluation described in the preceding chapters, the TREASURE team bracketed the project with a more formal evaluation process based on the Theory of Change framework. At the project outset, our evaluator, Professor Mick Healey, facilitated a workshop attended by members of the team and Reference Group in which the first stages of a Theory of Change framework were developed. This involved description of the current situation as the participants saw it, articulation of our desired outcomes for the project (and hopes for its longer term impact), identification of drivers for change and recognition of barriers and enabling factors (both existing and required) to enable the project to succeed in its aims.

At the end of the project, the Project Leaders and Project Manager revisited the framework with the intention of evaluating what had been achieved, what challenges were still to be met, and what unanticipated barriers, enabling factors and outcomes had been encountered.

Table 14 and the subsequent comments provide a summary of this analysis.

**Table 14: Theory of Change evaluation of TREASURE**

Current situation	TREASURE perspective
What is the current situation (at start of project)? Describe it and list the drivers for change.	<p><b>At the start of the project, we summarized the current status of UREs as follows. UREs are:</b></p> <ul style="list-style-type: none"> <li>• Assumed to develop generic skills as well as discipline-specific skills and declarative knowledge</li> <li>• Increasingly positioned as elements of the curriculum that are assessed for grading</li> <li>• Unique, one-off experiences, shaped by individuals' conceptions of the purpose of research experience and not subject to cycles of curriculum development</li> <li>• Highly personal, giving students individual attention/contact with staff in a way not normally possible in an undergraduate course</li> <li>• Sometimes core elements of elite degrees, sometimes open to all.</li> <li>• Typically assessed on the basis of product rather than process (assessment modelled on Honours processes, placing heavy weight on a final, formal report)</li> </ul> <p><b>At the start of the project, we identified the following drivers for change:</b></p> <ul style="list-style-type: none"> <li>• External policy drivers (e.g. AQF, the generic skills agenda) likely to make UREs even more common</li> <li>• Institutional drivers such as differentiation of higher education from further education likely to place more emphasis on research activities</li> </ul>

	<p>of HEIs, with “simplest” way to expose undergraduates to research through UREs, without careful consideration of the special learning opportunities they offer.</p> <ul style="list-style-type: none"> <li>• Inter-HEI differentiation: most universities now strive for increased research income, higher research rankings – the differences are in what type of research is emphasized, rather than whether research is placed above or below teaching. This pushes individual staff in non-research-intensive institutions to strengthen their research activities in order to avoid being “forced” into teaching-only positions – and hence pushes towards growing and capturing your own research students to work on projects. If seen as a way to achieve this, the educational potential of UREs may be lost/downplayed.</li> <li>• Intra-institutional drivers: as some staff become research “stars” in their departments, URE supervision may seem a good use of their teaching load, often as a trade-off for a reduction in conventional coursework teaching. Decreased connection of research-intensive staff with standard curriculum may result in increased likelihood of inappropriate assumptions about e.g. prior knowledge, skills, workload etc.</li> <li>• Few HEIs provide staff with training on how to design and supervise a URE – UREs are therefore likely to be shaped by academic’s own experience of research training, which is inevitably narrow even if positive.</li> <li>• Current understanding of actual learning in UREs, and constructively-aligned assessment, is limited.</li> <li>• Limited understanding also makes it difficult to determine best scaffolding/ positioning of UREs within curriculum – what benefits should be made available to everyone (e.g. are they the most effective way of developing a particular generic skill or attribute)?</li> <li>• There is a genuine need for more (measurable) equity in students’ assessed engagement with research – factors such as required time commitment, assumed skills/ knowledge aside, both staff and students need to be clear about what is reasonable to aim for, and what key benefits students might have the right to expect.</li> </ul> <p>External drivers (e.g. TEQSA) that increase accountability/ transparency requirements are likely to push assessment of UREs towards some form of standardization – the worry is it will not</p>
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	reflect the actual value of UREs, or enhance their value to reach their full potential, but instead will result in the imposition of a bureaucratic “minimum standards” approach.
<b>Desired Outcomes</b>	<b>TREASURE perspective</b>
What will the outcomes of the project be for stakeholders?	<p><b>Our initially-articulated desired outcomes ranged from those for students, those for staff and institutions to those for the wider sector.</b></p> <p><b>For participating students:</b></p> <ul style="list-style-type: none"> <li>• Improved awareness of what they are and could be gaining by engaging in research</li> <li>• Improved learning outcomes</li> <li>• Improved alignment of assessment activities with learning outcomes</li> <li>• Improved understanding of methods, processes and lived experience of research in their discipline</li> <li>• Increased focus on project processes as opposed to outcomes</li> </ul> <p><b>For participating academics:</b></p> <ul style="list-style-type: none"> <li>• Clearer articulation and justification of own intended learning outcomes when supervising projects</li> <li>• Better understanding of how to identify what learning is or is not occurring</li> <li>• Better understanding of projects as designed learning experiences</li> <li>• Increased focus on project processes as opposed to outcomes</li> <li>• Improved ways of acquiring evidence on which to base assessment</li> </ul> <p><b>For participating institutions:</b></p> <ul style="list-style-type: none"> <li>• Happier students</li> <li>• Better integration of research and teaching activities</li> <li>• Better use of teaching time for research-intensive staff</li> <li>• Improved basis for moderation between different UREs; more justifiable URE grading outcomes</li> <li>• Concrete evidence of progress towards generic skills/attributes</li> </ul> <p><b>For higher education sector:</b></p> <ul style="list-style-type: none"> <li>• Access to evidence base acquired during project leading to better understanding of special learning opportunities offered by UREs</li> <li>• Access to resources developed during project, allowing dissemination of good practice made possible in participating institutions</li> </ul>



	<ul style="list-style-type: none"> <li>• Improved experience for students</li> </ul> <p><b>As the project evolved, we became aware of additional outcomes that we either hadn't articulated or hadn't thought of in the first place. We also became aware of an additional, initially overlooked stakeholder group: ourselves! By the end of the project, we can add the following desired outcomes.</b></p> <p><b>For participating students:</b></p> <ul style="list-style-type: none"> <li>• Access to a safe, diary-like space to record thoughts and questions they might otherwise suppress</li> <li>• Increased realization of the value of such thoughts</li> <li>• Increased understanding of their own learning processes and habits</li> <li>• Increased confidence to engage in metacognition about their research activities</li> <li>• Development of disposition to keep using skills such as critical analysis and reflection in other contexts</li> </ul> <p><b>For participating academics:</b></p> <ul style="list-style-type: none"> <li>• A more student-centred stance</li> <li>• Immediate evidence on which to base interventions and changes to project design – a basis for applying the same flexible, responsive approach to project design as they would in their research activities</li> </ul> <p><b>For higher education sector:</b></p> <ul style="list-style-type: none"> <li>• Access to evidence base on which to make decisions about how to teach and possibly assess generic skills such as critical thinking</li> </ul> <p><b>For the project team:</b></p> <ul style="list-style-type: none"> <li>• Better awareness and understanding of our own evolving thinking</li> <li>• Improved reflective/critical thinking abilities</li> <li>• Immediate evidence on which to base interventions and changes to project design – a basis for applying the same flexible, responsive approach to our own project design as we hoped to encourage in supervisors</li> <li>• Improved empathy with academics and students</li> <li>• Clearer understanding of practicalities of implementing reflective blogs</li> </ul>
Processes / Activities	<b>TREASURE perspective</b>
What activities are required to achieve the desired outcomes for the	<b>At the start of the project, we had recognized one overarching requirement – to build an evidence base with which to improve our understanding of what actually happens in UREs. To do this, we assumed we needed to engage students in regular</b>

project?	<p><b>reflections focused on their project work. These reflections would simultaneously provide:</b></p> <ul style="list-style-type: none"> <li>• individual supervisors with evidence of their students' thinking during specific projects;</li> <li>• Individual students with a record of how their thinking changed during a project; and</li> <li>• the TREASURE team with a resource to draw on in designing appropriate assessment strategies.</li> </ul> <p><b>We thought that all we needed to do to achieve this was:</b></p> <ul style="list-style-type: none"> <li>• Recruit URE supervisors to participate.</li> <li>• Work with supervisors to develop prompt questions for students to respond to.</li> <li>• Implement online learning logbooks.</li> <li>• Interview students and staff about what they felt they'd gained from the experience after it was over.</li> <li>• Analyse the combined data to identify commonalities and variation in learning.</li> <li>• Develop guidelines as to what might be good targets for assessment.</li> <li>• Further refine the prompt questions to serve as diagnostic tools for the development of particular thinking skills/understandings of the nature of research.</li> </ul> <p><b>As the project progressed, our beliefs about what was necessary for successful outcome evolved (in some cases rapidly) to include:</b></p> <ul style="list-style-type: none"> <li>• Surfacing academics' intended learning outcomes through interviews</li> <li>• Surfacing and description of academics' beliefs about the skills and attributes needed by good researchers in their disciplines through interviews</li> <li>• Discussions with academics about the value and ease of students' engaging in reflection as part of the project process</li> </ul> <p>Development of an evidence base that could persuade academics that students can productively engage in reflective practice and go on to value reflecting on their learning later in their degrees.</p>
Enabling Factors / Resources	<b>TREASURE perspective</b>
What is needed to do the activities leading to the desired outcomes for the project?	<p><b>At the start of the project, we were aware that we needed the following enabling factors:</b></p> <ul style="list-style-type: none"> <li>• Buy-in to the project's aims, at the institutional level, to give the project some chance of getting off the ground</li> <li>• Buy-in to the project's aims, at the level of individual academics, so that they</li> </ul>

	<ul style="list-style-type: none"> <li>○ Engage with their students' reflections and</li> <li>○ are open to changing their practice on the basis of the evidence acquired</li> <li>• Buy-in to the project processes, at the level of participating students, so that they <ul style="list-style-type: none"> <li>○ Engage with the reflective logbooks in a prolonged way, allowing (self-)identification of change and development during a URE</li> <li>○ Engage honestly with the reflective logbooks, rather than telling us what they think we want to hear</li> <li>○ Engage deeply/ unashamedly with the reflective logbooks, so that they allow themselves the space to express thoughts and questions that they might not otherwise articulate</li> </ul> </li> <li>• Sufficient resourcing to allow for effective project management</li> </ul> <p><b>As the project progressed, we realized that there were additional factors required, including:</b></p> <ul style="list-style-type: none"> <li>• Engaged, active unit convenors willing to discuss the value of reflection/ metacognition with students</li> <li>• Finely-judged incentives such as a clear but fair contribution to assessment for logbook upkeep</li> <li>• Substantial time investment on the part of the project manager in developing resources to facilitate use of the Learning logbooks platform</li> <li>• Substantial time investment on the part of the project team in reflecting on the appropriateness of the prompt questions</li> </ul> <p>Substantial time investment on the part of the project team in reflecting on the range of things that could be learned from the students' voices.</p>
Longer-term impact	<b>TREASURE perspective</b>
What long-term changes will your project achieve?	<p>At the start of the project, we genuinely hoped for sector-wide revolution in approaches to designing and assessing UREs, hoping in particular to foster two shifts in emphasis:</p> <ul style="list-style-type: none"> <li>• away from product towards processes, and</li> <li>• from the experience as a "taste" of research to a well-thought through learning experience with recognizable learning outcomes.</li> </ul> <p>By the end of the project we still hope for this, but have become more sanguine, realizing the key to successful implementation of the Learning Logbooks model lies in persuading those "in the middle" – the discipline-based coordinators of units using or</p>

	<p>consisting of research experiences – of their value. We have developed and will continue to develop a series of resources to help make use of Learning Logbooks, but buy-in at the institutional level of DVC(E)s etc is not an effective way of making them happen in a meaningful way. Unit and program coordinators play a critical role in ensuring their sustainability beyond the life of TREASURE and the support the project has been able to provide.</p>
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At the end of the project, the following had become clear to us:

#### **Current situation:**

- Many undergraduates experience research through the inclusion of “mini” research experiences or projects embedded in conventional coursework, or through more structured and/or tightly-focused learning activities that take students through a specific sequence of research steps or that seek to introduce a particular aspect of research (such as conducting a literature review). Because the two project leaders worked at an institution that had embraced the notion of immersive, full-semester, unit-load research projects (particularly in the science disciplines), our initial intention was to focus on these. However, the rich range of ways in which undergraduates *actually* experience research led us to widen our net and include a range of different models of research experience.
- Because we started with science, UREs in science dominate the evidence base acquired in the project. The fact that science favours a passive voice, and that students are taught to write about their own science in the passive voice, past tense, meant that a shift to a more personal account was difficult for some, and difficult to accept for some academics. This presented a barrier to making learning visible that we had partially, but not fully, anticipated.
- While some students enthusiastically embrace reflection, others are not so comfortable or inclined towards reflecting, and others still are not comfortable with committing their reflections to written form. Thus in some cases, the Learning Logbooks may not reflect the level of sophistication of thinking that students are actually engaging in. Although we anticipated this, we did not do anything to prepare students to reflect or help them see the value of written reflection. There are substantial implications here for anyone considering using Learning Logbooks to assess e.g. student achievement with respect to critical thinking; it would have been helpful for us to reflect more on this, and how we might address the issue within the project.

#### **Drivers and enabling factors:**

- External drivers such as the AQF and TEQSA were largely irrelevant, causing activity at the institutional level but rarely influencing the actions of individual staff (and completely beyond the students’ spheres of awareness).
- Institutional support turned out to be largely irrelevant: what was essential were unit-level champions, whose engagement with the student voice as heard in the Learning Logbooks transformed their own understanding of what UREs can and do provide.
- We thought that taking on Honours would meet with substantial resistance while the smaller, lower-year level projects would be easier to get a toe-hold in. However with hindsight, Honours projects, for which the grading criteria often refer to processes and practices, requiring assessment of “independent thinking,” “critical thinking” etc., and for which grading criteria are common, explicit and well-established, may well have been the best place to start.

### **Learning Logbook processes and activities:**

- Recruiting academics as project participants was not easy. We would hope that the evidence base we have built up, and the resources being developed (the “nuggets” etc) will help to persuade future URE supervisors and course convenors of the value of this type of activity, but active participation pre-supposes a rather student-centred stance. Such a stance is likely to be strengthened through engaging with students on this personal, individual level. However if a student-centred approach is initially absent, little is likely to change.
- The TREASURE team ran workshops for supervisors and unit convenors. However, the reality of the student experience in an immersive research project is one in which direct, day-to-day supervision is often delegated to post-docs and more senior research students. If these people, effectively acting as unpaid tutors, are not aware of the potential for learning, the intended learning outcomes, likely “trigger” conditions for transformative learning to take place, etc., benefits may be limited. We do not want to suggest that UREs should be solely supervised by experienced academics – indeed as is made abundantly evident in the Logbooks, students engaged in immersive projects benefit significantly from a team environment in which multiple levels of expertise and experience are present. More experienced students and early career researchers such as post-docs may be closer to the student’s own zone of proximal development and therefore more able to help them make the next steps in their own development. Similarly a continuum of research expertise means that undergraduate students are less likely to see an unbridgeable gap between themselves and the lead researcher, as different levels of knowledge and stages of development are made visible to them. However, discussion between lead researchers and more junior peers of what the aims, purposes and intentions might be for undergraduates participating in their research program is likely to be highly beneficial. Such discussions would also have the positive side-effect of encouraging early-career researchers to reflect on effective supervision, facilitation and teaching more generally.
- At the start of the project, the TREASURE team discussed whether or not URE supervisors should be given access to their student’s Learning Logbook. Although we were keenly aware of issues of vulnerability and power relationships between students and supervisors/convenors (most of whom were also involved in assessing their students), the prior experience of the two Project Leaders in using reflective writing in a first year science course had led them to believe that reflection was most beneficial if it was responded to. Our own practice of providing feedback to students on their reflections had convinced us that this feedback helped students to see their own voice and opinions as valid and valued, and thus to develop more confidence. We also felt that feedback could be used to identify and highlight subjects or issues for more critical analysis. We therefore decided to give supervisors access to their student’s Logbook, to enable this type of feedback to take place. However, we did not provide supervisors with any guidance or resources on how to effectively provide feedback; this was, in hindsight, a mistake.

- In fact, only a very small number of URE supervisors actively engaged with their student's logbook during the course of the project. The reasons for this are complex, but may include presuppositions on the part of the supervisor that
  - The relatively intensive, personal mode of interaction means that the supervisor is already properly informed of the student's anxieties, confusions and moments of enlightenment
  - The Logbooks may say things the supervisor doesn't want to hear
  - The logbook is another thing to read and that it will not add a great deal to the supervisor's understanding of the project's progress
- In addition, it may be that supervisors were not aware of the potential value of providing feedback on the student's reflections, or did not know how to respond to them constructively. Those supervisors who had more than a 'one-off' exposure to their student's Learning Logbook were more likely to engage with them in subsequent projects, suggesting that engagement itself was sufficient to make their value visible at least in some cases. The interviews we conducted with supervisors once projects had been completed strongly suggest that the logbook can offer a distinctly different perspective on student learning, leading supervisors to recognize that they do not always have insight into their student's anxieties, confusions etc. Thus if the practice becomes a normalised part of UREs, and supervisors are provided with the kind of guidance on feedback that we neglected to provide, we believe supervisors will also increase their use of the logbooks as they become more familiar.
- For convenors of courses with embedded research components, the situation is different as the numbers of students enrolled may make the workload in reading logbooks overwhelming. While convenors did find logbooks useful, managing the extra reading required was a challenge.
- Prompt questions need to be carefully tailored to unit contexts and desired learning outcomes – they can be effective in directing students' attention away from aspects of their research in preference to a focus on others – that is, the questions sow the seeds of reflection, and since students only have limited time they are likely to reflect on what is being highlighted for them by the questions in front of them. For example, questions about research processes and responses to immediate problems are likely to provoke student reflections on these issues, rather than, say, the dynamics of group work or the student's own ability to communicate effectively. Thus if a unit convenor's primary concern is to encourage reflection on different forms of communication, questions need to be selected that will direct students to focus on this.
- The language of the prompt questions requires careful attention, needing to reach students but also connect with disciplinary discourse.
- People (at all levels) sometimes missed the point about the Learning logbooks, with some students adopting an entirely procedural voice/account, and some supervisors/convenors failing to think about how they might contribute to project and/or assessment design.
- Creating and maintain the Learning Logbooks system was not straightforward! Although the majority of staff who expressed an opinion said they valued the Logbooks, very few people valued them enough to consider investing the time/effort into set up and administration. The process may thus be unsustainable without normalisation and infrastructure investment, for example through developing ways to implement them within existing Learning Management Systems or e-Portfolio software. Because TREASURE was a multi-institution project involving universities using different LMSs, an external platform was needed to allow all students to have the same functionalities and user experience. If Learning Logbooks are implemented on a single unit basis, this can

be done using other mechanisms (for example, both Blackboard and Moodle already have blog functions, although access and structure cannot be controlled as we could with edublogs). However a more ambitious approach (and probably more beneficial) approach would provide students with a Learning Logbook to engage with throughout their degree – a project that would require more substantial planning and effort.

- Although we did not set out to relate the prompt questions and analysis of student responses to existing theoretical frameworks such as Perry's schemes for intellectual and ethical development (Perry 1970), Baxter Magolda's model of epistemological reflection (Baxter Magolda 1992) or Barnett's three tiers of critical thinking (Barnett 1997), it became clear that these provide powerful lenses for analysing the level of sophistication of students' thinking. They could thus be used to inform the development of banks of prompt questions in the future.

#### **Other project processes and activities:**

- We tried to treat the Reference group as a group. In hindsight, this was unnecessary and led to an inadequate engagement with its members, as we sought to arrange teleconferences with all present and failed to find mutually do-able times, and sent all materials to all Reference Group members regardless of their area of expertise and particular interest. A more tailored approach, calling on specific members of the group to give feedback and advice on specific aspects of the project and only attempting to bring them together to bracket the project in its initial and final stages, would probably have been more effective (and more efficient).
- We successfully engaged with senior management figures, particularly at ANU and UWS – however very little resulted from these activities, with recruitment and participation relying on personal contacts at the micro-level.
- In addition, attempts to engage with senior management can be (and indeed were) rendered redundant when individuals at those levels moved on, and all corporate memory was lost. We should have anticipated this, as the life cycle of DVCs/PVCs in specific posts is ever shortening.
- The project team itself experienced periods of fragmentation given changing roles, institutions and localities, and wasn't able to work as collaboratively as was initially envisaged. Again, given the decreasing stability of academic life should have led us to anticipate such issues, although probably not to the extent that they did occur (the resignation of one of the two Project leaders being a rather drastic example of fluctuating academic careers!).
- Because of our initial focus on immersive, individual projects in science disciplines, we have had a lot more time to analyse and digest the Learning Logbooks resulting from these UREs than those arising from the Social Sciences, Arts and Humanities (most of which were completed in the final months of the project). Our analysis and the resources we have developed to date therefore has a strong bias towards both science and individual, apprentice-style experiences of research. This will, however, change with time, as the project leaders continue to work on the evidence-base provided by the Learning Logbooks from all units, and to develop additional resources. In a way we have become victims of TREASURE's success: thoughtful, critical analysis of over three hundred learning Logbooks within the timescale of the project was never really going to be possible!
- The project ran well over budget. We were fortunate in that extra financial support was available, partly from one of the participating institutions and partly from the research budget of one of the project leaders. Some of the extra costs were associated with harvesting and organising logbook entries for further research; this was beyond the scope of the TREASURE project (although will contribute to future dissemination through refereed publications). However,

because of the changing roles of the project leaders and the high level of uptake of Learning Logbooks, we placed greater reliance on the project manager than anticipated and her resulting increase in hours was essential to the success of the project.

**Desired and actual outcomes:**

- We initially framed the desired outcomes primarily around staff practice, but actually we were concerned to improve student experience and outcomes with staff in a facilitative role.
- The main function of the project was to make things visible, rather than to make things happen (although making things visible may ultimately lead to action/change).
- The development of a Prompt Question Framework pre-supposed a generically applicable set of “useful” questions. In fact, the questions are highly sensitive to disciplinary context and desired learning outcomes, meaning that although we can provide illustrative examples, each implementation will need to be developed with clear aims in mind. On the other hand, our generic set of questions did prove robust enough to be useful at least across a range of science disciplines and across the highly varied implementations of UREs. They may thus be seen as a useful template for future sets of questions.
- The Learning Logbooks were highly effective in revealing students’ thinking and learning. In fact, it would be fair to say that they significantly exceeded our expectations in this respect. In many cases, they
  - provided evidence of students thinking critically, independently and creatively
  - showed students developing interpersonal skills and confidence
  - revealed deepening understanding of the underlying purpose and meaning behind professional habits and approaches (such as logbook keeping or rigorous adherence to safety procedures in the lab)
  - demonstrated increasingly fluent acquisition of disciplinary discourse(s)
- The Learning Logbooks revealed a great deal more than simply learning outcomes that might be assessed. They also showed the emotional load that projects put on students, such as
  - significant levels of commitment and desire, a sense of ownership, and responsibility both to a team and to the progression of the research itself
  - the tendency of the usually unconfident student (unconfident due to the unfamiliar environment and requirements of research) to internalize failure
  - the overhanging fear of not finishing – of failing to produce an output – due to e.g. technical problems or other delays outside of their control.
- This is a very important point, since few conventional assessment activities give any access to the student’s emotional and personal development.



**Long term impact:**

A key message is that if UREs are to be normalized as part of student learning, a change in attitude is needed – they need to be positioned as for students and about learning and personal development, not for supervisors and about getting some research done.

We do not have an effective mechanism for communicating our findings either to participants or through the sector; while conference presentations and workshops were effective in generating enthusiasm, this only infrequently led to action. In planning the project, we underestimated the barriers to changing practice more broadly.

An essential next step is to draw out commonalities and differences between undergraduates experiences of research in the currently well-analysed science area and the much more neglected spheres of the Social Sciences and Humanities. The existing prolific literature on UREs in the sciences provided platform from which to launch TREASURE; the relatively lack of understanding of UREs in other fields means that our analysis will necessarily be slower and require more care. (However, the relatively rich body of literature on reflection in these fields compared to science may be to our advantage.) There are substantial potential long-term impacts regarding wider understanding of e.g. teaching for critical thinking and the development of confidence/expertise, which may feed into debates and policies around the generic skills agenda.

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# Appendices

## Appendix 1: Semi-structured interview protocols with URE course convenors in Science

These interviews took place in Stage 1 of the project, 2012, and involved 8 Special Topics course convenors in Biology, Physics, Earth and Marine Sciences, Environment, Mathematics, Chemistry, and Psychology at ANU.

### Preliminaries

How long have you been convening special topics/IRPs in discipline area?

How many students usually take this option/course? (Is it offered every semester?)

Do you directly supervise any student research?

### Learning in UREs

What do you intend your students to learn within the research project?

Are there aspects of research you think it is important for students to learn in your project. (Why do you think that?)

What do you expect students to learn in the URE, (eg. content, skills, ways of thinking)? (do they have problems with anything?)

How do you assist students to achieve this learning?

How will you know it has taken place?

Do you assess or evaluate these aspects of their learning? How?

Who undertakes the day-to-day supervision of the student undertaking the project? If it is not you, please indicate who does undertake this activity.

### Additional Questions for Convenor

Do you think there is anything common to UG research projects in your discipline or across disciplines? (generic, common, outcomes?)

Describe the two most different/ distinct projects you have supervised.

How do you compare/ relate the learning gains by the students in them? How were these gains assessed?

Are you aware of any learning outcomes for IRPs? Did you write them? Do you assess against them? Are IRP learning outcomes generic?

Does your school/area compare student performance across topics, is there any moderation of assessment?

If there is, in what manner, what is being moderated and why?

## Conceptions of research

What characterizes research in your field?

Give at least three adjectives that describe research practice in your field.

Give at least three adjectives that describe the qualities necessary to be a good researcher in your field.

Where do new ideas for research come from?

What kinds of questions are valid research questions (in this field)? Give examples.

What kinds of questions are not valid research questions in this field? Give examples.

Can you give some examples of the kinds of activities that researchers in your discipline engage in.

## Appendix 2 : Semi-structured interview questions for former students of Science Under the Microscope, ANU

Looking back, what do you think you learned from SUTM?

Did it change or contribute to changing your views about science and scientific process? If so, how?

Did it have any impact on your views about effective approaches to learning?

Do you approach your studies in your subsequent courses

differently? Follow-up: Are you involved in PAL, and if so do you think your experiences in SUTM had an impact on how you work in PAL?

Do you find yourself reflecting on things you've learned, or how evidence is being used in a scientific argument? If so, is this deliberate or does it just happen naturally? Give examples

...

Can you describe to me what reflection is?

## Appendix 3: Participation statistics for TREASURE

### Overall people participation

- Total number of students: using logbooks 330, interviewed or providing feedback 37 students.
- Total number of researchers: 111 supervising students participating, 27 research supervisors interviewed.
- Total number course convenors: 14 staff convening courses participated in pilots of learning logbooks, 18 course convenors interviewed in total.
- Total number of courses/units: 19 courses/units used learning logbooks during TREASURE piloting rounds
- Courses continuing to use Learning Logbooks: ANU: BIOL 3208/3309, SCOM 3003, small number of ASCs (based on individual supervisors); online courses in College of Asia and the Pacific from 2014. Other universities: Questions adapted to be used in Honours at Griffith.

### Course convenors interviews

Total: 18

#### **Prior to using the logbooks**

2012, 12 Course convenors:

- ANU: 8 Special Topics course convenors in Biology, Physics, Earth and Marine Sciences, Environment, Mathematics, Chemistry, Psychology
- UWS: 4 course convenors from Aquatic Ecology, Mammalian Cell Biology. Geochemistry, Quantitative Project (Mathematics & Statistics),

#### **After using logbooks**

2013, 6 Course convenors:

- ANU: 3 convenors from Special Topics courses in Biology, Earth and Marine Sciences, Science Communication
- UWS: 1 convenor from Advanced Science Project course
- UC: 2 convenors from Global Social Movements and Methods of Inquiry.

### Other Teaching staff participation

Total: 6

- UWS: 1 Integrated Science Unit teaching staff member talking about online journals
- ANU: 5 ANU staff teaching incorporating reflective writing tasks in Biology and Environment, discussing issues encountered and approaches.

### Research supervisor interviews

Total: 29

#### **Prior to commencing logbook piloting:**

- 2012, 6 researchers ANU: new second year course on Big Questions in Biology, staff lecturing into course, looking at their ideas of ILOs and reflection, science a new course incorporating reflection/



- 2012, 5 researchers at UWS: from across sciences who supervise UREs for students in Advanced Science Program, looking at their ideas of ILOs and reflection, Physiology, Chemistry, Geochemistry, Mathematics

### **Research Supervisors whose students used Learning Logbooks in UREs**

- 2012, Sem 2, ANU Special Topics BIOL3208/09: 6 research supervisors about student learning and use of logbooks
- 2013, Sem 1, ANU Special Topics BIOL3208/09: 6 research supervisors
- 2013, Sem1, UWS 1 Advanced Science Project research supervisor.
- 2013, Sem 2, ANU Special Topics BIOL3208/09: 3 research supervisors

Student participation in developing evidence for reflection and in providing feedback on logbook usage.

Total: 37

### **Ideas about reflection to inform pilots:**

2012: ANU 10 students, who had undertaken a course with a strong focus on reflection and critical thinking re: Nature of Science to find out how they valued reflection and their course, sustainability of changes in thinking processes critically, reflection etc. role of evidence etc.

### **Students Feedback on experience of using Learning Logbooks**

2012: Total: 17 students

ANU based: 1 x Focus Group in BIOL3208/09, 4 students

Interviews: 1 environment student, 1 Physics student responded to Questions via email.

UWS based: 5 x Focus Groups in Aquatic Ecology, 11 students

2013: Total: 20 students

ANU based: 11 students online feedback

UWS based: 1 x Focus Group in ASP A, 3 students; 1 Skype student interview; 5 students online feedback

UC based: No student feedback

### **Academic participation in ILOs and PQF workshops**

Total: 61 academics across three participating institutions

- ANU July 2012: 9 staff drawn from biology, chemistry, physics, environment workshop on ILOs in UREs and PQF consultation.
- ANU: April 2013: 27 staff drawn from biology, physics, medicine, environment, visual arts, engineering, humanities, finance and applied statistics, science communication, politics, astronomy
- UWS 17/07/2013: 12 staff drawn from science, nursing, research roles more generally, Academic Senate, linguistics and literature and humanities.
- UC 17/05/2013: 13 staff drawn from education, humanities, social sciences, biomedical sciences, forensics, business, environmental science, physiotherapy, applied ecology, nursing

## Appendix 4: Protocol for semi-structured interviews academic staff whose students used Learning Logbooks

### Course/unit Convenors

What do you think your student learned about the nature of research in this project? (Skills, ways of thinking in the URE?)

Do you think the Learning Logbook helped your student think about the process of research?

Did you think the prompt questions helped students focus on critical aspects of their research and/or their learning?

Did the Learning Logbook make you more aware of your student's understanding?

Was there any discussion between you and your students on any aspects of the Learning Logbook?

Overall, did you think the Learning Logbook was a worthwhile part of your course or unit?

Would you use a Learning Logbook again?

Did you get any feedback from supervisors about use of the Learning Logbooks.

How did you find the mechanics of using the Learning Logbooks?

Have you read your students' logbook postings and when did that occur?

### Research Supervisors

What do you think your student learned about the nature of research in this project? (skills, ways of thinking in the URE?)

Do you think the learning logbook helped your student think about the process of research?

Did you think the prompt questions helped the student focus on critical aspects of their research and/or their learning?

Did the learning logbook make you more aware of your student's understanding?

Did you discuss anything arising from the Learning Logbook with your student?

Would you class this as a successful or unsuccessful project?

Do you think if you had looked at the Learning Logbook earlier it might have been possible to make it more successful?

Overall, did you think the Learning Logbook was a worthwhile part of your student's project? Would you use a Learning Logbook again?

## Appendix 5: Student feedback question sets

### Focus group prompt questions for students who have used Learning Logbooks during 2012, 2013

Did keeping learning logbooks in your unit/course prove useful to your learning? If so, how? If not, why not?

Were the regular questions helpful prompts? Are there any that you would change? If so which ones and why?

Can you provide any specific examples of when you found thinking about your research through your logbook entries particularly useful?

Conversely are there examples of when you found thinking about your research through your logbook entries particularly challenging?

Overall were the learning logbooks a worthwhile part of the research project experience?

Have you any suggestions about what else would have helped you to keep/use your learning logbooks effectively?

Would it have helped to have got together as a class group to share your experiences of the logbook entries?

### Semi-structured face-to-face interviews with students who had used a Learning Logbook 2012

Did you find the learning logbook useful for your learning? If so, how? If not, why not?

Did you find the regular questions helpful? Are there any that you would change? Which ones and why?

Can you give specific examples of when you found thinking about your research through your logbook entries particularly useful?

Can you give specific examples of when you found thinking about your research through your logbook entries particularly challenging?

Overall, did you think the learning logbook was a worthwhile part of your project experience?

What else would have aided you in keeping your Learning Logbook?

## Online interviews questions for students who had used a Learning Logbook 2013

How did you find using a Learning Logbook in your course/unit?

Did you have any problems with actually making posts, or with the technology?

Did you find the Learning Logbook useful in your project? Did it contribute to your learning? If so, how? If not, why not?

Can you recall any questions that you were asked to respond to that you thought were useful in your project? Can you give me an example?

Are there any questions that you would change? Which ones and why?

Overall, did you think the Learning Logbook was a worthwhile part of your project experience?

Have you idea or suggestions for changes or improvements that would have assisted you to keep your Learning Logbook?

What do you think reflection is?