Students' use and understanding of feedback in a university context: How and why students use feedback

Amanda Harper

Faculty of Education and Social Work
The University of Auckland

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Abstract

Students often report that feedback experiences at university are insufficient to make progress. The size of many large science courses means the provision of personalised and timely feedback to individual students is challenging. Online systems have been promoted as a way students can receive feedback for learning. This thesis investigated a technology system designed to provide feedback and help to students. The goal was to determine the extent to which students engaged with learning opportunities that deepen their understanding as they work toward their learning goals. Of equal importance has been checking with the students themselves about their understanding and choices they made with respect to their feedback use in different learning contexts during their undergraduate biology courses. To facilitate this study, Hattie and Timperley's (2007) model of feedback was used as a framework to inform both the research design and subsequent analyses.

Utilising a quasi-experimental approach mixed with an interpretive qualitative study focus group design, this study was conducted in two sequential phases. The first phase investigated the extent to which students used feedback information when it is provided in a self-directed online homework system in a first-year biology course, and whether this supported learning and improved achievement on summative assessments. Structural equation modelling demonstrated that feedback was not necessarily accessed and used by students, but that students with weaker starting competence, who persisted with using the online system information throughout the entire course, were helped academically by using hints.

In the second phase, qualitative approaches provided a richer insight to students' perceptions about their use and level of engagement with feedback in the online system and across their undergraduate experience. Students were selected from Phase 1 data according to whether they were high or low users of feedback in the online system and high or low achievers. The use of Hattie and Timperley's feedback model identified similarities and differences in the students' perceptions about how and why they used feedback.

In the online system, students used feedback for building domain knowledge and rehearsal, in preference to using feedback to support their learning processes and progressing to a deeper understanding. Students prioritised feed up and feedback at task level, contributing to their sense of agency in learning for summative assessments by building information capital. The delay in recognising the value of feed forward for cognitive activities in learning highlighted the importance of self-regulatory skills at university. Multiple aspects of a learner's situation influenced the strategies they used when using feedback in general, including time

constraints, a focus on summative assessment, the level at which they received feedback, the consequences of feedback use at different levels, their sense of wellbeing in their relationships with teachers and peers and their emotions and feelings. This study supported Hattie and Timperley's assertion that receiving and using feedback requires much skill by the students, particularly at self-regulation and process levels. Students in this study prioritised their engagement at task level. Although students attended to the goals of: what they need to know, where they are in relation to these goals and what they need to do to get there, the findings of this thesis showed these goals can compete against each other, leading to different outcomes from inconsistent and unpredictable feedback use.

The thesis makes a useful contribution to the practice of the teaching of biology, in terms of the importance of supporting student use of feedback by addressing the contextual aspects within which formative assessment is delivered. The provision of low-stakes learning opportunities that incorporate feedback use at different levels needs to recognise the multidimensional influences on students' willingness to receive and use feedback. Supporting students to develop metacognitive skills to ensure formative assessment is productive, and addressing negative emotions that affect students may enable them to reframe their perceptions of feedback and how they use it.

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Chapter 1

Introduction and overview

This chapter introduces the study which is concerned with formative assessment practices in undergraduate science education. The practice of formative assessment in higher education brings multiple challenges, that I have similarly experienced in my work as a practitioner to support student learning. The chapter concludes with a justification for the significance of the study, together with the research questions and an overview of the thesis chapters.

On becoming a teacher–researcher

During my teaching career, I worked in secondary schools teaching science and biology, before moving to higher education working in first-year biology courses. As a teacher of biology, my approach resonates with Brookfield's (2006) three core assumptions of a skilful teacher:

- Skillful teaching is whatever helps students learn.
- Skillful teachers adopt a critically reflective stance towards their practice (explain and justify why we are doing things)
- The most important knowledge skillful teachers need to do good work is a constant awareness of how students are experiencing their learning and perceiving teachers' actions. (p. 17)

I have always been interested in ways to support productive learning experiences of students, while reviewing and checking my practice so I can implement learning environments to help students gain a deep understanding of the discipline. Key to both of these endeavours is knowing how the students are experiencing their learning. A refreshing constant has been students' fascination with biology. The biological sciences continue to be exciting for research and learning. New knowledge and fields of study have developed in biology and continue to excite and inspire students to engage with the discipline. Growth in interest has brought growth in student numbers.

The dramatic growth in student numbers during the early 2000s was welcomed by the large research-intensive university where I work, as the funding model was based on numbers of students enrolled in courses. Enrolment growth was highly desired and embraced. At the same time, my institution was building a partnership with the government of the day to address future economic prosperity by the application of knowledge-based creativity and innovation (Hood, 2001). The phrase "catching the knowledge wave" was a signal to many people that

developing skills and knowledge was critical for their futures and that tertiary education was important: a message that was prevalent in marketing material.

The courses I was involved in serviced pathways to professional programmes by providing a filtering mechanism for identification of high-calibre students. An unprecedented growth in course enrolments redefined my experience in a "mass" higher education system. In my role as an undergraduate course coordinator, I found myself organising large classes of over 1000 students, requiring existing course design to be scaled up to accommodate this growth. This approach included the lecture style of teaching, which is recognised as an efficient way to present extensive factual and complex content (Waldrop, 2015). The contrasting contexts I experienced when teaching in secondary- and tertiary-level systems highlighted some assumptions about how students learn.

The growing body of knowledge in the biological sciences brought challenges to teaching undergraduate courses. Many scientists, cognisant of the continued development in complexity and scope of knowledge, believed students' understanding and retention was key (P. C. Taylor, 2014), so student learning was predominantly the remembering of facts delivered by traditional lectures (Alberts, 2010). However, unpacking assumptions is important in critical reflective practice (Brookfield, 2006). Passive learning experiences, such as didactic lectures, can be a disincentive to learning and continuing in science (Bradforth et al., 2015). In the course I coordinate, multiple cohorts of students used to report that they felt unsupported to retain the knowledge they were expected to learn. The increased numbers of students brought an increase in diversity of students and increased multiplicity of learning backgrounds and needs.

As a practitioner, I responded to these challenging demands, by structuring some opportunities for the students to support their independent learning outside the traditional lecture and labs. Experimenting with different approaches, I introduced a learning management system (LMS) as a first significant foray into e-learning. To do this I worked with colleagues from the then Department of Management Science and Information Systems at my institution who had developed an "in-house" LMS called Cecil (Sheridan, White, & Gardner, 2002). The LMS brought new efficiencies to teaching, with functionality in online communications, a gradebook and facilitated organisation of students (>1000) into groups for laboratory classes. It facilitated more growth in class size as new programmes came on stream where the course I coordinated was core. Through the LMS, I was able to improve support to students by providing easy access to resources, including multimedia. We were able to build in self-assessment with feedback, with opportunities for students to work toward mastery of the content (Gunn & Harper, 2007).

Next, I included a Pearson Education product, MasteringBiology, in the course structure as regular homework. MasteringBiology includes a comprehensive repository of activities aligned with text book content that can be customised to support learning outcomes in the first-year biology courses. The strength of this software application is that it provides tutorial activities with animations and tasks that the students could use to learn and review the concepts and content or practice. As there are feedback options in the MasteringBiology system, I introduced online formative assessment to students in response to student evaluations that had indicated dissatisfaction with feedback opportunities for learning. Post-implementation of this online homework system, some evaluation comments indicated the students found the system useful and appreciated that it was incorporated into course design. Some student evaluations, however, stated that they found it "trivial." As a practitioner, I was aware there is often more to the student experience behind these comments.

The use of technology is an effective way to support learning experiences (Hattie, 2009) but the student evaluations raised questions about the effectiveness of this system in these large undergraduate classes. I had arrived at the point where there was a pressing need to bring the world of research into my practice and explore the assumptions about student learning. Taking on both these roles required me to do what Cochran-Smith and Lytle (2009) call "working the dialectic" (p.93) of research and practice. Prompted by challenges in the context of my practice, the incentive to gather evidence led me to this research, which in turn has led to informing practice, demonstrating inquiry and practice as a "reciprocal, recursive and symbiotic relationship" (Cochran-Smith & Lytle, 2009, pp. 94–95). Practitioner research is about generating knowledge that can be used locally, but may also be relevant to other contexts with the inclusion of interpretive frameworks. Undertaking this study has facilitated practice-centred research in a system that retains many traditional assumptions about learning in classes where students' needs and expectations are changing. It is important to gain knowledge to inform further changes in practice.

The context of first-year tertiary education

While in recent times there has been unprecedented growth in students enrolling in undergraduate education at university, retention of these students is a concern in many institutions (Peach, 2005). Factors involved in students' decisions about whether to continue their studies are complex; however, it is clear that academic issues contribute to the decisions leading students to discontinue higher education (Radloff, 2011).

In the New Zealand tertiary sector, over the last 2 decades, there has been a substantial increase in the number of students in university education (Vlaadingerbroek & Taylor, 2010). This is part of a worldwide trend in higher education as degree qualifications become increasingly important in the labour market (Wolf, 2010). Participation in higher level learning is considered to be essential for full engagement in the knowledge society and is the key to prosperity (Gilbert, 2005). Gilbert (2005) argues "people see knowledge in economic terms, as the primary source of all future economic growth" (p. 25). This view is driving the demand for higher education where it is no longer a privilege but a right for students who see it as a path to a good job and greater financial security. These students are likely to view themselves as clients of the university, and expect support to help them achieve this aim (Krause, Hartley, James, & McInnis, 2005).

As admission to university requires students meet academic criteria, first-year students understandably expect they have the skills to experience learning success and complete qualification(s). The *Australasian Survey of Student Engagement* (AUSSE) confirmed attrition is a concern for many universities (Krause et al., 2005). The same survey, in 2010, in New Zealand, suggested students from all eight New Zealand universities may be less engaged in their studies during their first year as compared with students from the USA. Further, one-third (29.4%) of New Zealand university students have seriously considered or planned to leave their current institution prior to completing their qualification. Of these students with departure intentions, 26.8% (or 8% of all university students) indicated this was for academic reasons (Radloff, 2011). Attrition in the first year is costly to individuals, institutions and governments (Krause, 2005).

Learning biological sciences in first-year university classes

For a number of decades, the teaching approach in science, technology, engineering and mathematics (STEM) subjects has been focused on building knowledge alone, using traditional methods where students are "talked at" often through lectures rather than engaged in activities to help them learn (Kirschner, Sweller, & Clark, 2006; Miller & Tanner, 2015). Bradforth et al. (2015) assert there is a growing awareness of more effective teaching methods in the sciences that facilitate students to develop skills to become self-regulated learners. However, in the biological sciences, where a growing body of knowledge is a particular challenge, progress has been impeded in part by the priority given to this rapidly expanding body of content. In addition, many teaching academics prioritise research activities due to incentives and opportunities for career progression (Bradforth et al., 2015).

The current design for learning in large biological sciences classes in many universities is structured into lecture series delivered in lecture halls accommodating hundreds of students. Laboratory classes provide opportunities for doing science, but the lecture format is where most of the body of knowledge is delivered. At each lecture, students will sit for 50 minutes with the expectation they are using strategies that allow them to learn. This approach has endured in universities for some time, originating in Western European universities ~900 years ago. Karl Popper was familiar with these approaches in New Zealand universities. He was employed at the University of Canterbury from 1938 until the end of 1945. As a philosopher of science, Popper sought to understand why science was the most effective form of human knowledge, although he did not see humans as having absolute knowledge. Rather he viewed the testing of ideas (new and old) as important and leading to "forever learning" in science. Prior to his return to London, Popper gave a series of informal talks during a visit to the University of Otago in May 1945, which included discussion about the teaching of science.

> Our system is based on the passive view of science, i.e. 'the bucket theory' of the mind. This theory holds that our minds are passive receptacles like buckets into which information is poured through the various orifices provided by the sense organs. It implies that the mind is passive in learning, and entirely neglects the essential part of learning, namely knowledge in action. This 'bucket theory' is so widespread that it overwhelms teaching entirely and threatens even the organisation of research. In spite of the psychologists' view that we are teaching better, we have still the idea that the more hours you teach the better. (Penny, 2012, p. 21)

Although some teachers and students would argue this system still predominates, many current biologists believe students are not being taught as well as they need to be (Freeman et al., 2014). In their comprehensive meta-analysis of performance in undergraduate STEM courses, Freeman et al. tested the hypothesis that lecturing maximises learning and course performance. Freeman et al. found that compared to students taught by traditional lecturing, the students who experienced active learning (constructivist) methods improved examination scores by 6%. Further, the students in classes with traditional lecturing were 1.5 times more likely to fail than students in active learning classes. The lecture method, however, is not necessarily inherently flawed and can be configured to include elements that help students learn (Brookfield, 2006). While there is increasing evidence for constructivist rather than exposition-centred course design in science teaching, Eddy and Hogan (2014) found that many students are discontinuing studies in STEM fields because of the traditional practices used. Many university biology teachers recognise students learn better when they participate in and reflect

on their own learning process (Bradforth et al., 2015). Nevertheless, some academics consider their job is about communicating content as the factual knowledge that students learn by rote recitation. They question the benefits of approaches that they believe require more preparation, taking time away from their research (Waldrop, 2015).

Students as learners in university

Although many first-year students expect university to be different, Brinkworth, McCann, Matthews, and Nordstrom (2009) found there is often a mismatch between student expectations of how they are going to learn and the teaching methods used. In their study, a high percentage of students indicated they still expected quick feedback on work and ready access to teachers. It is often assumed that students in large first-year courses are independent learners and that success is more likely when students take responsibility for their outcomes (Brinkworth et al., 2009). As there are limited opportunities for interaction with teachers in large classes, taking responsibility for their own learning is essential for first-year students. Further, Brinkworth et al. (2009) found from student surveys that successful transition to university depends on a student's ability to make a rapid adjustment to a learning environment that requires greater autonomy and individual responsibility. As autonomous learners, key skills include the ability to create internal feedback and self-regulation mechanisms that allow them to monitor their progress in learning (Zimmerman, 2008).

For many students, the requisite skills of a self-regulated learner only develop over time within each specific discipline (Kantanis, 2000). Kift (2008) believed first-year students need to understand what it means to be an autonomous learner through teaching that builds on prior learning experiences and promotes self-assessment.

> (A) good first-year curriculum design aids transition from a student's previous educational experience to the nature of learning in higher education and their new discipline as part of their lifelong learning journey. (p. 16)

As such, assessment practices should provide early feedback on progress to students and information for teachers to incorporate in future teaching (Boud & Falchikov, 2005; Kift, 2008; Zepke & Leach, 2010). However, at university, assessment is predominantly a summative collation of evidence about achievement. As assessment practices influence the learning strategies students develop (Guskey, 2003; J. Taylor, 2008), they tend to focus on maximising marks or grades at the expense of developing higher order thinking skills such as problem solving, prediction and creative thinking (Miri, David, & Uri, 2007). Summative assessments contribute to a formal judgement of achievement and have consequences for

students gaining qualifications and progression on career paths. Because the stakes for students are high when the assessment leads to passing and failing, they attend more closely to what they need to know to pass or obtain desired grades (Harlen & James, 1997). Consequently, these assessments provide limited opportunities for feedback and review, which can facilitate productive student learning (Nichols, 2007). This narrows the curriculum and commonly leads to surface rather than deep learning, promoting cramming and similar exam preparation strategies. This has implications where a course has predominantly summative assessment (Muldoon, 2012), as the students may not fully engage strategies that foster deep learning. Long-term students are less likely to have internalised concepts and content such that it can be used in different contexts from the initial learning situation.

Incorporating effective formative assessment is critical to enhance deep learning at university (Boud & Associates, 2010). Formative assessment supports students to work toward achieving the required learning goals for disciplinary content and higher order skills such as critical thinking and problem solving, in a course. Feedback as a central component of formative assessment can provide the diagnostic aspect and information that enables students to take action to improve their learning. Interactive formative assessment with dialogue is important in mediating learning while students are developing these skills (Cowie & Bell, 1999). The provision of this dialogic feedback to first year students is challenging for teachers, particularly given the diversity in the levels of prior biology learning of students enrolling in undergraduate biology courses (Rayner, 2014). Often these are the contexts where students are still developing the skills of an autonomous learner (Kift, 2008) and are more dependent on feedback information from teachers.

Many studies have confirmed the efficacy of feedback as a powerful influence on learning (Black & Wiliam, 1998; Hattie & Timperley, 2007; Kluger & DeNisi, 1996; Sadler, 1989; Shute, 2008). Although the use of feedback has powerful effects on learning and achievement, the use of formative assessment in the tertiary learning environment is highly variable in practice, which may contribute to limited effectiveness (Harlen & James, 1997). Students place value on feedback, which they perceive as facilitating high-quality learning outcomes (Higgins, Hartley, & Skelton, 2002). Although tertiary students can develop the capability to interpret and apply feedback (Sadler, 2010), it is not always apparent whether they are able to recognise and understand that they have an active role in using the feedback to enhance their learning and achievement. Beaumont, O'Doherty, & Shannon (2011) reported students believe they experience a radically different culture of feedback as they transition to higher education from secondary school. They perceive a shift from having teachers guide

them, to monitor and progress their learning at secondary school, to the expectation by tertiary teachers that they can monitor their own learning (Brinkworth et al., 2009). When teachers provide feedback at tertiary level, it can still have a limited impact if not used by students (Sadler, 2010). Students particularly value feedback that allows them to develop their understanding, as most effective for learning (Lizzio & Wilson, 2008). If feedback is perceived as having value, and it is accessible, such as online, then it will more likely be used by students (Hattie 2009).

Feedback through online systems

The use of computers to generate feedback may address some of the difficulties encountered in providing effective feedback information in large classes in higher education. Hattie (2009) reported "the most effective forms of feedback that provide cues or reinforcement to the learner, are in the form of video, audio or computer-assisted instruction feedback, or relate feedback to learning goals." (p. 174). Individualised feedback to students is now possible via computer-assisted online systems and has the potential to improve student performance and learning experience (Henly, 2003; Sly, 1999; Wang, 2007).

Combining 76 meta-analyses on computer-assisted instruction in schools, Hattie (2009) found that the average effect size for improving achievement was $d = 0.37$ (se = 0.02) (Hattie, 2009). He reported a reasonable degree of variability across the meta-analyses, which may highlight a number of issues such as the complexity of the learning contexts and inconsistency of practice by teachers and students. The range of technology used in the studies included in the meta-analyses was wide; the studies were mainly about teachers using computers for instruction and fewer studies were about students' use of such systems for learning. Hattie (2009) identified some contexts where computers were used effectively, including situations when the student, not the teacher, was in "control" of learning and when feedback was optimised. Although end-users (students) are probably not becoming more skilled in using technology for learning, and the effect of computer-assisted learning is not increasing with the sophistication of technology advances (Hattie, 2009), the use of online activities is a potential solution for managing feedback practices in large classes (Carless, 2015).

In essence, computers can respond to all student interactions in a timely manner, something normally difficult to achieve in classes of hundreds of students with one lecturer, even with many tutors. Nonetheless, a limitation of pre-programmed computer responses is that their fit to the specific needs of a particular individual may not be sufficient to meet the

needs of individual students and therefore enable task completion. A further constraint arises when a learner's understanding is already well-established; feedback on successful performance may have a trivial impact, since students are already competent. Computer-generated feedback has potential for meeting the feedback requirements of students needing more support, such as students from non-traditional backgrounds, international students where English is not their first language and students with disabilities (Hounsell et al., 2007). An online teaching environment may hold a key to effective assessment practices by expediting the provision of feedback to students with diverse needs and expectations (Muldoon, 2012).

The significance of the research study

At university, first-year biological science students may face academic challenges, with the consequence that they withdraw from their studies before completion. These challenges include learning in a traditional education model where receiving and retaining the body of knowledge has priority and the opportunities for formative assessment that allows them to develop their understanding are limited. However, when such opportunities are available, students do not always make the most of these low-stakes learning environments.

Many tertiary educators and researchers assert that feedback is central to the development of effective learning and that it empowers students to become self-regulated learners (Boud & Associates, 2010; Carless, 2015; Kift, 2008; Zepke & Leach, 2010). However, although feedback as part of formative assessment is desirable, there are many issues and practical logistics involved in providing it. These issues include:

- While teachers recognise the value of feedback in learning, it may not always be used by students and can lead to students not viewing feedback as useful in the long term. (Price, Handley, Millar, & O'Donovan, 2010).
- Studies on tertiary students' perspectives indicate students believe they do not necessarily receive useful feedback to increase their achievement (Beaumont et al., 2011; Carless, 2006).
- Where feedback has become common practice in higher education, for many students there seem to be insignificant learning gains (Hattie & Timperley, 2007; Sadler, 2010).

It has been reported that the provision of feedback does not necessarily lead to improvement (B. Crisp, 2007). Sadler (2010) argues that learning from being told is fundamentally flawed as a general strategy, and if learners passively receive feedback information, this is similar to the transmission model of teaching. For students to make learning gains they need to take action in some way to use the help provided as feedback (Sadler, 2010). However, student perceptions

about assessment and their approaches to learning are strongly related and the provision of feedback may not necessarily lead to in-depth learning (Struyven, Dochy, & Janssens, 2005). Thus, student interaction with and responses to feedback are complex (Lipnevich, Berg, & Smith, 2016). A model proposed by Lipnevich et al. considered the many factors influential to or impacting on a student's response and possible action after the point at which feedback is available to them. They suggested further research to unpack the complexities proposed in the model. This research explored aspects of this model. As such, it also allows me to reflect on assumptions I have made about feedback in learning, in order to understand first-year biology students' use of online feedback, their help-seeking behaviour, the relationships between the use of the feedback and their achievement in the biology course.

The central question therefore was:

> **How is feedback conceptualised and used to support learning by tertiary biology students?**

Chapter 2

Literature review

Transitioning from school to university

> "The first year is such an important touchstone for the quality of the undergraduate experience"
>
> (McInnis, 2001, p. 113)

In the New Zealand tertiary sector, there has been a substantial increase in the number of students progressing to university education in the last decades (Vlaadingerbroek & Taylor, 2010). This is part of a worldwide trend in higher education as degree qualifications become increasingly important in the labour market (Wolf, 2010). Participation in higher level learning is considered to be essential for full engagement in the knowledge society and to provide the key to prosperity (Gilbert, 2005). Gilbert argued, "people see knowledge in economic terms, as the primary source of all future economic growth" (p. 25). This is driving the demand for higher education and the expectation that tertiary education is no longer a privilege but a right. Higher education has become the norm rather than the exception in New Zealand where over 60% of school leavers progress to tertiary studies (New Zealand Ministry of Education, 2018). Large-scale or mass education systems were a feature of the industrial age when traditional disciplinary knowledge was important. Another important aspect of such mass education systems was to "sort" people according to likely employment destination. These education systems continue into the knowledge age, where knowledge as innovation is the key driver of economic growth (Gilbert, 2006). Pressure for change in current education systems is driven by changes in the needs of learners, economies and society. There is an increasing need for individuals to continue learning post-secondary schooling, rather than a select group (Strachan, 2002). Many students entering university in the 21st century are familiar with this knowledge economy and consider their career options carefully, often regarding their participation in higher education as more for private good and a path to a good job and greater financial wealth. "Overall, first-year students continue to see university study as an important means of preparing them for a career as well as an opportunity to pursue study in areas that interest them" (Krause et al., 2005, p. v).

Consequently, these students are more likely to view themselves as clients of the university, wishing to obtain a "portable degree" and expect the accompanying resources to

help them achieve this aim. In this quest, they are also more likely to seek advice from academic staff (Krause et al., 2005).

Despite selection of the most academically able into first-year university courses, retention rates and progress of students from first to second years is a concern for many universities. Krause et al. (2005) concluded that efforts to enhance the first-year university experience have been piecemeal in the main, with improvements in student retention hard to come by. The 2010 AUSSE that was conducted in 55 higher education institutions and included eight New Zealand universities, provided data and analyses about student engagement and retention in these institutions (Radloff, 2011). In New Zealand, 29.4% of students have departure intentions where they have seriously considered or planned to leave their institution prior to completing their qualification. This is similar to the high rates of attrition found internationally in surveys that assess the extent to which students engage in educational practices in higher education institutions (Kuh, 2009). Attrition at first year is costly to individuals, institutions and governments (Krause, 2005b), and understanding students' departure intentions is important in determining ways to effectively enhance student engagement and increase student success. Facilitating transition has become a research focus in universities concerned with attrition/retention. It is commonly known as the "first-year experience" for which there is a comprehensive literature. Much research has been published over several decades from the USA (Astin, 1997, 2003; Pascarella, 2006; Tinto, 1975), the United Kingdom (Harvey, Drew, & Smith, 2006; Yorke, 2000), Australia (Kantanis, 2000; Kift, 2008; Krause et al., 2005; Lawrence, 2005; McInnis, 2001; McInnis, James, & McNaught, 1995) and New Zealand (Zepke & Leach, 2007, 2010a, 2010b).

Tinto (1975), in his synthesis of research, identified different forms of leaving behaviour, where dropout may occur due to academic failure, which he distinguished from voluntary withdrawal (Tinto, 1975). Tinto proposed a longitudinal model for the process of dropout which attributed attrition to the interaction of multiple factors.

> a longitudinal process of interactions between the individual and the academic and social systems of the college during which a person's experiences in those systems continually modify his goal and institutional commitments in ways which lead to persistence and/or varying forms of dropout. (p. 90)

Much of the subsequent research has drawn on Tinto's model of departure and acknowledges factors influencing attrition are complex, and include social and personal, as well as academic. Students entering university for the first time need to adjust to many different aspects in their new education experience (Krause, 2006). Lawrence (2005) proposed these

aspects are contextual and include sociocultural competencies, university-based literacy and self-management (Lawrence, 2005). Harvey et al. (2006) reviewed 750 publications exploring first-year experience, emphasising there is no one single first-year experience; there is a multiplicity of experiences. They reported recurrent themes including performance and retention, and performance and persistence, where social and academic integration are important. Social transition underpins a successful transition to university for many students (Kantanis, 2000). Many students arrive at university with preconceived expectations about socialisation that are not realised (Kantanis, 2000; J. Smith & Wertlieb, 2005). In general, students enter university with unrealistic social and academic expectations and this misperception may impact on performance (J. Smith & Wertlieb, 2005). Another significant area in the literature reviewed by Harvey et al. (2006) is support for the first year where good practice includes appropriate and integrated interventions to assist students as they adjust to a different institutional life. They argued for gradual induction processes to avoid information overload and unnecessary bureaucratic procedures. From this review, research suggests learning-skills development is best contextualised and embedded in the curriculum rather than being supported by stand-alone courses or workshops. Hattie, Biggs, and Purdie (1996), in a review of student learning interventions, also assert that the evidence suggests that learning skills are most effectively developed within a specific context rather than as generic initiatives. However, learning-support services may be inadequate in a contextualised model where there is lack of clarity and understanding among staff, or students are not aware of the service (Peach, 2005). On the other hand, decontextualised learning support may have less relevance to students struggling with specific course demands. Peach (2005) emphasised the importance of collaboration between learning advisers and academic staff in supporting students in the learning environment. Recently, Kift (2015) concluded in a review article that a "successful and sustaining first-year experience must be the curriculum and its framing of student learning and engagement" (p. 68) as this is what all students have in common. Kift claimed it is not sufficient to tinker around the periphery of the curriculum and developed a transition pedagogy framed around the identification of six first-year curriculum principles (FYCPs) (Kift, 2009). Assessment is one of the FYCPs, indicating the importance of transitioning in terms of assessment to higher education with the provision of feedback key to this process. When students have problems adjusting to the style of assessment, they are more likely to consider dropping out (Krause, 2005a).

Assessment has a critical role in guiding students' academic life. It is generally believed and widely stated that assessment drives the student academic experience and hence student

learning (Au, 2007; J. Taylor, 2008). Assessment practices are required to fulfil multiple functions which can result in tensions in practice such as assessment for productive student learning and assessment as judgement of student achievements and accountability (Carless, Salter, Yang, & Lam, 2010). Where high-stakes assessment predominates, there is limited opportunity for feedback and review, and in first-year learning environments this can be compounded by less peer interaction. Students are also bombarded by the importance of grades, which are seen as the ticket to success.

Many academics expect and assume students are independent learners when they begin first year; however, the requisite skill base for many students can only develop over time within each specific discipline (Kantanis, 2000). Where there is a disjunction between secondary and tertiary learning environments many students will require a period of readjustment and familiarisation. This can be mediated if the transition is reasonably seamless (Kift, 2008).

Kift (2008) addressed some of Krause et al.'s (2005) concerns about the lack of progress in enhancing the first-year experience in Australian universities. She argued that the first year should be student focused (Kift, 2008). Drawing on Boud (2005), Kift (2008) recommended first-year students need to understand what it means to be an independent learner through teaching that builds on prior learning experiences and promotes self-assessment. Assessment practices should provide early feedback on progress to students and information for teachers (Boud & Falchikov, 2005; Kift, 2008). In a review of the literature on student engagement in post-secondary education, Zepke & Leach (2010) selected research articles which approached student engagement from five different perspectives. Each perspective is supported by strong empirical and theoretical evidence (Zepke & Leach, 2010a). From their synthesis of the research reviewed, Zepke & Leach (2010) suggested nine propositions to enhance student engagement, with three propositions relevant to formative assessment. The three propositions are:

> Create conditions that enable learners to work autonomously, enjoy learning relationships with others and feel they are competent to achieve their own objectives.
>
> Promote learning that is active and collaborative and fosters learning relationships between learners and with teacher.
>
> Assist students to develop the social capital needed to be successful learners and citizens. (Zepke & Leach, 2010a)

These propositions blend academic and socialisation transition issues, which are also integral to some models of formative assessment with feedback. For example, Bennett (2011)

identified working with peers as one of five important strategies essential to enable students to take responsibility for their own learning (Bennett, 2011). However, the implementation of peer interaction in the learning environment is dependent on teachers' practices and strategies.

Theoretical frameworks and learning

In their review of the research on the first-year experience, Harvey et al. (2006) concluded the first year is a time of considerable cognitive growth and appears to be important in developing learning behaviour. Teaching practices that enhance student learning are critical to student academic development. Models of learning and theoretical frameworks are crucial in supporting teachers to develop conceptions of learning and teaching (Fostaty Young, 2008). Further, Fostaty Young argues conceptions of teaching are largely composites of individuals' assumptions, knowledge and beliefs about teaching and learning. Conceptions are subject to change as a result of reflection on experiences and exposure to alternative ideas from other teachers. Frameworks also offer opportunities to explore and revise personal conceptions of teaching and learning. Some relevant conceptual frameworks will be considered here.

Behaviourism

According to a behaviourist view of learning, there is a change in behaviour in a desired direction. With a focus on how the external factors help to shape the learning processes, the environment is arranged to elicit the appropriate response (Merriam, Caffarella, & Baumgartner, 2007). Knowledge is broken down into skills and sub-skills, described as behavioural objectives for learning. This is followed with skills testing which measures performance (what students can do) rather than competence (what they know) (Wheatley, 1991). In many respects, behaviourism is still the most prevalent teaching model in practice today (Jackson, 2009). Behaviourism underpins investigations about interventions or changes in curriculum which can lead to changes in students' performances and behaviours and can explain the environment within which change occurs. It does not focus on why or how changes may come about (Duit, 2007). With this distinction, the teacher's role is construed as being able to train students to respond to instruction correctly, with positive feedback in the form of non-specific praise. With correction of mistakes, it is intended students will make the connection between a signal/stimulus and the appropriate response (James, 2006). This behaviour modification does not always elicit the intended response and behavioural objective, as demonstrated by what and how students sometimes learn. From our students' point of view, assessment always defines the actual curriculum" (Ramsden 1992, p 187, quoted in Biggs, 2003, p 140).

As Biggs (2003) explained, what students learn depends to a major extent on what they think they will be assessed on. Assessment practices send the "signals" to students about what they should be learning (Biggs, 2003). Students are reacting or responding directly to their learning environment and this has a backwash effect on how students learn. This effect is particularly powerful in high-stakes settings (James, 2006).

Constructivism

Many current conceptions of learning are based on theories of constructivism (Shepard, 2000). In constructivism theories, learning is thought to involve a process of building meaning systematically as new knowledge combines with old in a process of restructuring (Fostaty Young, 2008). According to Merriam et al. (2007), meaning is made by the individual and is dependent on the individual's previous and current knowledge structure. Learning is an internal cognitive activity in which there is an emphasis on "understanding," and problem solving is the context for knowledge construction (James, 2006). Differences between experts and novices are marked by the way experts organise knowledge in structures that make it more retrievable and useful. The role of the teacher is to help "novices" to acquire "expert" understanding of conceptual structures and develop strategies to solve problems. Formative assessment is an important integral part of pedagogic practice as this provides opportunities such as discussion, which support students to develop mental models. Students can scaffold their prior understanding to knowledge structures and also apply concepts to novel situations (James, 2006). This requires interplay between teaching and assessment as students attain learning goals and new understandings. Von Glasersfeld (2005) argued a constructivist orientation can modify a teacher's attitude, with the realisation that students perceive their environment in ways that may be very different from those intended by the educators.

Sociocultural theories of learning

The key idea that sets constructivism apart from other theories of cognition was Jean Piaget's idea that knowledge does not have the "purpose of producing representations of an independent reality, but instead has an adaptive function" (cited in von Glasersfeld, 2005, p. 3). Piaget clarified knowledge as being grounded in the organism's experiential world. Piaget's use of the concept of adaptation stems from biology, where it indicates a particular relationship between living organisms and their environment (von Glasersfeld, 2005). In evolutionary biology concepts, organisms do not adapt per se, rather adaptation is a population characteristic indicating the adaptation process is group dependent. For knowledge to be adaptive, it is a function of many individuals interacting with their environment. By many accounts,

sociocultural learning theory stems from the work of Vygotsky, who explored how learning unfolds not through an individual's acquisition of information but through an individual's engagement with others (Honig & Ikemoto, 2008). According to the sociocultural perspective, learning occurs in groups, with interactions between individuals and the social environment. Implicit in this idea is that learning is a social collaborative activity and people develop their thinking together. Learning involves participation, such that the learner shares what is learned with the social group. They are involved in shaping and being shaped by a community of practice. James (2006) argued for sociocultural learning approaches, "the teacher needs to create an environment in which people can be stimulated to think and act in authentic tasks beyond their current level of competence" (p. 57). In this expansive learning environment, students can scaffold their learning with the assistance of experts, who include the teacher and often a peer. This enables learners to deepen their engagement in collaborative tasks, where teachers and students jointly solve problems and all develop skill and understanding (Honig & Ikemoto, 2008).

Assessment

Assessment functions at many levels to affect and measure learning. Assessment is a single term encompassing different purposes and ideas, which are sometimes competing. Assessment may function to certify achievement (summative) or to aid learning (formative). Black and Wiliam (1998a) similarly identified multiple purposes of assessment as: to support learning, to report achievement, and to satisfy the requirements of public accountability, and suggested the functions or purposes of formative and summative assessment are the extremes of a continuum (Wiliam & Black, 1996). Many of the multiple purposes of assessment, such as the motivation of students, the diagnosis of difficulties, the certification of achievement and accountability to the public, can be competing or in conflict (Earl, 2003; Heritage, 2010). However, Black and Wiliam (1998a) emphasised the tension between these purposes is dependent on what instrument is used, who conducts the assessment and how this is interpreted. Due to higher education institutional needs, summative is usually the predominant type of assessment and is also referred to as *assessment of learning*. The main purpose of these often-large-scale assessments is to certify learning for accountability or quality assurance, for which information is usually reported as grades and a rank order of students relative to one another, is established (Guskey, 2003). This type of assessment is important for meeting critical milestones from one learning stage to the next, such as measuring readiness for progression from secondary schooling to higher education or professional accreditation. However, the information available

to learners from this type of assessment is limited in providing direction for improvement. By contrast, the focus for formative assessment is on obtaining information about student strengths and weaknesses in a non-evaluative context to be used in determining activities that would benefit the attainment of education goals (Cizek, 2010). In *assessment for learning* emphasis is shifted to a formative approach and occurs during learning rather than at the end. Critical to this approach, is the role of the teacher to understand learning needs and interact with students to aid as feedback to scaffold each step in learning (Earl, 2003). A further type of formative assessment has been called *assessment as learning*, in which the role of the student is extended beyond contributor to the assessment and learning process, to also become a critical assessor of their own work. Here, the students personally monitor what they are learning, and use this as feedback to make adjustments to their understanding (Earl, 2003). Boud and Falchikov (2006) proposed that where students are active assessors of their learning reflects the kind of highly contextualised learning faced in work and life. Further, they argued that focus on this type of formative assessment would foster future learning after graduation (Boud & Falchikov, 2006).

Assessment used for summative purposes acts as the currency of education, as the gatekeeper for selection of individuals into particular jobs, professions, or access to further education. As first-year students progress to university, they are familiar with high-stakes summative assessments, after all this is the most recent milestone achievement in learning they have experienced. What is not so clear is their experience of formative approaches and practices. In the tertiary sector, formative feedback about learning is often under-utilised, limiting the information available to students to advance their learning (Jonsson, 2013; Kahu, 2008). Without feedback to support learning, students are limited in their progress through higher education achievement milestones. Further, research indicates that grades and marks have limited formative effectiveness by comparison and can act to deter learning among low-ability students (Black & Wiliam, 1998a). Sadler (1989) criticised universities for being excessively focused on evaluation in the form of summative assessment, as is the case in Australian and New Zealand universities (Orrell, 2006). This strong belief in summative assessment is derived from traditional views of testing and scientific measurement of the early 20th century when testing was used to ensure specific skills were mastered at particular levels (Shepard, 2000). This was necessary at a time when curriculum design reflected the belief it was more efficient to develop expertise for specific roles in society. Traditional standardised testing and the emphasis on accountability have led to assessment and learning often occurring as separate activities. Assessment practices conducted at the end point of a learning cycle, can

lead to the development of a high-stakes assessment system. However, Bennett (2011) disputed this position on summative assessment as oversimplification and argued the relationship between formative and summative is more complex. While fulfilling the primary purpose of documenting what students know, Bennett suggested there can be secondary purposes of support for learning, where motivated students build expertise if the assessment contains domain-rich content. Further, where summative tests identify key areas that are linked to learning progression, feedback to teachers can facilitate focused formative follow-up (Bennett, 2011).

It has been identified that successful transition to university requires students to be independent learners with sound skills such as time management and self-monitoring of progress (Kift, 2008). Where learning periods are delimited by 3-month semesters, the focus on summative assessment can divert attention away from using assessment practices that improve learning. The information summarising the achievement status of students is often not available in time to teachers to adapt instruction for the benefit of their learning. In contrast, aspects of formative assessment use the quality of student responses to further shape and improve the student's competence (Sadler, 1989). Nicol (2009) argued that formative assessment and feedback practices can be used to enhance the first-year experience through course redesigns (Nicol, 2009).

Effective feedback in formative assessment and learning

Benjamin Bloom (1968) expanded the understanding of formative evaluation from an act of ascribing worth or merit to results, to situations where classroom assessments were used in a practical and effective way to improve learning for mastery (Cizek, 2010). Over time, students, through regular assessment, would be able to correct their learning, which was in contrast to traditional testing practices at that time (Bloom, 1968; Guskey, 2010).

> We have for so long used the normal curve in grading students that we have come to believe it… Quite frequently failure is determined by the rank order in the group rather than by their failure to grasp essential ideas of the course … Finally, we proceed in our teaching as though only the minority of our students should be able to learn what we teach. (Bloom, 1968, p. 2)

Bloom argued that most students can master what we teach them if we give them time, and he saw it as the responsibility of teachers to "find the means." One such means was formative assessment in which small diagnostic tests were administered for well-defined content portions of a course to identify if learning had occurred and identify what may still be required for

subsequent learning. In the case of incorrect test answers, appropriate remediation was provided and reinforcement of learning occurred when answers were correct (Bloom, 1968).

Sadler (1989) elaborated on Bloom's ideas with the notion of feedback as the key element in formative assessment. He argued the primary distinction between formative and summative assessment relates to purpose and effect and not to timing. With the purpose of summative to provide certification, it is essentially passive and does not normally have an impact on learning, although it can have consequences for a student's educational future. Sadler (1989) emphasised the importance of the teacher and student in a learning relationship, where the teacher is able to provide information to the student about the quality of performance, and how this can be improved. The effect of this is feedback, when the student uses the information to improve their performance in some way (Sadler, 1989). Sadler (1989) developed a foundational model of formative assessment in terms of function and required conditions. Sadler's process model has subsequently formed the basis of other investigations and research on formative assessment; for example, it has been used to define formative assessment and as the theoretical framework to inform research design and analysis (Bell & Cowie, 2001; Dixon, 2008; Rawlins, 2007). Sadler (1989) stated the key or decisive element in learning is feedback that provides information about how effectively something is being done, and as such, feedback is essential information to be communicated to students to enable progression. Sadler (1989) uses Ramaprasad's (1983) definition of feedback: "Feedback is information about the gap between the actual level and the reference level of a system which is used to alter the gap in some way" (Sadler, 1989, p. 120).

Feedback exists only when it is used to alter the gap so that the learner comes to hold a concept of quality similar to that of the teacher. It is not about receiving informational content from the teacher. Critical to Sadler's model is that the learner has an active role to play in this formative process, although students do not always make use of the feedback information (Jonsson, 2013).

> The learner has to (a) possess a concept of the standard (or goal, or reference level) being aimed for, (b) compare the actual (or current) level of performance with the standard, and (c) engage in appropriate action which leads to some closure of the gap. (Sadler, 1989, p. 121)

The efficacy of feedback in learning has been explored in a number of studies. In their meta-analysis on the effect of feedback interventions, Kluger and DeNisi (1996) reviewed 131 studies that met their criteria for inclusion. From these, they estimated 470 effect sizes, which were based on 12,652 participants and 23,663 observations (reflecting multiple observations

per participant), and concluded that feedback has a moderate positive effect on performance. However, they demonstrated variability in the effects of feedback on performance with over 38% of the effects being negative. Most effective feedback included correct information on performance for relatively non-complex tasks whereas praise was ineffective (Kluger & DeNisi, 1996).

Subsequent to this, there has been progressive interest and focus of attention on classroom assessment with a view to the improvement of learning (Black & Wiliam, 1998a). In their review of the effectiveness of formative assessment, Black and Wiliam identified several studies which ranged from 5-year-olds to university undergraduates, across several subjects and countries. These studies, based on both descriptive and quantitative data, supported strengthening the practice of formative assessment because it produced significant and substantial learning gains.

The efficacy of feedback in learning was also borne out in a review of empirical literature (Hattie & Timperley, 2007). In their review of 196 studies describing nearly 700 effects, Hattie and Timperley reported that feedback had an average effect size of 0.79 SD. For this review, feedback was conceptualised as "information provided by an agent (e.g., teacher, peer, book, parent, self-experience) regarding aspects of one's performance or understanding" (p. 81) and typically occurs during informal classroom assessment or activities. The effect of feedback was greater than student prior cognitive ability, socioeconomic background and reduced class size. However, the type of feedback and the way it is given can be differentially effective, with the highest effect occurring when students receive information feedback about how to do a task more effectively. Highlighting what they considered to be the main purpose of feedback, to reduce discrepancies between current understandings and performance and a goal, Hattie and Timperley (2007) proposed a feedback framework. This framework for effective feedback integrates three questions: "Where am I going? (What are the goals?), How am I going? (What progress is being made toward the goal?) and Where to next? (What activities need to be undertaken to make better progress?)" (Hattie & Timperley, 2007 p.86). Each feedback question works at four levels: task, process, self-regulation and self. These three questions are not interpreted or implemented in a linear way. Furthermore, the importance of ensuring that feedback is targeted at students at the appropriate level is crucial to effective feedback.

In his review of formative assessment, Bennett (2011) questioned the efficacy of "general practices" associated with formative assessment in facilitating learning: "the research does not appear to be as unequivocally supportive of assessment practices as it is made to

sound" (p.13). Bennett questioned the validity of meta-analyses that are said to support the efficacy of formative assessment. He argued the studies are too disparate to allow meaningful summarisation. In particular, he claimed that the Black and Wiliam review of 1998 included a very diverse set of studies and questioned if these can be summarised by a single, mean effect-size statistic. Further Bennett also claimed no source is given for the effect sizes attributed to formative assessment, which he found significant given the Black and Wiliam article is frequently cited as evidence of the large impact of formative assessment. Other studies were called into question where they were unpublished (and not peer reviewed), observational, non-random groups of potentially highly motivated students, and other variables such as concurrent interventions and innovations. However, Bennett (2011) conceded the Kluger and DeNisi meta-analysis is real and focused (on feedback), although the mean effect size for the impact on performance is 0.41, less than that claimed by others. This agrees with an earlier review (Shute, 2008). Bennett (2011) also proposed a theory of action which defines the characteristics and components of formative assessment and, importantly, how these work together. This, he claimed, is critical to evaluate the underlying mechanisms that are supposed to cause the intended effects. Bennett's theory of action reconceptualises formative assessment as a comprehensive system incorporating five key strategies of sharing learning expectations, questioning, feedback, self-assessment and peer assessment. However, Bennett was cautious where evidence of student learning involves making inferences by teachers about what students know and can do. If wrong, then the basis for adjusting instruction is weakened. Similarly, if inferences are correct but instruction is adjusted inappropriately, less learning is likely to occur. This is related to the importance of including specialised aspects of content domain knowledge as part of formative assessment processes. Where a teacher has weak domain understanding, they are less likely to know what questions to ask, what to look for in performance, what inferences to make and how to adjust instruction (Bennett, 2011).

Qualitative approaches too, provide insight into learning processes (Bell & Cowie, 2001). What may be viewed as disparate information in a quantitative study, such as different contexts, variance in learning levels, age, etc., in a qualitative approach can reveal commonalities and possible generic attributes. Given the personal nature of learning and teaching, it is not always possible to form absolutes or determine cause and effect. Other factors can interact with formative feedback, resulting in variable success such as individual characteristics of the learner and aspects of the task (Shute, 2008).

Formative assessment as part of a learning paradigm

Many of these reviews proposed effective formative assessment occurs as part of teaching to support and progress learning, and is integrated into learning tasks to achieve learning competency and achievement standards (Black & Wiliam, 1998b). Black and Wiliam referred to educational policies across many countries ignoring what is happening in classrooms, treating learning environments as "a black box," a term derived from systems engineering, where more consideration is given to inputs from outside, such as resources, parental concerns, management rules and requirements, and then outputs such as knowledgeable and competent students are expected to follow. Black and Wiliam (1998b) comment that it is usually left up to teachers to make the inside (of the black box) work better but that this can be impeded by counterproductive inputs. They consider formative assessment one aspect of teaching inside the black box that is "at the heart of effective teaching" (p. 2). This reflects the understanding of formative assessment as a process fundamental to the practice of teaching and learning and not simply a measuring instrument (Heritage, 2010). Many of the studies reviewed by Black and Wiliam showed that the use of formative assessment helps in raising achievement, especially for low-achieving students. This is a powerful argument for the efficacy of formative assessment.

From their review, Black and Wiliam (1998a) proposed criteria for effective formative assessment: teachers making adjustments to teaching and learning in response to assessment evidence; students receiving feedback about their learning, with advice on what they can do to improve; and, students' participation in the process through self-assessment. The importance of the quality of feedback is echoed in many reviews and studies along with the quality of the teacher-student interaction (Bell & Cowie, 2001; Bennett, 2011; Hattie & Jaeger, 1998; Hattie & Timperley, 2007; Jonsson, 2013; Sadler, 1989; Winstone, Parker, Rowntree, & Nash, 2017).

Formative assessment in New Zealand science education was explored by Bell and Cowie (2001) in response to trends in the education system highlighting the need for formative assessment. They identified key characteristics of formative assessment from classroom practice. Many of these characteristics confirmed alignment with other studies. These included responsiveness, the importance of professional knowledge and experiences, and participation by students and teachers. This study also emphasised the dynamic, flexible, and context specific nature of these processes. A final key characteristic identified was that of student disclosure and the extent to which an assessment task produces evidence of student learning and thinking. The degree of disclosure was influenced by type of assessment, interaction, and source of potential harm and trust. In the teacher and student relationship there is a power

imbalance that will influence the communication in some way. Communication is often involved in feedback. How this is managed will influence the feedback experience of the student. Sadler (1998) claimed that what teachers bring to an episode of learning when framing feedback is highly complex, and includes the ability to appraise; knowledge to assess the degree of correctness; attitude and empathy with students; and knowledge of the subject, criteria and standards. Teacher contributions to learning episodes indicate many possibilities for student learning; however, students do not always value or make use of the feedback they receive (Beaumont et al., 2011; Carless, 2006; B. Crisp, 2007; Jonsson, 2013; Robinson, Pope, & Holyoak, 2013).

Student participation in formative assessment for learning

The student's role in formative assessment is critical so he/she does not remain dependent on teacher feedback, without the capacity to develop as a self-sustaining lifelong learner (Hattie & Timperley, 2007; Heritage, 2010; Sadler, 1989). Where the teacher provides remedial advice to close the gap, the learner maintains dependency on the teacher. Sadler (1989) proposed an instructional system where students develop self-monitoring evaluative expertise, although he acknowledged this does not come automatically. It is critical students understand the feedback and know what to do with it (Hattie & Jaeger, 1998; Sadler, 1989). Willingness to trust and engage in the feedback dynamic can be mediated if students are trained to interpret the feedback and make connections to the work they are producing for verification and improvement. Many of the models emphasise the students' capacity to monitor their own learning. This is dependent on a student possessing a concept of the standard required, comparing their level of performance with the standard and taking action to close any apparent gap. The quality of feedback has been identified as a crucial issue and is contingent on feedback from teachers being more than delivery of content for learning. Teachers also need to assist students to develop skills to make judgements about their learning and teach them strategies to regulate their own learning. Feedback concerned with praise (of the person) for effort is often used because it is thought to promote a positive self-image that may lead to higher self-esteem, more effort and higher achievement. It is not, however, as effective as feedback specific to the task and the learner's response. The learner needs to understand what strategies are required to attain high standards (Hattie & Timperley, 2007; Sadler, 1998).

Understanding the effectiveness of feedback can be compounded by other factors. Formative assessment, like all educational measurement, is an inferential process because we cannot know with certainty what understanding exists in a student's head (Bennett, 2011).

More often, these inferences are uncertain and subject to unintentional bias. As Hattie and Timperley (2007) indicated, “feedback has no effect in a vacuum” (p. 82) and it must occur in a learning context. Further, some types of feedback are more powerful than others, with the highest effect occurring when students receive information that allows them to close the gap and the lowest effect sizes when related to feedback about the person. As feedback is part of the teaching and learning process, there is variance due to the human factor (teacher and student) such that the effect of feedback as part of formative assessment will facilitate learning only under the right conditions (Bennett, 2011). Effects of feedback can also be detrimental when students experience deficient patterns of formative assessment where practices are inconsistent and incoherent. Students who do not have the skills to interpret feedback often mask this by developing survival skills (Sadler, 1998). Conversely, for students who are actively engaged in formative assessment practices and understand how to use feedback, lifelong learning is fostered (Boud & Falchikov, 2006).

Feedback at university

Models of learning which embed feedback into the teaching process include a signal–response system between student and some agent of information which facilitates improvement in performance (Bennett, 2011; Hattie & Jaeger, 1998; Sadler, 1998). At some point it is anticipated the student will become the agent of information after developing evaluative strategies which allow self-monitoring. In tertiary learning environments, where there is a marked increase in the student:teacher ratio, less opportunities exist for verbal feedback to individual students. This is not to say opportunities for feedback don’t exist post-secondary schooling, but that these may take on different forms using technologies which allow learners flexibility in their time management. A more detailed synthesis of 74 meta-analyses conducted by Hattie (1999), which included information across 7,000 studies, demonstrated the most effective forms of feedback can be in the form of video-, audio-, or computer-assisted instructional feedback for which task complexity is reasonably low and learning goals are specific (Hattie, 1999; Hattie & Timperley, 2007). Kluger and DeNisi’s (1996) study showed that this combination appeared to have the most impact provided the task was challenging (Kluger & DeNisi, 1996). Although feedback is part of university learning, it takes on a number of forms: as part of lecture sessions, tutorials, online individual activities, marks from tests and individual sessions with teachers. However, there is a paucity of research related to feedback and its relationship to learning at the university level. First-year students’ understanding of feedback and level of skill as self-monitoring learners are based on their prior experiences at

secondary school, including their study toward exit qualifications. These students have gained university entrance from a range of qualifications recognised by the New Zealand government (Vlaadingerbroek & Taylor, 2009).

Feedback and self-regulated learning

A fundamental objective of the theory of formative assessment is the development of self-regulated learning (SRL) strategies. Butler and Winne (1995) described SRL as the pivot upon which student achievement turns. They focused on the functions of feedback as twofold. Firstly, feedback that informs students about content in a domain, although this is minimally sufficient to affect knowledge construction i.e., this feedback is informational capital. Secondly, they proposed feedback should provide information about cognitive activities for learning and guide students toward more productive engagement in learning activities where they can process the domain specific information (Butler & Winne, 1995). Feedback use in formative assessment supports students' self-regulation actions (Andrade & Cizek, 2010). Nicol and Macfarlane's (2006) model of SRL includes aspects of feedback such as clarifying what a good performance is, facilitating self-assessment, and providing opportunities to close the gap. The model also highlights encouraging positive motivation and self-esteem. Hattie and Timperley's 2007 model presents effective feedback as feed up (goals), feed back (progress toward goal) and feed forward (what to do to make better progress). SRL is more likely to occur when students have self-assessment proficiency (Panadero, Jonsson, & Botella, 2017); however, even where they are able to think about the quality of their own work, the conditions required for effective self-assessment may not be present (Andrade, 2010).

Andrade (2010) indicated the key conditions such as modelling, access to clear criteria on which to base self-assessment, cueing when it is appropriate to self-assess, providing direct instruction in self-assessment, and practice. However, without access to feedback, and the opportunities to use feedback, students are unlikely to become proficient in SRL. According to Clark (2012), students who have a strong sense of self-regulation, have effective study habits and actively engage in academic work, and use a meta-process where they plan, monitor time, structure a productive work environment and use social resources. Further, students need a strong sense of self-efficacy and collective efficacy by working in mutual learning relationships where formative feedback circulates among learners (Clark, 2012).

Theory and research on SRL has been a rapidly growing field since the 1970s (Panadero, 2017; Winne, 2005). As self-regulated learners, students take control by using a variety of strategies and tactics, including seeking help and feedback, in order to achieve their

goals. Students learn within a complex context where they also need to manage their emotions and the personal circumstances that influence their strategic decisions (Andrade, 2010). Several models have emerged that attempt to represent the cognitive, motivational and emotional aspects of learning in a conceptual framework (Boekaerts, 2011; Pintrich, Marx, & Boyle, 1993; Winne & Hadwin, 2008; Zimmerman, 1990). The models indicate that SRL is a cyclical process that have three main areas of activity: (meta)cognition, motivation and emotion, although each model has a different emphasis (Panadero, 2017).

In his review of SRL models, Panadero (2017) concluded that SRL interventions are successful ways to improve students' learning if designed properly, taking into account the situation and context. He notes that students' educational levels lead to differential effects in terms of SRL interventions, with older students more likely to benefit from more metacognitive aspects, as the requirement for increased performance of cognitively demanding tasks may require more specific strategies in a higher education setting.

Background to students entering higher education in New Zealand

Changes in secondary school qualifications in New Zealand over recent decades have led to a range of school-leaver qualifications being used to meet entrance requirements to universities. More students are entering first-year courses as they seek higher education qualifications, arriving with diverse academic experience and achievement levels. The background of students as they transition to university is relevant to the context of their learning in a new setting.

Education reform in New Zealand: Secondary school qualifications

External examinations are part of the global educational landscape. For external examinations, the assessment purpose is summative as the certification of achievement and accountability to the public. In New Zealand, registered secondary qualifications certify students' successful graduation from school and some students may proceed to a university based on this qualification (Vlaadingerbroek & Taylor, 2009). Prior to 2002, all national exams were "normative in nature with numerical quotas for passes and inter-subject statistical scaling designed to ensure that the cluster of candidates attempting any pair of subjects gained similar distribution of marks in both subjects" (Crooks, 2002, p. 248).

The New Zealand National Certificate of Educational Achievement (NCEA) is a standards-based qualification that has internal assessment and external examinations undertaken by students to gain entrance to universities in New Zealand. University entrance can be gained via other qualifications, including Cambridge International Examinations (CIE) and International Baccalaureate (IB), which are norm-referenced assessments. While the

standards-based NCEA is the dominant university entrance qualification, CIE and IB are also popular options (Vlaadingerbroek, 2006). Many schools, parents and prospective students view CIE and IB qualifications to be more aligned with university assessment policy and hence more appropriate preparation for university.

The government established the New Zealand Qualifications Authority (NZQA) in 1990 to implement a seamless qualification system, with the intention to manage change in assessment policy, encompassing both academic and vocational qualifications. It was intended this "superstructure" would extend from Year 11 at school to postgraduate level. The NZQA planned to adopt internally assessed, competency-based assessment across the entire curriculum (Vlaadingerbroek & Taylor, 2009). However, the tertiary sector was not willing to become part of the National Qualification Framework (Philips, 2007). As providers of degree-level education, the universities insisted on maintaining their independence (Hall, 1995). Because universities focus on international recognition and have their own degree-approving body, there was concern about the "validity" of an outcomes-based approach as the basis for constructing components of a degree (Hall, 1995). It was considered unsuited to university learning as it encouraged the fragmentation of knowledge over integration and critical thinking (Barrington, 2004). However, the university sector was supportive of a unified senior secondary qualification (Dobric, 2006).

Education reform at this time was essential to facilitate wider participation in learning to meet the needs of the knowledge society. Traditional practices, where grading culled significant proportions of students, reinforced the expectation that learning success is limited to a small proportion of the population. This level of gate keeping was costly in that it was alienating many young people from learning. Curriculum design can also affect progression in learning. Bolstad (2006) described traditional curriculum and associated norm-based qualifications as meaning the majority of students were retained in the non-compulsory senior secondary group completing qualifications for the university entrance pathway and did not necessarily consider alternative pathways.

The introduction of standards-based qualifications: NCEA

Standards-based assessment (SBA) was implemented in New Zealand with NCEA, as part of education reforms. The design of NCEA embraces the shift from a testing and examination culture to using assessment practices which influence learning and students' attitudes to learning. SBA advocates suggest that it "ameliorates competition, reduces anxiety, increases intrinsic motivation, and promotes achievement, cooperation, self-efficacy, metacognition and

deep learning" (Gipps, 1994 n.p). Underpinned by research evidence regarding the influence of assessment, NCEA was also influenced by overseas competency-based systems. These appealed due to the flexibility garnered by a modular approach (Strachan, 2002). In a modular approach, a qualification system can be designed to meet the multiple needs of both vocationally and academically oriented students (Philips, 2003). As part of this design, there has been a shift toward wider participation in curriculum decisions in secondary schools (Bolstad, 2006). The trend has been toward increased validity, a wider range of assessment methods, assessment referenced towards standards rather than ranking, and assessment better integrated with learning (Strachan, 2002). This aligns with the change in purpose of education where students are being equipped for lifelong learning important for the knowledge economy. "Assessment must move from 'gatekeeper to gateway' (Gifford, 1992, p. 5), to encourage further learning rather than to signal its end...for purposes of 'selecting in' [rather] than 'selecting out'" (Strachan, 2002, p. 263).

The implementation of NCEA had both pedagogical and practical implications of assessing students against separate achievement standards (Alison, 2007). This can compromise teaching and learning through atomisation where students learn in discreet bits. However, high-stakes assessment can also influence teachers and learners to focus more narrowly on aspects which can be examined. Strachan claims there is not much evidence to justify the view that examinations outdo internal assessment and that the case for external examinations was more about distrust of teachers than measurement of attributes desired by universities (Strachan, 2002).

As NCEA was designed as a school exit qualification to provide information about students' skills and achievements for an array of vocational destinations, curriculum decisions were no longer determined by universities, further fuelling the concern about adequacy of NCEA qualifications where subjects are less content rich and more skills focused (Bolstad, 2006). Consequently, many students who progress to university arrive with diverse backgrounds, sometimes without relevant subjects for a particular course of study. This can result in being unprepared for their chosen programme. Academics generally assume that students have had a suitable preparation for university study at school. This includes having the requisite learning strategies and the cultural capital to adjust to university life and expectations. Preparedness of students is considered critical to performance success in first year (Buntting, 2006; Lowe & Cook, 2003; Rayner, 2014). Enrolling into university courses, which are generally open-entry, means students do not always have the prerequisites for appropriate discipline domains to ensure preparedness (Vlaadingerbroek & Taylor, 2010).

NCEA is viewed by its critics as a "soft" qualification for many reasons. These included the expectation of a higher pass rate than the external examinations it replaced. Further, the internal assessment components were viewed as increasing opportunities for students to plagiarise and cheat on assessments, resulting in a decline in academic rigour (Goh, 2005; Rawlins et al., 2005). Interestingly there was concern that comparisons between schools would be difficult and that it would be challenging for students to meet university entrance requirements. This criticism reflected the traditional culture of norm-referenced assessment methods. After the first iteration of level one NCEA, Elley, Hall, and Marsh (2004) commented that, "the use of different levels of achievement will not be sufficient for the needs of tertiary institutions, the grades for each standard will not be as reliable as the marks from the" (p. 17). The debate as to the adequacy of SBS qualifications to prepare students to be university ready was not new. McInnis et al. (1995), in a survey of Australian academics, found many were concerned about the inadequacies of the background of students: "dissatisfaction with the academic quality of students more than doubled between 1978 and 1993... Indeed, less than a third of academics in 1993 were satisfied with the academic quality of students" (p. 5)

The outcome during the 2000s was the proliferation of other qualifications, including CIE and the IB, being offered to students (Vlaadingerbroek & Taylor, 2010). Vallender (2009) argues CIE "appeals strongly to schools and parents who espouse a competitive, status-conscious grammarian education philosophy" (Vallender, 2009).

Secondary school qualifications and transition to university

For many students, what happens in secondary schools can be dislocated from later learning experiences at university (Philips, 2007). Results from NCEA, CIE and IB can be used to gain entrance to university. Whereas CIE and IB have external high-stakes examinations leading to university programmes, NCEA has a wider focus, opening many pathways to school leavers. A subset of these includes further academic study. A New Zealand Council of Educational Research survey (Hipkins, 2010) of secondary schools included NCEA in the survey items. This survey showed increased support for NCEA by 2009. It was seen as a credible qualification in the wider community with the focus moving away from the previous norm-based system. Parents from decile 9 and 10 schools (in high socioeconomic areas) were supportive of alternative qualifications such as CIE and IB (Hipkins, 2010). This survey also showed, where parental anxiety about NCEA was documented, concerns related to a range of aspects of their child's learning and progress, including how information about progress was communicated, in particular, the desire for normative information to see how their child

compared with others nationally. This reflects criticisms of NCEA and the reluctance of some schools to change from an examination-focused system that sorts students to be labelled as successes or failures. Scrutiny of NCEA since its introduction has emphasised the potential "dumbing-down" of the curriculum. Critics believe academic achievement is compromised by the increase in vocational subjects available to students who then opt out of more traditional subjects similar to those at university. Also, the formative aspect of the learning approach, which includes feedback to students as they work toward a standard or level achievement, is questioned by many including parents and universities. The use of feedback to "close the gap" and gain understanding occurs as teachers clarify and share criteria for success. A student may require multiple attempts before there is an improvement in learning. Traditionally, the expectation is that a pass is determined by one assessment attempt (Philips, 2007). This is an example of the confusion about the purpose of assessment: that it primarily functions as summative high-stakes examinations. Further, there is difficulty with accepting formative experiences for enhancing learning as legitimate assessment activities.

Student perceptions of NCEA design as a formative learning device were found to be positive in a study to explore the impact of NCEA on motivation and learning. In this study, many students commented on the opportunities to improve their understanding by repeating internal assessments (Meyer, McClure, Walkey, McKenzie, & Weir, 2006). At post-secondary, there is a lack of literature about NCEA students' perspective on formative learning at university level and whether this assessment experience aids transition to the nature of learning in higher education.

In New Zealand universities, undergraduate assessment practices focus on certifying achievement and accountability rather than assisting learning. This certification purpose aligns with the dominant summative assessment philosophy of tertiary education (Strachan, 2002). This philosophy has been shaped by cost, power of tradition, selective valuing of some skills over others, insufficient understanding of flaws and consequences of past practices, and the influence of those advantaged by the system in the past, who have little wish to see this pathway to privilege broadened (Strachan, 2002). In New Zealand universities, internal assessment and learning leading to assessment are often viewed as subordinate to examinations. While examinations are an important component of implementing assessment policy where accountability and gaining public confidence is a priority, internal assessment can be just as effective in documenting and certifying student achievement (Strachan, 2002).

There is variation in performance of first-year students in relation to their previous assessment experience. Shulruf, Hattie, and Tumen (2010) considered different models using

NCEA and CIE data (2875 students) to predict performance after 1 year at the University of Auckland across all disciplines. It was found that the best of the NCEA models is almost five times more effective in predicting first-year students' GPA during their first year at university than CIE. This model considered the level of achievement standard where greater weighting was given to merit and excellence. It was suggested the higher correlation between NCEA and university success may be due to similarities in the assessment systems, as both require ongoing assessment during the year/semester involving a variety of tasks, together with a final examination (Shulruf et al., 2010). The formative learning aspect in NCEA is explicit to students and supports their learning process. High levels of achievement in NCEA also reflect the skills requisite for successful learning where students develop formative assessment strategies (Rawlins, 2010). Although, in many undergraduate courses, there is a final examination, this may be preceded by internal assessments which also contribute a percentage of marks to the final grade, and this aligns with assessments in NCEA which are also internally assessed. The Shulruf et al. study suggests an implicit understanding of formative learning skills, which have been established by a learner during their secondary education, can influence subsequent learning situations and performance at university. Whether or not this is the case, investigation of student perspectives about assessment in relation to their performance in first year is required.

Admission to university does not always match competency in subjects to programme choice. This can impact on preparedness for university courses where there is an assumption that students have attained basic knowledge and content domain skill set. Many students underestimate the importance of prior experience in specific disciplines and focus on strategies to gain a high GPA, based on subjects in which they can gain high marks/grades or merit/excellence. Further, the proliferation of subject options and pathways at secondary school means students delay decisions about career paths and maintain a wide focus. Conversely, some schools in low socioeconomic areas are limited in the range of subjects they can offer, including science disciplines. At secondary schools offering NCEA, this complication with subject selection and availability can create "chokepoints" where students meet credit requirements but not in the specific areas required to meet university entrance criteria (S. Smith & Timperley, 2008).

For NCEA-qualified students, the transition from secondary to tertiary education is a period when they are effectively going from SBA to high-stakes assessment. Standards-based reform have had a positive impact on student learning and achievement, in particular students are no longer competing against each other but achieve to a set standard. Under norm-based

examination systems certain ethnicities, particularly Māori and Pasifika, and also students from low income families can be disadvantaged (Shulruf et al., 2008).

In universities, the focus on retention is even more imperative since the Tertiary Education Commission changed the funding model in 2007, from one of participation, commonly known as "bums on seats," to a completion model (Vlaadingerbroek & Taylor, 2010). Importantly, government contribution to the funding costs for teaching undergraduates is determined by students successfully completing courses. As the funding model is now related to student achievement, the student skill set, which includes independent learning skills, is important for retention. In first-year large class environments (up to 1300), students are expected to work independently and teaching staff often do not develop a comprehensive understanding of each student's learning profile.

Chapter summary

The goal and expectation of students as they begin higher education is successful course completion. However, student recruitment includes rhetoric focused on marketing types of degree qualifications rather than the learning journey. While students will be well-informed about the degrees on offer at their university of choice, they will not necessarily have received explicit information about requisites for tertiary study (Krause, 2006). In this regard, students are at risk of disregarding useful skills acquired during their secondary education.

Formative assessment is considered integral to the quality of learning in education systems (Black & Wiliam, 1998a). Feedback, as a component of some formative assessment activities, is considered the mechanism by which learners can progress their learning and develop the skills to be self-regulated (Bennett, 2011; Hattie & Timperley, 2007; Sadler, 1989). However, in the New Zealand tertiary sector, feedback is often under-utilised as a mechanism to provide information on performance that can be used to advance learning (Kahu, 2008). Summative assessment often takes precedence in New Zealand universities as accountability of performance is the critical information required for degree completion. How students interact with and understand formative assessment at tertiary level is, to a large extent, based on their previous experience, usually at secondary school. Students in secondary learning environments experience distinctly different assessment systems due to the variety of exit qualifications (e.g., NCEA, CIE and IB). These qualifications include formative and summative assessments but with differing emphasis as the students prepare for high-stakes examinations. Further, the distinction between formative and summative assessment is not always clear to students and teachers, and often the same results" are used for both purposes

(Harlen & James, 1997). As the design of NCEA has an emphasis on assessment *for* learning, it is recognised students may have a different assessment experience prior to university than students who complete high-stakes examinations. In a multi-method research project Meyer et al. (2006) investigated the relationship between NCEA and student motivation to learn. The findings indicated there are generally positive perceptions regarding the impact of internal assessment on both teaching and student learning. Students generally viewed internal assessment as enhancing their study patterns and performance as well as enabling them to pace their workload better than what would otherwise occur with only end-of-year examinations (Meyer et al., 2006). Cowie, Jones, and Otrel-Cass (2011) have drawn on a number of long-term studies focused on increasing student engagement and achievement in science across the primary and secondary sector. These studies observed science teaching and learning of 5- to 18-year-old students, and have highlighted, through interviews with students, that assessment practices have social, emotional and cognitive impacts that are intertwined. They concluded classroom assessment, including access to feedback, is a key influence on how students build their science identity (Cowie et al., 2011). If a strong science identity also influences students to progress to learning science at tertiary level, then skills associated with formative feedback may be useful in their learning process. A recent study involving postgraduate university students in the UK identified students wanted to learn from feedback, but found this difficult to achieve. Furthermore, cognitive styles were found to impact on students' perceptions of the value of different forms of feedback (Evans & Waring, 2011). Other studies on student perceptions about feedback have revealed there can be a disparity between teachers' and students' preferences, which occurs when there is a lack of discourse about assessment (Carless, 2006; Rawlins, 2010).

Evidence of first-year performance has been investigated by Shulruf et al. (2008), showing that there is a higher correlation between NCEA and GPA attained by students in first year than students entering with the CIE qualification. Their study was about predictive power and not comparative academic performance. The proposed thesis intends to explore students' perceptions of their learning and how this is reflective of NCEA competency and grades in first-year biology courses at the University of Auckland.

As feedback can be very powerful in enhancing learning, the perspectives of first-year students about their models for learning warrant further investigation. How feedback impacts on their performance at first year and whether this aligns with their perspectives will be the main question in this thesis.

NCEA does not exclusively prepare students for university, but, as a standards-based assessment system, prioritises long-term learning skills. In his report to the Qualifications Development Group of the Ministry of Education, on the proposals for development of the NCEA, Black (2001) recommended a number of points for future consideration. Significantly, he suggested investigating student perceptions about factors (including assessment regimes) that would be helpful in identifying why students are likely to persist with higher education. The students would need to have experience of both secondary and tertiary education to have a perspective on why they may continue their education or not.

> In pursuing the aim of enhanced participation in further education, it is important to consider the outlook of those who do not do so at present, many of whom will have rejected, or failed at, present ways of teaching and learning. The factors that influence students to stay, or not, in post-compulsory education ought to be the focus of some research studies, particularly in relation to the perceptions that students might have of the status and value to them of such study, and to their own judgement of the likelihood that they will both enjoy and succeed with the types of study, and their assessment regimes, that are on offer. (Black, 2001, p. 23)

In addition, after finding mainly positive student perceptions about standards-based assessment, Meyer et al. (2006) also called for more investigation into student attitudes and performance:

> Longitudinal research would also enable our educational system to monitor for unanticipated positive and negative side effects based on the actual evidence of student attitudes and achievement, rather than media reports or political agenda. Particularly when an educational innovation is motivated by presumed benefits to students, outcomes should be monitored to investigate those features of the innovation that are either working well or require modification. (p. 71)

The research questions

Given there are multiple influences on tertiary students' use of feedback during undergraduate study, the current study was designed to investigate the question **"How is feedback conceptualised and used to support learning by tertiary biology students?"** Further questions will guide the study:

i. Do first-year biology students engage with online feedback as part of formative assessment?

ii. Does help seeking in an online environment have an effect on student summative achievement?

iii. How do students approach learning in an online learning environment in terms of their understanding of feedback?

iv. What do students understand about feedback in terms of sources, utility and support for learning?

v. How is students' use of feedback affected by the context within which feedback is given?

Chapter 3

Theoretical framework informing the research

In mixed-methods research, a theoretical foundation is a stance (or lens) that provides direction for the many phases of the study (Creswell & Plano Clark, 2011). The current study has been informed by many comprehensive theories about assessment and feedback, drawn from the work of researchers from the last 50 years. In reviewing Kuhn's four types of paradigms, Morgan (2007) identified the more specific version "paradigms as shared beliefs in a research field" (p. 51) as meaningful for combining quantitative and qualitative methods (Morgan, 2007). An advantage for studies guided by this type of paradigm involves the examination of the work of actual researchers. As Wiliam (2011) has noted, theories of assessment and feedback in the context of learning proposed by many researchers have signalled notable shifts in shared assumptions since the 1960s. There has been a shift from predominant views of educational assessment as norm-referenced testing separate from instruction to more guided development of an individual's learning toward become self-monitoring. Although many of the earlier theories underpinning assessment practice no longer provide an adequate way of thinking, it is important to be mindful of these shifts in theories about assessment and feedback. Many of the earlier ways of thinking about assessment have a residual influence in current assessment practice. In this study, the primary theoretical framework used to inform the data collection and analysis is Hattie and Timperley's 2007 theory and model of feedback. This chapter outlines some of the research contributions to the concept of feedback alongside and relevant to the justification for using Hattie and Timperley's 2007 model to inform this study.

Assessment and feedback

Theories of assessment and feedback are inherently informed by, if not derived from, existing theories and meta-analyses. Many studies on feedback have sought to elucidate the properties or mechanisms of feedback and the circumstances or systems in which feedback may be most effective. In the mid-20th century, Benjamin Bloom (1968) questioned the usefulness of the predominant educational instruction of the time, where the needs and differences of individual learners were uncoupled from the teaching process (Bloom, 1968). Bloom challenged the expectations of teachers in a system where a sorting process excluded many students from progressing to further educational goals as evidenced by the "normal curve" which ranked students in a distribution that is appropriate to "chance and random activity" (p. 2). A learner's

competency was indicated by their rank position displayed in a grade distribution (normal curve) and did not necessarily reflect the real achievement of students such as “high achievers.” This mindset was challenged by the idea that there exists the potential for all students to learn a subject to a high level, triggering further investigations in this field. Thus, the countenance of assessment in education began to change, with a shift to consideration of strategies that promote the fullest development of the learner. Formative evaluation was a term first introduced by Scriven (1967), as having the capacity to provide diagnostic information to learners and teachers, and subsequent identification of the particular ideas, skills and processes that are proving difficult and require further work. Bloom (1968) identified the importance of feedback to teachers as information enabling modification in future instruction through group instruction, and feedback to students about steps that can be taken to correct difficulties (corrective behaviours).

Wiliam (2011) claims Bloom’s introduction of the process of “feedback” into the language of assessment has been counterproductive as he separated the information from actions required for improvement (Wiliam, 2011). Although the concept of feedback was in wide usage across many disciplines, there was little consensus on a definition. Ramaprasad’s (1983) definition clarified feedback as information communicated in a system or organisation about a gap or discrepancy between and actual and reference level, that only becomes feedback once it is used to alter the gap. “The information about the gap, by itself, is not feedback. The information can be called feedback only if, and when, the information is used to alter the gap” (Ramaprasad, 1983, p. 8). In learning contexts, a response or action by students to “do” something to correct errors (i.e., Bloom’s corrective behaviours) would be required to alter a gap and enable gains in learning to be made. Where this affects future performance, then the information provided becomes feedback. The action(s) taken by learners where the information is validated as feedback in the learning cycle continues to be an important research question, including for the current study.

Feedback as knowledge of results was a predominant feedback intervention for the early 20th century despite many of the knowledge of results research studies of the time having major problems such as inconsistent results and poor methodology (Kluger & DeNisi, 1996). Knowledge of results can be summative in delivery and purpose and does not necessarily support further learning or effect improvement (Sadler, 1989). Sadler challenged the definitions of Kulhavy (1977) and Kulik and Kulik (1988), who adopted Kulhavy’s generic definition of feedback was “any of the numerous procedures used that are used to tell a learner if an instructional response is right or wrong” (p. 211). Kulhavy (1977) went on to identify the

potential in feedback for learning, beyond knowledge of results, suggesting when errors occur, students are able "to engage in corrective behaviour" (p. 224), although there was no evidence to support the efficacy of such behaviour in the literature at the time. Kulhavy proposed a continuum of feedback information from the basic correct or incorrect to increasing complexity providing corrective information to a point where the feedback becomes new instruction. Kulhavy asserts "feedback performs its corrective function correctly only if mistakes result from faulty interpretation and not lack of understanding" (p. 224). According to Kulhavy, it is the learner's failure to comprehend the material in the first place that means feedback will have nothing more than a cursory effect on performance. Sadler (1989) rejected this notion of feedback and argued that formative assessment requires a conceptualisation and technology distinct from summative assessment (Sadler, 1989). Further, he identified feedback information having an effect as the key element in formative assessment (Sadler, 1989). This is in contrast to the provision of informational content to the learner in a passive state. Although Kulhavy (1977) posited how feedback can influence learning, he acknowledged that it is important to "expand the canvas so that it includes a most important feature – the student" (p. 224). When developing a theory about feedback, Sadler's focus included students in an active role. He built on Ramaprasad's universal definition of feedback, in which the information is not feedback until it is used in some way to alter the gap (by the learner). If the information does not allow for an appropriate action then it is merely "dangling data" and not effective feedback. The critical conditions in Sadler's theory of feedback, centre on the *student* simultaneously having a concept of the standard (reference level), comparing their level to this standard, and then taking appropriate action, resulting in closure of the gap. Under these conditions, the student is able to become "self-monitoring." Sadler claimed it is preferable to reduce dependency on the teacher, although it is important the student has access to the teacher's guild knowledge in order to understand what constitutes a quality performance and develop their own evaluative expertise.

The role of the teacher and student in the feedback process influences the level of agency that learners have, whether it is minimal and feedback use is mechanistic, or students are more responsive (Boud & Molloy, 2013). Hattie and Timperley's model positions the student in terms of receiving and responding to feedback and, as such, provides a framework in which to explore student use and understanding of feedback.

Hattie and Timperley (2007) framework of feedback

Hattie and Timperley (2007), in a comprehensive meta-analysis of feedback, synthesised substantial evidence about the effectiveness of feedback, which has utility in identifying the moderators with greater effect sizes. This summary underpins their theoretical stance about the properties and conditions whereby feedback promotes effective learning. Hattie and Timperley (2007) also concur with Sadler (1989) that the closing of this gap, between what is understood and what is aimed to be understood, is the purpose of feedback, which should "reduce discrepancies between current understandings/performance and a desired goal." (Hattie & Timperley 2007, p.86). They conceptualise feedback as information provided by an agent (from a diversity of sources) about aspects of one's understanding or performance. This resonates with the general definition put forward by Ramaprasad (1983) and applied to learning by Sadler (1989); both focus on the action required such that information given becomes effective in learning processes, i.e., feedback. Hattie and Timperley (2007) provide a further lens on the action undertaken, by revisiting the assertion that there is a continuum of instruction and feedback. The continuum concept is valuable in removing the discontinuous or discrete aspect often associated with learning in blocks or modules with learning outcomes (Hattie and Timperley, 2007). Hattie and Timperley's definition of feedback includes the various contributions or actions of students, teachers, peers, family and others as part of the complexity, fluidity and intricacy alluded to by Kulhavy (1977). These actions are critical in reconstructing what was unfettered information into productive and effective feedback that enhances learning in some way. Hattie and Timperley (2007) proposed a model which presents feedback operating as part of a multidimensional and granular process, which supports Sadler's (1989) assertion that "student development is multidimensional rather than sequential" (p. 123). Finally, Hattie and Timperley (2007) unpack the term feedback, indicating subtle differences that were previously covered by one term. More feedback terms have been incorporated that appropriately reflect the intended effect of the different information available when actioned by students.

The multidimensionality aspect: Four levels

Dimensionality manifests in the four different levels at which feedback can operate or influence its effectiveness:

- task
- processing
- regulatory

- self-levels

Although there is no hierarchy intended in these groups, in that there is no requirement for one level at which feedback should operate before another, it is argued that an order of events and hierarchy becomes implicit from the influence of prior learning experience and research studies. A surface understanding of learning involving the acquisition of knowledge is related to task, whereas, developing strategies to correct errors or misunderstanding, by understanding process leads to a deeper understanding in learning. Surface learning is considered a lower level or less cognitively demanding level than deep learning.

Feedback about a task or product may provide information about whether it is correct or incorrect through to further content needed for the task to be accomplished. Task-level feedback can be more straight forward for teachers to provide to students and thus encourages a focus on more surface knowledge learning that is specific to the context. Consequently, feedback operating at the task level is considered to occur more frequently; however, it is not transferable to different contexts involving task completion. Feedback about task is more effective when corrective information is provided about errors (Hattie & Timperley, 2007; Kulhavy, 1977).

What comes first? Task, process or self-regulation.

Feedback about task is context specific and often independent of other task feedback which may account for this level being more prevalent in learning environments. However, this can limit performance if feedback about process or how to complete tasks, which is transferable, is not provided (Hattie & Timperley, 2007). The inter-relationships of the levels are an important aspect of the multidimensionality. Learners are engaged in adding to their knowledge and understanding, encountering new contexts as they progress through courses working toward final goals. Learning in new contexts requires feedback at any one of these levels and high performance is achieved or maintained by switching effectively between levels. A self-regulated learner will be aware when task-level or process-level feedback is appropriate.

Feedback about process incorporates understanding the learning processes required or how to go about completing a task. Clearly, in many cases, it is preferable this occurs before or alongside a task stage activity. Alternatively, task or regulatory feedback may signal that access to process feedback is needed to reduce a discrepancy.

Feedback about self-regulation is considered in this model along a continuum of learner behaviours from minimal self-regulation strategies through to learners who are able to self-manage their learning. The interplay with or switching to other feedback levels relates to the

learner's position on the continuum of self-regulatory proficiency. Hattie and Timperley propose that there is a transactional cost involved in seeking feedback that relates to self-regulatory proficiency. Costs relate to effort required (in feedback seeking), face costs (potential loss of self-efficacy) and inference costs (the risk of inaccurate use of any feedback). Students with metacognitive skills of self-assessment and who are able to evaluate their learning needs, are more adept at knowing when and how to seek feedback from others. These students are more likely to switch with ease between levels. In contrast, for students who have these skills to a lesser degree, costs may be higher and they are less likely to interact with feedback levels.

Hattie and Timperley include feedback about self as a person, as approbation is present in learning environments and often replaces the other levels at which feedback operates. They distinguish between personal feedback as positive or negative evaluations of the person, which direct attention away from the task and do not translate into increased performance. Praise that positively describes ability and effort can enhance self-efficacy and so indirectly impact learning gains, although this was found to be age dependent in a study involving 8- to 12-year-olds (Burnett, 2002). This age-related variation in effect, although limited, suggests feedback about self also operates on a continuum, intertwining with the other dimensions or levels of feedback. Any risk to self will be incorporated by the student into the transactional costs associated with receiving feedback.

Information seeking

Approaches for seeking information provide further dimensionality in Hattie and Timperley's model. In the model, information about how to reduce discrepancies between current performance and a goal can be sought by asking any or all of three questions at any one of the feedback levels. The questions ("How am I going?", "Where am I going?", and "Where to next?") can lead to learner actions that have an effect to reduce the discrepancy. Hattie and Timperley qualify these questions as *feed back*, *feed up*, and *feed forward* respectively. Unpacking the previously overarching term *feedback* to the three terms feed back, feed up and feed forward is a strength of the theoretical framework. The type of action becomes implicit to the learner. It is timely to revisit Ramaprasad's (1983) definition for feedback as it operates to regulate a system, where an action has reduced the gap between the reference level and the actual level. If "How am I going?" is the equivalent of feedback applied to a learning context, the learner has confirmation that the information given and action taken has allowed them to reach the goals they set out to accomplish. When the action reduces the gap between two levels,

and is effective in maintaining stability in the system, it is negative feedback (Ramaprasad, 1983). Conversely, if the gap is widened, then it is positive feedback. “Positive” feedback is viewed as pushing the system in the direction it is already going and can tend to toward instability, whereas “negative” feedback produces stability by bringing a system back to a former state. Ramaprasad (1983) points out this is contrary to commonly held beliefs about positive and negative feedback and may cause confusion. “In common parlance, and some scientific literature, the distinction is based on the emotional connotation to the recipient, of the action triggered.” (p. 9). Incorporating feed up and feed forward in the model is similar to distancing the reference level in relation to the actual level of the learner, and feed back is confirmed when the consequence of the action taken has closed the gap. Feed up and feed forward lead the learner to take on more responsibility that can build metacognitive skills and mean they are more likely to work in the regulatory level. The addition of these questions is important to facilitate progress in learning to become a fluid and dynamic process as the questions are repeated by the learner. Learning will occur where the reference level is shifted, the gap widened and then the gap reduced by learner action. The terminology of feed up and feed forward have different implicit meanings to feed back and help clarify the type of action that is effective to support learning.

Student participation in formative assessment incorporating feedback is key (Hattie & Timperley, 2007; Kulhavy, 1977; Sadler, 1989). Research on student perspectives about feedback indicates that they want feedback to support their learning (Beaumont et al., 2011). What needs further clarification is what feedback means to students in terms of the actions they need to or want to take in order to support their learning.

Chapter summary and reflection

How information is used as feedback or feed forward in the context of learning science is also important to consider. Many students have empirical views of the nature of science; their view of learning and the learning process can be limited in that they conceptualise learning as the transfer of prefabricated knowledge that is stored in memory (Duit & Treagust, 1998). This passive view of learning can influence how students work with and act on information they receive about their progress. A further influence on the use of feedback in learning can be a person’s commonplace understanding of the word, e.g., it can be a comment, observation or a rebuttal. This can carry both positive and negative connotations which can subconsciously influence a student’s way of thinking and behaviours. Feedback also has a distinct meaning in science where is it is used to describe regulatory processes in systems (both natural and

physical). For example, homeostasis in biological systems maintains thermal, chemical and biological conditions through feedback. Feedback in this regard is bringing a system back to a desired point of balance. The system is regulated and, in a sense, under control of processes. When balance is reached, no further action is required. Boud and Molloy (2013) identified issues with the language of feedback based on its previous use in many fields including the sciences. These residual effects of the concept of feedback in other contexts have led to ideas and beliefs that feedback is external information about performance and students could benefit if they choose. There was an assumption that change could be brought about without the student taking part, such that feedback was synonymous with “telling” which is similar to the transmission of information (Boud & Molloy, 2013).

Chapter 4

The research process

In this chapter, the research process and procedures are outlined under the following sections: the research methodology, practice site and context, research design, sampling, ethical considerations, data collection, analysis of the data, and ensuring trustworthiness.

Methodology

In trying to make sense of and understand the nature of phenomena within their environment, people may rely on experience, reasoning and research, which are not mutually exclusive, but can work in complementary ways (Cohen, Manion, & Morrison, 2007). In conducting research, experience can provide sources of questions and hypotheses relevant to the researcher's context. The orientation of this research was a form of inquiry as practitioner research conducted in the context of an undergraduate tertiary education setting. As such, the methodology is sensitive to this context (Somekh, 1995). Somekh (1995) referred to "how strongly action research methodology is determined by the culture of the participants and their institutions" (p. 345) in reference to the researchers' values and also their understanding of their colleagues' needs and expectations.

As a practitioner, the research in this study was motivated by my interest in students' learning behaviour and their perspectives during formative assessment to progress learning processes and achievement. The first part of the study occurred in an online context as part of a first-year biology course, and the second part took place during the same students' senior undergraduate courses. As for many university courses, blending online activities into course delivery was an intentional adjustment made to teaching practice as a means to manage enrolments in excess of 1000 students in the undergraduate course examined in this thesis. In this large course, the delivery approach reflects education as a commodity (or an investment) (Carr & Kemmis, 2003). The lecture focus and online delivery of knowledge as transmissible content and activities was key to providing resources via "fair" access where students take opportunities to progress learning. Further, teaching staff were able to monitor student uptake and engagement with activities as part of self-directed learning. Investigating the practice of providing online feedback was important in order to identify if adjustments or changes were required to improve student engagement and achievement in this course.

The first phase of the research employed a quasi-experimental approach. This phase recognised the culture within which the course is taught and investigated whether the investment in the online component of the course is a justifiable outcome in terms of student achievement. In a sense, it asked the question "does this work in fulfilling the needs and expectations of the teachers involved in the course?" Cochran-Smith and Lytle (2009) describe this approach as educational practice that is "provable" and provides certainty. The quasi-experimental approach to this phase of the research, while providing some certainty about the practice of online learning, also established an informed base from which to explore uncertainties about students' use of online feedback and feedback in general (Cochran-Smith & Lytle, 2009).

As part of the research of this educational situation, it was also important to investigate the human perspective, which has the potential to consider different issues related to the personal structuring of knowledge by individual learners (Carr & Kemmis, 2003). There are many deeply embedded traditional aspects of university teaching in the institution concerned and practitioner research has the potential to develop an open and questioning intellectual stance on teaching (Cochran-Smith & Lytle, 2009). In the context of large cohorts, which are part of the mass education model, insider research has the potential to interrogate the teaching culture and lead to what some may view as constructive disruption. However, using the knowledge generated, the intention was to be helpful and enhance the student learning experience, as practitioner research is applied research in which "the primary goal is to facilitate social change" (Neuman, 2006, p. 28)

Practitioner research outcomes can be effective on a small or large scale (Reason & Bradbury, 2001), and this research can inform the local educational setting within which it was conducted, a large first-year university course in biology. However, the research design used multiple forms of inquiry that incorporated a longitudinal aspect where participants reflected about feedback. The intention was to generate a deeper insight into learning in a higher education setting where findings could inform learning experiences of future undergraduates. Through the inclusion of interpretive frameworks and theories of learning it is also possible to inform and potentially transfer to other contexts (Cochran-Smith & Lytle, 2009; Denzin & Lincoln, 1994; Lincoln & Guba, 1985). The extent of influence of research findings is moderated by the different purposes, positionalities, epistemologies of the practitioner researcher, and the needs and expectations of university teachers for whom there is some relevance (Cohen et al., 2007; Herr & Anderson, 2014; Somekh, 1995). Hence, selecting the

appropriate methodology is key to guiding the processes of the research as well as the attitudes and beliefs of the audience (Cohen et al., 2007; Neuman, 2006).

Research paradigms

The research process reflects researchers' paradigmatic positioning and also their theoretical stance or methodology. Paradigms may be defined as worldviews or sets of basic belief systems that guide research. A researcher's paradigm reflects his/her beliefs about what reality is (ontology), what counts as knowledge (epistemology) and how one gains such knowledge (methodology) (Guba & Lincoln, 1994; Morgan, 2007). How a researcher views the constructs of social reality and knowledge influences how they will go about conducting research and evaluating others' research (Cohen et al., 2007). The approach used in this education research project moved away from a single paradigm by incorporating the positivist/postpositivist and interpretivist paradigms. As ontological assumptions inform epistemological assumptions, which in turn inform methodology and give rise to methods used to collect data, the multiple paradigms underpinning this research are examined next. Firstly, distinctions will be drawn, as the paradigms represent fundamental differences in outlook and alternative assumptions that influence the research process. Secondly, qualitative and quantitative methods that have stemmed from these distinct paradigms enabled a broader approach to the research, and will be examined (Morgan, 2007). A multi-paradigmatic approach offers less-restrictive and valuable alternatives to science education researchers, facilitating a transformative research that is important in addressing science learning in the 21st century (P. C. Taylor, Taylor, & Luitel, 2012).

The positivist, postpositivist research paradigm

Quantification in sciences such as mathematics, physics and chemistry has been the perceived model for precision and dependability in research, allowing verification (positivism) or falsification (post-positivism) of a priori hypotheses (Guba & Lincoln, 1994). As such, the focus is on a subset of variables while disregarding other contextual variables that may influence the outcome. Positivism, also known as the scientific paradigm, is familiar to science education researchers as it is well integrated in Western science academic culture (Howe, 2009; Treagust, Won, & Duit, 2014). The positivist approach to knowing about the world emphasises the importance of objectivity, systematic and detailed observation, testing hypotheses through experimentation and verification. Knowledge is generated deductively by way of hypothesis testing and, with the scientific procedures of verification, results can be generalised to other situations. The predominant belief is that objective accounts of the world can be given, and the

function of science is to develop explanations in the form of universal laws (Punch, 2005). Positivism emphasises the discovery of causal relationships and careful empirical observations (Neuman, 2003), where reality is external to the researcher. Educational researchers who adhere to this school of thought "eliminate their biases, remain emotionally detached and uninvolved with the objects of study and test or empirically justify their stated hypotheses" (Johnson, Onwuegbuzie, & Turner, 2007, p. 14). Post-positivism is an extension of the traditional scientific worldview, or positivism in a more moderate form (Giddings & Grant, 2006). Under positivist assumptions, effects have a determinable cause and actions have predictable outcomes and the application of the principle of parsimony (where explanations should the simplest and most precise), can be at odds in a human context where so many variables contribute to the truth. For post-positivism, the linear process of cause and effect is modified and outcomes are considered the result of a complex array of causative factors such as culture, personal value systems and surroundings that interact to influence perceptions of the world (Treagust et al., 2014).

The interpretive paradigm

In contrast with positivism and post-positivism, the fundamental aspect of interpretivism is that reality can never be observed from the outside only, rather it is obtained through interactions and experiences of people. The interpretive paradigm concentrates on the meanings people bring to situations and behaviour, which they use to understand their world (Punch, 2005; Treagust et al., 2014). The interpretive research paradigm has emerged in the social sciences to break out of the constraints imposed by positivism. Derived from relativist ontology and constructivist epistemology, it is characterised by a belief in a socially constructed, subjectively based reality, one influenced by culture and history (Treagust et al., 2014). Nonetheless, it still retains the ideals of researcher objectivity, and researcher as collector and interpreter of data. Evidence is obtained from the "self-understandings of participants" (p.16) and the researcher interprets the significance of these self-understandings in ways the participants may or may not have been able to see (Grant & Giddings, 2002). Knowledge can be gained deductively or inductively to create a theory. For an interpretivist, realities are thought of as local, specific and constructed; they are socially and experientially based, and depend on the individuals or groups holding them (Guba & Lincoln, 1994).

Mixed methodology

The contributions of research of different paradigms to the education community is important when resolving social and educational difficulties (Bredo, 2009). A restrictive paradigm

focus has implications for research studies, in particular in science education, where a limited view may exclude the contributions of other types of research (Treagust et al., 2014). There can also be a tendency for researchers to undervalue studies underpinned by paradigms outside their worldview (Kincheloe & Tobin, 2009). Working with multiple paradigms that have different philosophical assumptions enables complementary research approaches to be incorporated into a mixed methodology (Johnson, 2009). Conducting research across multiple paradigms provides an opportunity for synthesising perspectives about relationships between phenomena and social behaviour (J. C. Greene, 2008) and additional insights can add value to the research:

> A mixed methods way of thinking is an orientation toward social inquiry that actively invites us to participate in dialogue about multiple ways of seeing and hearing, multiple ways of making sense of the social world, and multiple standpoints on what is important and to be valued and cherished. (J. C. Greene, 2008, p. 20)

Mixed methodology was originally defined under the general heading of method triangulation. Four basic types of triangulation were proposed by Denzin (1978): the use of a variety of data sources or data triangulation, the use of several researchers in investigator triangulation, the use of multiple perspectives to interpret the findings in theory triangulation, and the use of multiple methods to study a research problem in methodological triangulation. Multiple methods involving the use of quantitative and qualitative approaches allow the limits or weakness of one method to be offset by the strengths of another method (Tashakkori & Teddlie, 1998). Punch (2009) similarly states:

> The fundamental rationale behind mixed methods research is that we can learn more about one research topic if we can combine the strengths of qualitative research with the strengths of quantitative research while compensating at the same time for the weaknesses of each method. (p. 290)

This approach effectively generates numerical and narrative data that answer similar questions (Creswell, 2003). Leech and Onwuegbuzie (2009) similarly describe mixed-methods research as "collecting, analysing, and interpreting quantitative and qualitative data in a single study or in a series of studies that investigate the same underlying phenomenon" (p. 265). However, Tashakkori and Teddlie (1998) argue there is often no consistent paradigm or theory for mixed-methods studies. Giddings and Grant (2006), on the other hand, consider mixed methodology to be underpinned by postpositivist assumptions, although not confined to this paradigm. Punch (2009) claims that for mixed methods to develop, it is important to move past the either-or methodological thinking of the paradigm wars and have a willingness to embrace multiple

paradigms. The emergence of pragmatism is an underlying philosophical approach relevant to mixed-method design in that there is a focus on "what works" for answering research questions.

Mixed methods can also serve other purposes such as discovering paradoxes, contradictions or fresh perspectives. Where the research design involves different phases, sequential methods can potentially inform subsequent later stages. Overall, mixed methods can add breadth and scope to a project. Different designs are possible in mixed-methods research. For sequential mixed-method design, there is a qualitative phase of study and then a separate quantitative phase or vice versa. Because the two phases are quite separate, it is possible to present the paradigm assumptions behind each phase (Tashakkori & Teddlie, 1998). The process of sequencing qualitative/quantitative data collection or using inductive/deductive logic can be iterative and go through several cycles. The data can be analysed separately and then in a complementary manner. One set of data can be used to corroborate the findings from another (Giddings & Grant, 2006). However, Creswell (2003) contends that quantitative results would not necessarily relate to or confirm qualitative results (and vice versa) in the designs, requiring further inquiry by generating further questions or bringing to light more perspectives.

Mixed methodology in science education

Science research is about gathering evidence to support or falsify a hypothesis that has been built from existing scientific theories. Generally underpinned by a positivist paradigm, experiments are conducted to test predictions of the hypothesis, and variables investigated are defined by the research question. Karl Popper claimed certainty cannot be obtained by science research as most scientific statements retain their hypothetical character (Penny, 2012). Based on this uncertainty, Popper also questioned the concept of a scientific body of knowledge:

> There is no scientific knowledge in the general sense of the word 'knowledge.' We speak of knowledge in ordinary life as something we can be sure of. It is the higher standards that science applied which reduce 'scientific knowledge' to the hypothesis. The term 'body-of-scientific-knowledge' (for example, as in a textbook) is a misnomer – it is not a body and is not really knowledge. (cited in Penny, 2012, p. 14)

If research in the discipline of science means science knowledge is not fixed, then a lack of surety is a challenge to teaching science in higher education where curriculum is usually focused on "content," often from textbooks. Many lecturers focus on the delivery of a rapidly growing corpus of science research outputs, confirming a positivist worldview is predominant in science education. Tertiary science teachers' interest in research about learning is also influenced by a reductionist approach that pares back the variables to those involved in the

measurement and collection of data (Kincheloe & Tobin, 2009). P. C. Taylor (2014) describes the interplay between research and teaching in science as unique to the discipline.

> It is easy to appreciate why science educators are attracted to positivist research when we reflect on the way science (our primary discipline) has been represented in traditional undergraduate university science curricula as objective and uncontestable facts. A perception of the implacable objectivity of science has been reinforced by didactic teaching methods, "cookbook-type" laboratory experiments, and a museum-like encounter with the end products of scientific research rather than with the messy (inter/subjective) processes of creative discovery and consensual validation that produced them. (P. C. Taylor, 2014, p. 41)

Thus, if decontextualised, science education research may not capture the "messy processes" within the context where learning takes place. Consciously dispelling the paradigms of positivism/post-positivism, which provides for a clear and objective approach to building knowledge, creates conflict when adopting multiple philosophies in science education research (Bredo, 2006). Although, in education research, the importance of the diversity of research paradigms has been much debated (Morgan, 2007; Moss et al., 2009), multiple research paradigms are relatively new to science education. Consideration of sociocultural aspects in which science is conducted and taught is critical to achieve outcomes that are transformative, effective and relevant in the 21st century (P. C. Taylor et al., 2012). Similar challenges are experienced in inquiry-centred practitioner research that conceptualises inquiry as outcome and is a dynamic and fluid way of knowing in education practice (Cochran-Smith & Lytle, 2009), producing uncertainty rather than certainty and often leading to more questions and possibilities in teaching and learning. This lack of certainty is in contrast to the need for accountability in education research about what works to increase achievement, with a focus on educational outcomes. In this regard, quantitative approaches yield the appropriate validation of particular teaching steps or strategies that can be promulgated as part of professional development for teachers. As P. C. Taylor (2014) indicated, this objective and uncontestable approach is often preferred in science educational inquiry.

The research for this thesis, however, used an approach that involved both hypothesis testing and investigation into the sociocultural aspect of phenomena in the learning environment. The research combined quantitative and qualitative methods in a sequential fashion where deductive results from a quantitative approach informed the design and sampling for a subsequent qualitative study. Morgan (2007) refers to this integrated methodology, where there is movement back and forth between the different approaches, as pragmatism. In this

approach it is possible to have "a single 'real world' in which all individuals have their own unique interpretations of that world" (Morgan, 2007, p. 72). J. C. Greene (2008) sees the merits for a mixed-methods approach becoming a distinct methodology as it can lead to a better understanding of the multifaceted and complex character of social phenomena. A more central issue to the practice of a mixed-methods inquiry is *how* to mix (J. C. Greene, 2008). In this research, quantitative and qualitative approaches, underpinned by different paradigmatic views, were undertaken in two sequential phases.

Practice site and context for the research

This study took place in a large ($N \approx 40{,}000$), publicly funded, research-intensive university, situated in New Zealand's largest metropolitan region (approximately one-third of the national population). Entry to the university is selective in that students are required to have a minimum of 150 points from the best 80 credits earned in the New Zealand NCEA, Level 3, compared to the minimum entry score of 120 points used at all other universities. The university course that is part of this study, is a prerequisite for students majoring in biological science and intending to apply for programmes such as health and medicine.

The course is a single-semester 12-week course, with four 50-minute lectures each week in two sessions per day to accommodate students in groups of 600. Fortnightly laboratory classes involved 64 students in each session. There were no formal tutorial classes. However, a blended model of tutorial support provided opportunities for students to access learning materials and practice activities and a discussion board to facilitate peer-to-peer communication. MasteringBiology was a separate online resource that provided assignments customised by the teacher and presented as regular homework activities (i.e., formative assessment for learning).

The key concepts in the course included cell and molecular biology, microbiology and genetics, which were assessed in the mid-semester test. The second half of the course focused on evolution and biochemistry, assessed in the course final examination which is comparable to the earlier test.

Previous students in this course had reported dissatisfaction with insufficient feedback and were frustrated by limited opportunities to learn actively during a predominantly lecture-driven course. Given the constraints of providing feedback in large university classes, outlined above, to address these concerns, the course designers incorporated MasteringBiology into the coursework schedule as sets of online homework activities available alongside the relevant lecture material each week. The activities were due for completion at the end of each week. As

an incentive, there was a small contribution (4%) to the final graded course mark if the students completed by the due date, provided they scored a minimum of 50% correct for each activity. There was no penalty for using hints, although their use would increase the time taken to complete the assignment.

The course had two summative assessments (a mid-semester test and a final examination) contributing 74% of the final grade. The balance of the grade was made up of in-course work including laboratory assessments (22% of the grade) and 30 MasteringBiology assignments (4%). All assessments were summative in that they contributed to the final course grade.

MasteringBiology

MasteringBiology is a software application that provides a range of feedback systems. It is an online learning product developed by Pearson Publishing (2008). MasteringBiology is used globally to support first-year university students in different disciplines, by providing access to feedback (Rayner, 2008).

MasteringBiology provides an assignment area where teachers are able to specify resources and activities that align with lecture content and can be used to practise tasks that facilitate understanding and retention. The system provides tutorial activities with animations and relevant content in combination with objectively scored tasks that students can use for either practice or review. The system automatically scores the student response to the task and provides feedback about correctness and statements that reinforce the knowledge required for correct answers. The system also provides optional help, or hints, that students can use prior to the task or afterwards if the system scores their answer as incorrect. If students answer incorrectly, they can revisit the task with the option of seeking further help before re-attempting it. Hints are in the form of further information or clues, and in some cases, simpler questions.

The flow of student use of MasteringBiology is illustrated in Figure 1. The system provides tutorials which lead to homework tasks that are scored as correct or incorrect. Once the student finishes the task, credit is awarded in the course system, provided the task was completed on time and with at least 50% of the tasks answered correctly.

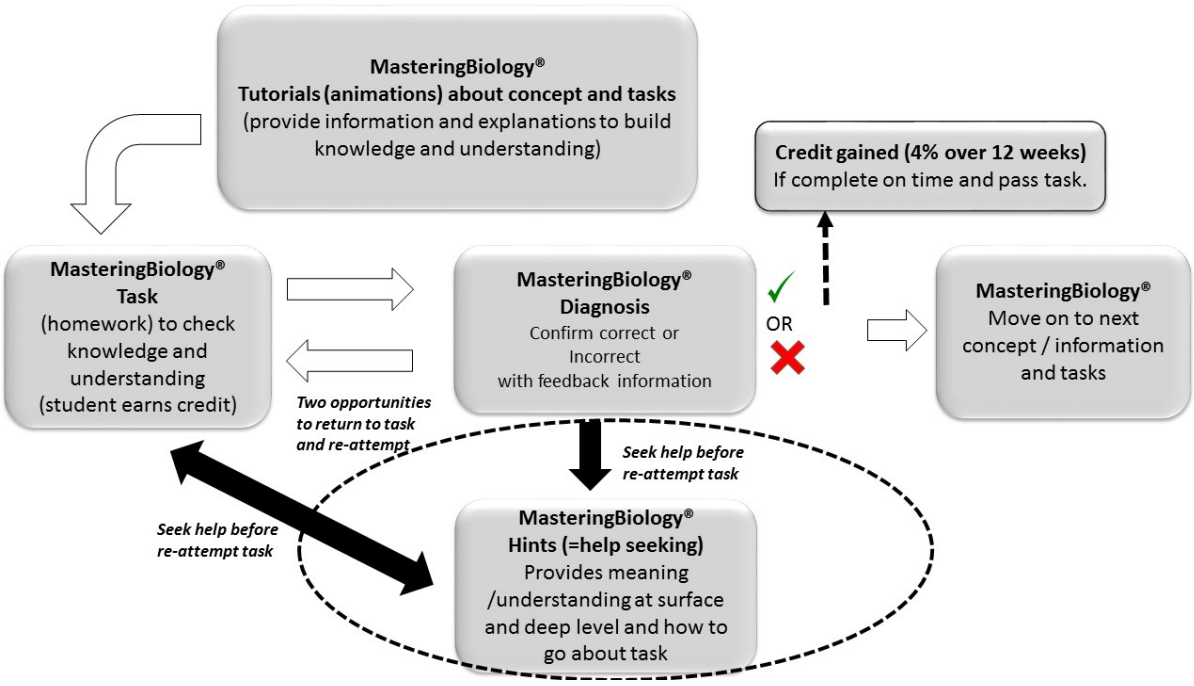

Figure 1. Pathway in MasteringBiology for activity completion, indicating options for help seeking.

Thus, MasteringBiology allows students to engage in "deliberative practice" (Hattie, 2009, p. 30) under learner-controlled conditions and to receive immediate feedback about correctness and options for assistive feedback. MasteringBiology provides feedback about "Where am I?" by confirming whether responses are correct as tasks are completed. It allows the student to return to wrongly answered tasks, and provides opportunities to obtain more information about the topic, and to know "What do I do next?"

When uncertain or wrong, students can seek help by clicking on "hints," which provide new information (e.g., further questions, diagrams or animated tutorials) that can scaffold further learning of the target knowledge structures (see Figures 2 and 3). Figure 2 shows a task on photosynthesis, which students complete by dragging correct chemical structures onto the fields in the diagram of the Calvin cycle. Figure 3 shows three incrementally complete hints with prompt questions that require students to use hint information to formulate a new response.

MasteringBiology® Question

Part A - Following carbon atoms around the Calvin cycle

The net reaction of the Calvin cycle is the conversion of CO_2 into the three-carbon sugar G3P. Along the way, reactions rearrange carbon atoms among intermediate compounds and use the ATP and NADPH produced by the light reactions. In this exercise, you will track carbon atoms through the Calvin cycle as required for the net production of one molecule of G3P.

For each intermediate compound in the Calvin cycle, identify the number of molecules of that intermediate and the total number of carbon atoms contained in those molecules. As an example, the output G3P is labeled for you: 1 molecule with a total of 3 carbon atoms.
Labels may be used once, more than once, or not at all.

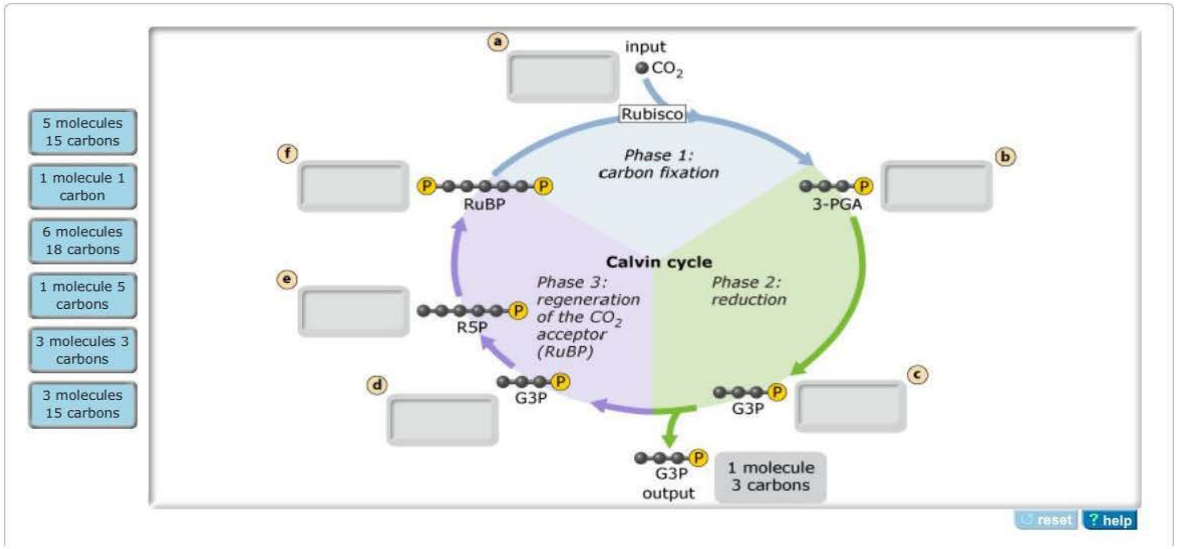

Figure 2. Panel A: Example of MasteringBiology question presented to students as a task on photosynthesis (Pearson Publishing, 2008).

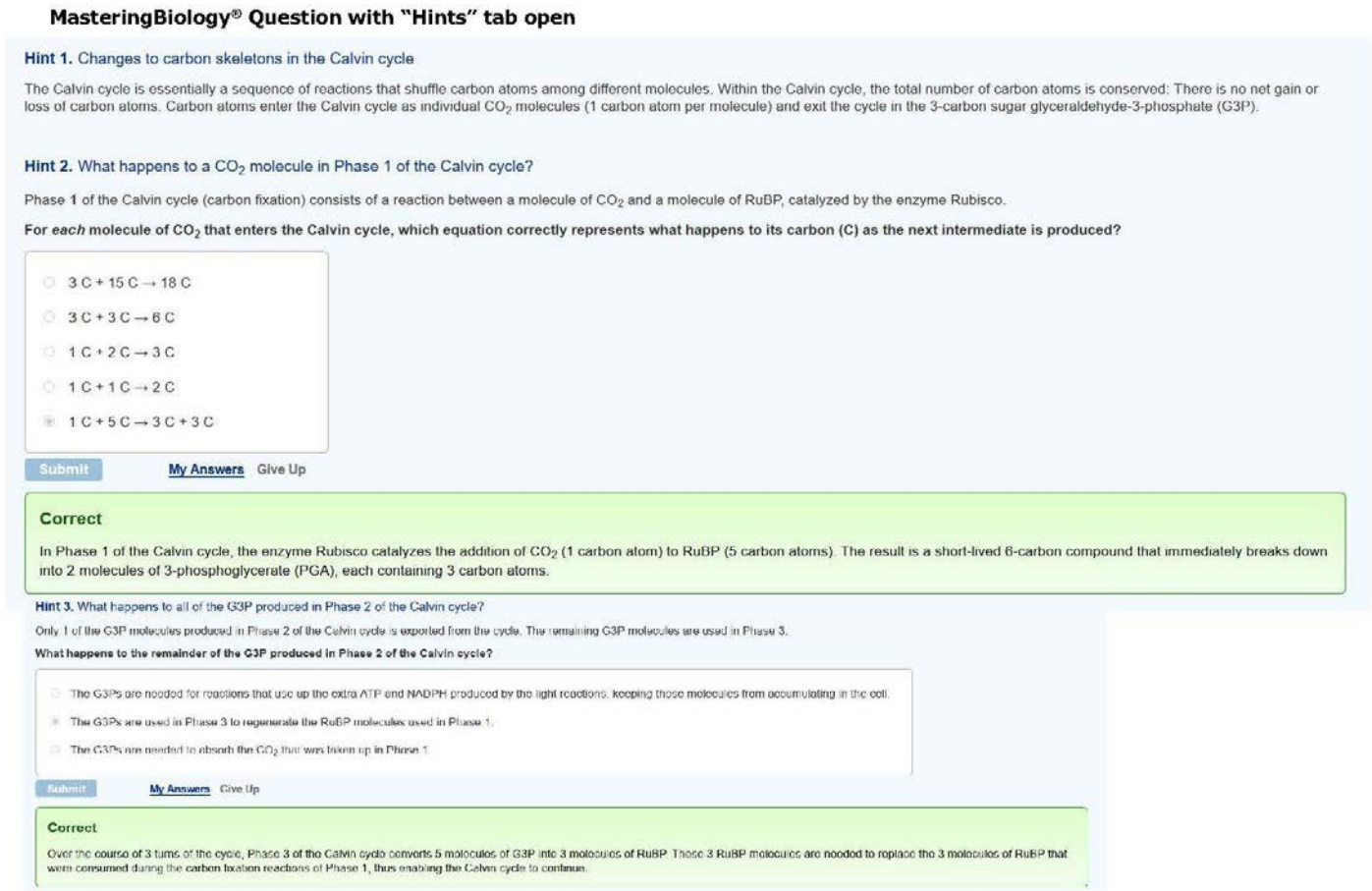

Figure 3. Panel B: MasteringBiology question showing hint information and questions available to help seekers (Pearson Publishing 2008).

"Seeking help is a learner proficiency, and many types of help-seeking behaviour can be considered aspects of self-regulation" (Hattie & Timperley, 2007, p. 96). Seeking out and making use of feedback as a means of improvement is associated with higher achievement (Brown et al., 2016). Thus, the formative feedback resources built into MasteringBiology (i.e., hints) require students to actively monitor and direct their own actions towards a learning goal in light of the scores and hints delivered by the system. Students' willingness to invest effort into seeking and dealing with the hint feedback information may be characteristic of effective learners, but is likely to be carried out by less-proficient learners who make more mistakes. This means that MasteringBiology aligns with several powerful learning forces, in that it allows and requires the self-determined action of the individual learner without oversight by the instructor, and is structured so that students can potentially receive or seek feedback that explains error, points to helpful resources, provides explanations, and offers multimedia tutoring. Nonetheless, if students are getting the test questions correct, their use of hints is likely to be minimal, suggesting that weaker students may refer to the hint feedback more than academically proficient students.

For research and teaching purposes, MasteringBiology stores data about student accuracy in answering tasks and the frequency of student repetition of items, use of hints, and other activities within the system. All data are stored on Pearson Education servers located in Waltham, MA, USA.

MasteringBiology and the theoretical framework used in this research

The structure in MasteringBiology can be mapped to Hattie and Timperley's model of feedback. However, the extent to which students can work at the various levels in the system depends on the settings, which are determined by the instructor. Table 1 shows how MasteringBiology course design and presentation settings, which are determined by the instructor, map to Hattie and Timperley's feedback framework.

Table 1
Operationalisation of Hattie and Timperley's Model of Feedback in MasteringBiology

Level (Not including Self-Level)	Question	MasteringBiology	System settings
Task	*Where am I going?* *(Feed Up)*	Declarative knowledge as part of instruction (written text, voice over, animation, annotated images)	Always viewable. Access not limited after completion of activity
Task Process	*How am I going?* *(Feed Back)*	Questions (formats include multiple-choice questions, multi-step questions, completion of diagrams by drag and drop). All questions have automated corrective information with confirmatory statement or prompt when incorrect.	Allows more than 1 attempt (up to 3) Shows if answer is correct No penalty if get incorrect before the last attempt.
Task Process Self-regulation	*Where to next?* *(Feed Forward)*	Hints that provide help as further information, procedural aspects, uses questions	Allows rework or practice Can always view hints No penalty for using hints

The research design: A two-phase approach

This research was conducted in two sequential phases (Table 2), combining quantitative and qualitative methods. The methods were complementary, with each producing discrete findings, which together provided a deeper insight of learning in a higher education setting than each provided on its own. The forms of inquiry used to answer the research questions included quantitative observation of students' patterns of feedback use during online learning behaviour, related to students' achievement, and qualitative focus group discussions.

The outcome of the quantitative phase was used to support the development of the design for the qualitative phase. The qualitative evidence was then used to provide further insights and depth of understanding of the quantitative results. The two-phase process facilitated design development during research and, with a longitudinal timeline, a reflective perspective was given to the study. Each phase involved multiple data-collection methods. Information about the participants, recruitment process and data collection for each phase will be outlined separately in the relevant chapter findings, along with details regarding design, data analysis and ethical standards pertinent to both phases of the research.

Table 2
An Overview of the Research Design

Central research question: **"How is feedback conceptualised and used by tertiary biology students in an online learning environment?"**

Sub-questions	Method	Analysis	Note
1. Do first-year biology students engage with online feedback as part of formative assessment? 2. Does help seeking in an online environment have an effect on student summative achievement?	**Phase 1 of research:** Quantitative data generated through the students' interaction with the online system MasteringBiology (e.g., feedback usage as pre-, post-question or none). Institutional data including demographics, previous subjects taken and achievement levels (e.g., entrance qualification and level of achievement, assessment performance).	Exploratory factor analysis Structural equation modelling	Phase 2: participants volunteers from cohort of 1250 students
3. How do students approach learning in an online learning environment in terms of their understanding of feedback? 4. What do students understand about feedback in terms of sources, utility and support for learning? 5. How is students' use of feedback affected by the context within which feedback is given?	**Phase 2 of research:** Qualitative data from four focus group sessions about students' understanding of feedback in relation to their engagement in the online context and other coursework. Purposeful sampling informed by analysis of quantitative data in previous phase, based on achievement and online help-seeking behaviour. Diamond ranking exercise on feedback as part of focus group discussion.	Thematic and inductive analysis	Phase 1: 20 participants volunteers from cohort of 1250 students

Chapter 5

Phase 1: Students' use of online feedback in a first-year tertiary biology course

Introduction

In Phase 1 of this study, student use of the MasteringBiology system was examined, in terms of help-seeking behaviour or hint usage and how this contributed to performance on formal assessments in the course for which MasteringBiology was used. This chapter outlines the research goals; methods, including sampling procedure; instruments used; data analysis; and results.

Phase 1 of the research

In Phase 1, a quasi-experimental rather than experimental study was undertaken to maintain fair allocation of resources to all students. This was to avoid negative reactions from students and the institution (Steiner, Wroblewski, & Cook, 2009). For ethical reasons, randomised experiments are hard to implement where subjects are undertaking educational activities that have consequences for their personal outcomes. Although quasi-experimental designs are often seen as inferior to an experiment in terms of causality, Steiner et al. (2009) argue the strongest quasi-experimental designs include features such as interrupted time-series analysis, regression-discontinuity analysis, and one pretest measurement, all of which were elements in this research. Student activity was observed within the MasteringBiology online system from response patterns recorded in the system. This involved gathering quantitative evidence from online tracking of students' use of formative assessment activities in the online learning environment. Determining online learning behaviour in web-based environments provides particular challenges as these environments are multifaceted and complex (Ferguson 2012, Sheard, Ceddia, & Hurst, 2003), and, further, students are often remote from their teachers. MasteringBiology allowed for data collection by capturing and recording student interaction with the system in an unobtrusive way. As with many online systems, this technology enabled collection of data on variables that was not possible with traditional teaching methods (Sheard et al., 2003). The MasteringBiology system recorded students' access to and use of hints, which provided feedback about how to answer the activity question if they were unsure. Using this feedback was optional and in addition to the automated feedback on correct or incorrect

responses. The hints contained further information as well as simpler sub-problems. The quantifiable data collected in the system was individual student's tendency to use optional areas of the system where they clicked on the hint tab, thus enabling them to progress their learning, i.e., an indicator of help-seeking behaviour.

It has been proposed using log-file data is an advantage, as measuring the actual behaviour is more reliable evidence than students' expressed opinions or reported behaviour (Ingram, 1999). Further, as Peled and Rashty (1999) suggested "if we mix these log files with student demographics and performance data and survey results, we will get a clear, powerful, and insightful picture of how students learn online" (p. 428). The data about hint use was collected from the MasteringBiology system and was then combined with institutional data. Demographic information was collected from the university's administrative system, Student Services Online (SSoL), and included: age, gender, entrance qualifications, rank score/grade average equivalent (GPE) at time of entry, degree/programme, major/specialisation, and ethnicity. All data were merged and coded for statistical analysis.

Research goals

The automated tutoring system provides a hint system associated with machine-scored tasks. Given the workloads and demands of students in the programme, it was anticipated that the additional hint system would be used primarily by students who are struggling to meet the target of 50% tasks answered correctly. Thus, making use of the hints is not necessary for academically proficient students who can get more than 50% of the tasks correct. However, the academic benefit of less-proficient students using hints is not well understood, and this is the major goal and contribution of the current study.

Since potential hint usage took place prior to two different assessment events, a temporal causal structural equation model was developed to explore the linear effect of prior achievement and hint usage on subsequent academic performance. The model was based on four hypotheses about the effect of prior achievement and hint usage. It was proposed that prior achievement would positively predict subsequent performance on the course (H_1), and that weaker, rather than stronger, students would use hints (H_2). It was also proposed that more frequent hint usage would predict continued usage of hints (H_3) and would positively contribute to course achievement (H_4) (see Figure 4).

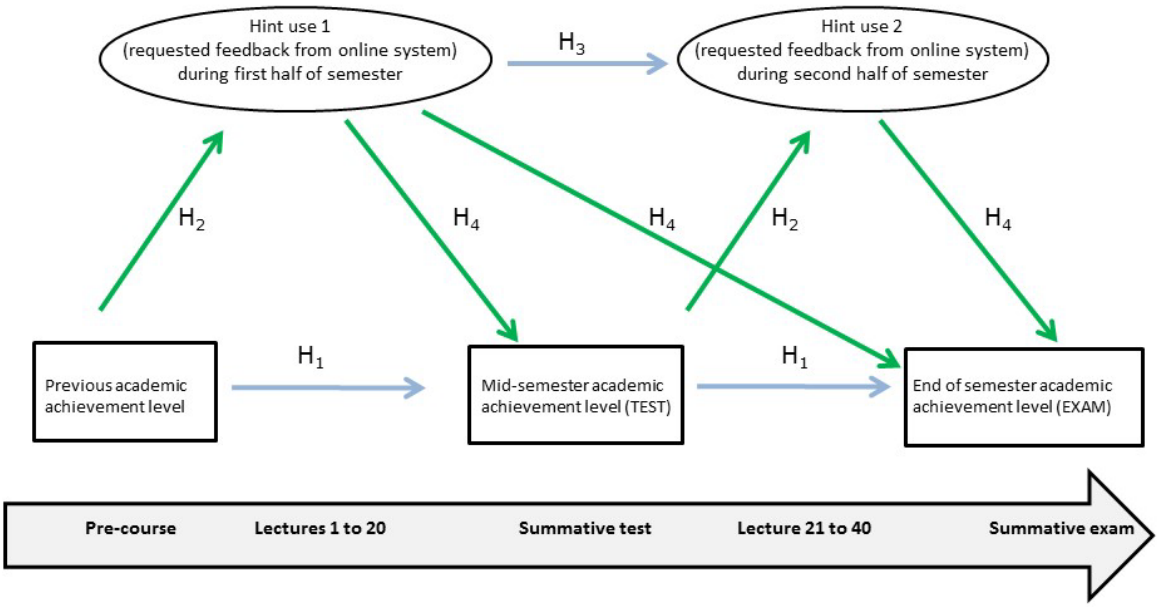

Figure 4. Proposed hypotheses concerning hint usage and academic performance.

Methods

The sampling frame and sample size for Phase 1

In Phase 1, the quasi-experimental approach used passive observational techniques where the data was collected in situ (Cohen et al., 2007). In quantitative research, nonprobability sampling is not often used as it can produce unrepresentative samples (Neuman, 2006). In deciding on the sampling strategy, judgements should be made about the required sample size, the representativeness and parameters of the sample, access to the sample, and the method used (Cohen et al., 2007). However, often the researcher must use whatever sample is available or use a convenience sample such as the current research where an accessible situation fits the research context and purpose (Punch, 2009). When participants are recruited by convenience sampling there is a risk of misrepresenting the population (Neuman, 2006). In this phase of the research, the target population was of known size (1,252 students first-year biology students), of which 918 students volunteered to participate giving a sampling ratio of 73.3%. Where there is a high response rate, it is more likely the sample is representative of the target population and sampling error is reduced. A response rate of 70% or higher is usually considered appropriate although this does not always alleviate the concern of non-representation of the population, as people who choose not to participate may be systematically different from people who do (Hibberts, Johnson, & Hudson, 2012). From an experimental perspective, there

was one “treatment” group in the online learning environment and all students were experiencing the same conditions. Where convenience sampling is used in a quantitative study it is important to provide the characteristics of the sample.

Participants

Of the 1,252 undergraduate first-year biology students in the course, 918 volunteered to participate. Of these volunteers, 65.3% were female and 34.7% male. The majority were in their late teenage years (M_{age} = 19.1 years, age range = 16–49 years) with modal age (43%) of the participants being 18-years old, followed by 36% aged 19. A third were majoring in biomedical science, the prerequisite for selection into medicine. Biology majors were 14% of the volunteers. Other applied majors, making up 12% of the volunteers, included food science and medicinal chemistry. Participants identified their ethnicity as follows: about one-third New Zealand European (Pākehā); 4% NZ Māori; 16.9 % Chinese; 9% Korean; 10% Indian; 12.3% other Asian; 3.7% from the Pacific Island region; with smaller numbers from Australia, Britain, Europe, Africa and South America.

Procedures

After gaining ethical approval, students were approached by an independent person seeking their interest in participating in this project. Students gave signed consent for their data from completing MasteringBiology online activities for homework to be gathered and analysed. The data for the participating students’ use of MasteringBiology were extracted from the online system and merged with course summative achievement, demographic and university entrance qualification information.

Instruments

Hint usage. Data were obtained from MasteringBiology on hint usage for eight assignments. The first assignment (Topic Cell and Molecular Biology) did not elicit any hint usage, nor did the final assignment for biochemistry, due 1 week before the exam. Hence, a maximum of six assignments had hint-use data. The distribution of usage showed high kurtosis, meaning that most students had zero usage and a few had extremely low usage. Therefore, all cases that had used one or more hints were recorded as 1, while all participants who had no use of hints were recorded as 0. Table 3 shows that as the mid-term test approached, almost half of the research volunteers had used hints, with an average of about one-third in the first half-semester. In the second half-semester, only 15% of volunteers made any use of the hints.

Table 3
MasteringBiology Frequency of Hint Use

Online homework assignment	Frequency of volunteers using hints	Proportion of volunteers (%)
Pre-Mid-semester Test		*M* = 37
CMB 7 (Cell and Molecular biology)	207	23
Micro 3 (Microbiology)	267	29
Gen 1 (Genetics)	437	48
Gen 2 (Genetics)	437	48
Pre-Final Exam		*M* = 14
Biochem 4 (Biochemistry)	135	15
Biochem 6 (Biochemistry)	129	14

Academic performance. Student academic performance on the course mid-semester test and final examination was obtained from university records. Both the test (M = 62.19; SD = 16.10) and exam (M = 63.21; SD = 20.00) were scored out of 100 using multiple-choice and short written questions. Student prior achievement was derived from entrance qualifications recorded in the university database as a GPE. The GPE was converted to a numerical scale, where 0 represents an average of fail grades (D–, D and D+), and 1 is C–, increasing by 1 for each increment through to 9 = A+.

Data analysis

The data available in this study represent traces (Webb, Campbell, Schwartz, & Sechrest, 1966) left by system users as they interacted with MasteringBiology within the constraints of a high-stakes introductory course in biology. Thus, the data are uncontaminated by researcher effects since they are naturally occurring phenomena left behind by the learners' autonomous efforts to master biology. Since the use of hints was hypothesised to be a contributing factor to higher academic performance, causal analysis of data is appropriate (Wegener & Fabrigar, 2000). Causal modelling uses the statistical power of regression analysis to examine the strength of linear associations between constructs to determine the proportion of variance explained in a dependent variable by a set of predictor variables (Hoyle, 1995). Since the data occur chronologically, the structural modelling reflects the role time plays by linking the data in the

same time order. The quality of fit of the model to the data is used to determine whether the model is a satisfactory representation and simplification of the complex data relationships.

Confirmatory factor analysis (CFA) was used to determine whether the frequency of hint usage could be legitimately aggregated into a latent tendency to use hints within the two time periods (i.e., pre-mid-semester test and pre-final exam). Understandably, topics for which there was no usage were excluded from analysis. CFA allows determination of (a) whether the grouping of items into a latent factor has good fit to the data, (b) whether the path values from the latent trait to the contributing indicators are statistically significant, and (c) the scale of variance explained by the retained paths (Bandalos & Finney, 2010).

Structural equation modelling (SEM) extends CFA by testing the strength and nature of relationships among factors and manifest variables (Klem, 2000). The structural model was a longitudinal autoregressive model (Figure 5) making use of a bivariate (i.e., hint usage and academic proficiency) simplex model. Each measure (i.e., hint usage and academic proficiency) is a function of the conceptually identical measure immediately preceding it. To account for the possibility that hint usage and academic proficiency influenced each other, cross-lagging between constructs was introduced (Curran & Bollen, 2001).

Given that hint usage and academic proficiency scores were continuous scales, maximum likelihood estimation in Amos version 23 (IBM, 2013) was conducted. For both CFA and SEM modelling, consistent with current practice (Fan & Sivo, 2007; Marsh, Hau, & Wen, 2004), models with statistically non-significant χ^2 per *df*, comparative fit index (CFI) and gamma hat >.90, and root mean square errors of approximation (RMSEA) and standardised root mean residuals (SRMR) <.08 were considered sufficiently close to the data to not be rejected.

Results

Hint usage CFA

In the first half-semester, data were collected for five tasks. Of these, only three tasks either had tasks with hints or actual hint usage. These were Cell and Molecular Biology Task 7, Microbiology Task 3, and Genetics Task 1. Genetics Task 2 was not kept in the model because the material, as advised to students, was not assessed in the mid-semester test. This meant it would not be a valid predictor of the relevant hint usage in that time period. In the second half of the semester, only two tasks had actual hint usage (Biochemistry Task 4 and Biochemistry Task 6). This two-factor model of hint usage in the first and second halves of the semester had

good fit to the data (χ^2 = 11.95; *df* = 4; χ^2/df = 2.99, *p* = .08; CFI = .93; gamma hat = .98; RMSEA = .064; SRMR = .024).

Structural model: Hint usage and achievement

The results (Figure 5) had good fit to the data (χ^2 = 76.34; *df* = 16; χ^2/df = 4.77, *p* = .03; CFI = .98; gamma hat = .99; RMSEA = .064; SRMR = .028). The path values indicated strong support for H_1 (prior achievement predicts subsequent achievement); GPE strongly predicted mid-semester test performance (β = .64); and mid-semester test performance strongly predicted exam performance (β = .80). Partial support was found for H_2 (weaker students use hints), in that the path from GPE to Hints 1 was moderately negative (β = –.34), but was zero from mid-semester test to Hints 2. Reasonably strong support was found for H_3 (initial use of hints predicts continued use) since the path from Hints 1 to Hints 2 was β = .65.

Finally, partial but weak support for H_4 (hint usage would positively contribute to course achievement) was found in positive path from Hint 2 to exam score (β = .12), but this was contradicted by the negative path from Hint 1 to mid-semester test score (β = –.17). The additional cross-lagged path from Hint 1 to final exam was also negative (β = –.10), further contradicting H_4. The total indirect effect of Hint 1 to final exam score was small and negative (β = –.06). The negative direct and indirect effect of Hint 1 on the final exam score may reflect the fact that the material studied in the first half of the course is not tested directly in the final exam. Nonetheless, use of hints in the first half predicted hint use in the second half of the course, and such usage did contribute, albeit in a small way, to final exam score.

Sex and ethnicity were introduced into the model as predictors of hint usage. However, neither was statistically significant, and so differences according to these demographic factors were not pursued further.

The total variance explained in the exam performance was R^2 = .665. The mid-semester test score was the strongest contributor (β = .80; R^2 = .64). Thus, the combined effect of hint usage at time 1 and time 2 was no more than 2.50%. The direct effect of Hint 2 usage to academic achievement was very small (β = .12; R^2 = .014). Nonetheless, its contribution indicates that prolonged hint usage can help weaker students.

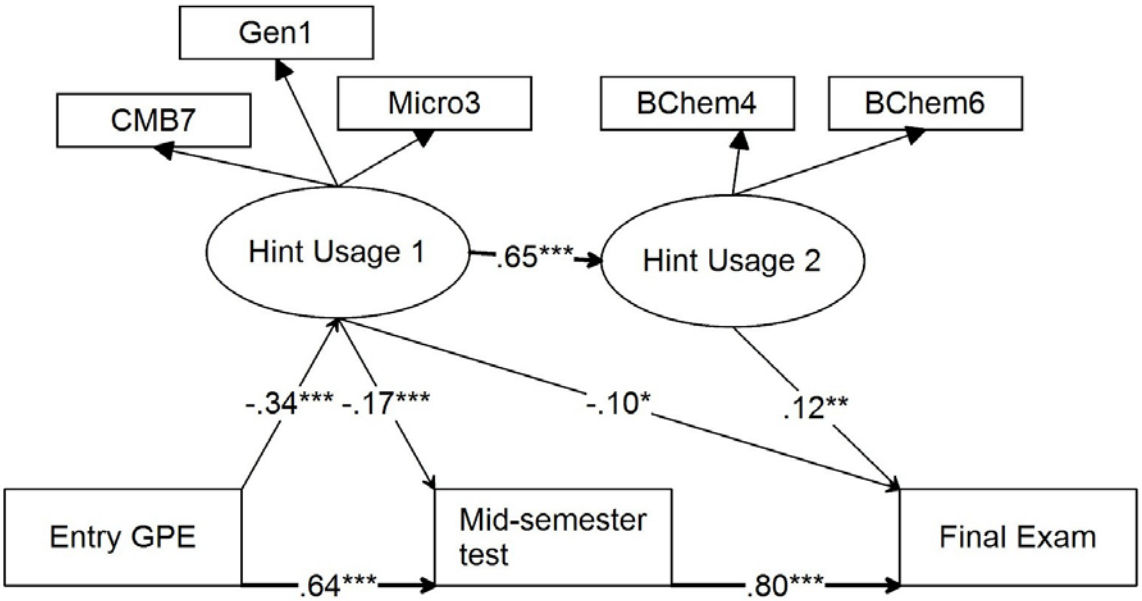

Figure 5. Schematic representation of relationships between hint usage and academic performance in mid-semester test and final exam.

Note. All values are standardised regression weights.

Chapter summary

To summarise the results, academically weaker students at the start of the course tended to use hints more, and this usage gave a small pay-off for achievement only if students persisted in usage across the course. Usage fell considerably after the mid-semester test, but persistence did eventually contribute a small positive amount to better performance. Understanding whether students engage with opportunities to receive feedback is an important factor in designing learning tools and assessment practices in higher education. As a first step in this process, Phase 1 investigated whether students engage with formative assessments and feedback when opportunities are available to them in a self-managing online system. The findings suggest that weaker students tended to make some use, and that considerable effort was needed before a positive contribution to performance could be seen. These findings raise questions about why so few students used the feedback in the system and why it took so much usage to see a beneficial contribution to results. It would be helpful to know why those who fully used the system did so, and how, in the students' opinions, such a system might better serve their learning needs. As it is critical to gauge the effectiveness of the assessment tasks in terms of students' learning approach (Sadler, 2015), the next chapter reports on the findings from the focus groups discussions where students' understanding of the MasteringBiology system was investigated by checking with the students themselves.

Chapter 6
Tertiary students' perceptions on feedback use in an online system

Introduction

In the first phase of this research, quantitative methods were used to investigate four hypotheses about students' behaviour in an online system, MasteringBiology, where activities and tasks were provided to support learning in a low-stakes, self-directed context. The Chapter 5 findings were derived from data generated directly from student interactions with the MasteringBiology system while in the first year of their undergraduate learning experience. As described earlier in Chapter 4, this system delivered content using a tutorial approach, consistent with good feedback principles by providing learning activities which the students were able to complete to check their progress toward the expected level of achievement and understanding. Feedback about success or failure, on task completion, included information confirming content or how to proceed where a student had completed incorrectly. There were opportunities for students to seek further help via hints, which were self-directed and without penalty. Not all students engaged in seeking help (provided as hints). Data analyses indicated that for the students who did seek help there was a small gain in achievement.

However, the empirical research on students' use of the MasteringBiology reported in Chapter 5 was not designed to consider other variables that are also part of the learning context. Therefore, insights into the students' use of feedback during their undergraduate biology course using the online system were investigated from qualitative data generated during focus group discussions. Hence, it was possible to also investigate the context, which may have influenced engagement with the MasteringBiology system, and students' understanding of their feedback experiences. This is because:

> Human behaviour, unlike that of physical objects, cannot be understood without reference to the meanings and purposes attached by human actors to their activities. Qualitative data, it is asserted, can provide rich insight into human behaviour. (Guba & Lincoln, 1994, p. 106)

Thus, within the interpretive paradigm, students' accounts provided a more extensive representation of events from their perspectives and notions of understanding, meaning and action.

In Phase 2, focus group discussions were conducted to investigate students' perceptions of feedback use in an online system. Participants were recruited from the Phase 1 sample pool. The focus group discussions occurred when this cohort of students had completed a further 2 years of undergraduate study. The methods, sampling procedures and process for conducting the focus groups are described in this chapter followed by the findings from the students' discussion and explanations about their experiences with feedback in the online system. These findings are organised to highlight the similarities among students in regard to their discussions about their interactions and experiences in using the online system MasteringBiology, as part of their first-year biology course and, secondly, to underscore the differences.

Phase 2 methods

Phase 2 addressed the research question "*What do students understand about feedback in terms of sources, utility and support for learning*?" and, as such, was underpinned by the interpretive paradigm where the central endeavour is to understand the subjective world of human experience (Cohen et al., 2007). Cohen et al. (2007) explain the different conceptions of theory which are relevant to this research. From the positivist viewpoint, behaviour is about responses to environmental stimuli that are effectively in the past, such as the demands of the course or the need to achieve, and the research intention is to lead to general theories of human behaviour. Whereas, interpretive approaches focus on intentional behaviour and are future oriented. Rather than test hypotheses, under the interpretive viewpoint, theory is emergent or generated and follows after the research has been done (Cohen et al., 2007). As the research arises from particular situations that give rise to multifaceted images of human behaviour then context is heavily implicated in meaning (Lincoln & Guba, 1985).

Focus groups

While there are many different qualitative methods for gathering data, I selected focus groups as the most suited to the research aims to bring insight into students' perceptions and experiences about using online systems and using feedback in their learning processes.

> Mixed methods approaches have used focus groups following the quantitative phase of research to illuminate results, that is, to transform these into "findings" by furnishing explanations, particularly with regard to surprising associations identified in the first part of the study. (Barbour, 2007)

In his review of the use of focus groups, Morgan (1996) noted a resumed interest in focus groups as a method for qualitative research in the social sciences during the 1980s. As quantitative studies were often based on imperfect assumptions about people or reality in

general, the potential for focus groups was recognised as a way to provide an environment where participants can be encouraged to share perceptions and points of view without the pressure of reaching consensus (Krueger & Casey, 2014).

Originally, focus group research was conducted using nondirective interviewing techniques in groups. This approach was developed for gathering information efficiently, such as the classic work of Robert Merton and Patricia Kendall (1946) to explore morale in the U.S. military for the War Department. Currently, focus groups are used in diverse fields such as social science research, health, evaluation and in education in conjunction with other methods. Underpinning focus group processes is the opportunity for people to explore and clarify their views that may be less accessible by other methods such as interviews (Kitzinger, 2007). Moreover, the focus group forum allows participants to explore issues according to their priorities, using their own vocabulary and generating their own questions. Smithson (2000) cautions that focus groups are not natural discussions but are discussions occurring in a specific controlled setting (Smithson, 2000). Through focus groups, it is possible to gain insight into beliefs and attitudes that underlie behaviours, as participants consider experiences and the reasoning behind their actions, beliefs, perceptions and attitudes. For this research, participants were encouraged to provide insights about their help-seeking behaviour (as feedback in formative assessments) and the relevance to their achievement.

Strengths and weaknesses of focus groups

Focus groups are flexible in that multiple ideas can be explored by a variety of individuals to provide data relatively efficiently. With an open response format, focus groups allow the researcher to interact directly with the participants, enabling opportunities for clarification and further probing of responses to obtain deeper levels of meaning (Stewart, Shamdasani, & Rook, 2007). Focus groups have a synergistic effect where participants can build on or respond to each other's comments. Differences in views can allow some participants to embrace or reject particular ideas, and for further exploration. The interactional nature of a group brings both strengths and weaknesses to the process. Group interactions allow the collection of rich and diverse experiential information (Kitzinger, 2007; Morgan & Spanish, 1984). The data is real for the group, as participants are responding to each other's comments, and are an accurate representation of the perceptions of reality for that group. However, the richness of group data is influenced by the group dynamic and as an integral element is not able to be disconnected (Carey, 1995). As such, focus group discussions are shaped by multiple social contexts, that is the relationships among the participants and between the participants and the moderator

(Hollander, 2004). Hollander (2004) considers that these contexts affect the data that is generated, demonstrated by focus group discussions with men about the impact of violence in their lives. Hollander found the propensity of men to discuss their true feelings was mitigated by their fear of appearing "unmanly" in front of other men. Censoring and conforming behaviours can occur in groups as people adjust their behaviours in response to their impressions of others as well as their personal background (Carey & Smith, 1994; Krueger, 1995). The group dynamic develops from interaction of the participants as the group creates its own social reality based on their internal thinking processes and responses to conversations as participants listen to each other and observe nonverbal signals such as body language. This can lead to the emergence of socially acceptable opinions (Smithson, 2000) as participants may modify their comments. Due to the perceived expectations of others, comments can be withheld, particularly where there is a lack of trust or a concern about confidentiality (Hollander, 2004). The silence of some participants or disregard for some views can potentially lead to a dominant voice (Smithson, 2000; Stewart et al., 2007). A dominant voice is where the opinion of one or more group member(s) becomes the only viewpoint clearly articulated in the discussion and a dissenting voice may be unheard (Smithson, 2000). A technique for managing this is homogeneity of groups with respect to age, gender, experience and education. In this research, each group was advised of the group characteristics during the introductory information. Apart from their common experience of being undergraduate students and participants in the research during the first-year course, the students were informed their grouping was based on their use of hints in the MasteringBiology system. Where participants do not contribute to the discussion spontaneously, another technique available to the moderator is to encourage participants to speak.

In some contexts, the group dynamic can facilitate the discussion around difficult topics by the less inhibited participants leading and building confidence or providing mutual support for other participants to contribute (Kitzinger, 2007). Group discussions can also generate more critical and negative comments than other methods such as interviews (Watts & Ebbutt, 1987). The extent to which participants feel comfortable to express their views impacts on the usefulness and validity of the data collected (Stewart et al., 2007). Participants may use the groups in ways not anticipated by the researcher (Smithson, 2000), although this can be mitigated by careful discussion design to obtain perceptions on a defined topic (Krueger, 1988).

Sampling frame and selecting the participants for Phase 2 focus groups

The participants in Phase 2 were recruited purposively from the original sample pool of students in Phase 1, who had given permission for research access to the data generated by their use of MasteringBiology. Purposive sampling is used when the characteristics of the target population are known and then specific individuals are sought based on characteristics relevant to the research (Hibberts et al., 2012; Neuman, 2006). In this study, the characteristics important to the sampling in Phase 2 were identified from the results of Phase 1. The Phase 2 sample was a nonprobability sample where some members of the original population would be excluded and others included (Cohen et al., 2007). In this research, participants were selected based on the characteristics of achievement level and help seeking (see Table 4). As the sampling method relied on students considering and agreeing to further their involvement in the research, then not every member of the original Phase 1 sample had an equal chance of being included in the Phase 2 sample. Given the relatively large sample from Phase 1, a maximum variation sampling strategy was used to ensure the different achievement levels were captured. This was combined with stratified purposive sampling by including students who use or do not use feedback from the hints in the online system, either before or after task completion, i.e., help seekers. I established a sampling frame based on the identification factors of "hint use" and "summative achievement" to represent the sub-populations that were of interest to the research question into use of feedback in online systems within the course and in other learning contexts.

Table 4
Sample Pool and Parameters for Purposive Sampling

Group #	Size of population available for sampling	Hint use /achievement	Help-seeking actions per activity	Achievement %	Grade range
1	68	Low/low	0	0–59	D– to C+
2	168	low/high	0	70–100	B to A+
3	190	high/low	1 to 3	0–59	D– to C+
4	90	high/high	1 to 3	70–100	B to A+

The students were emailed and invited to take part in focus group discussions with their peers. As can be seen in Appendix A the invitation indicated the purpose of the focus groups was to discuss their perceptions about the use of the online system and their experiences about the use

feedback in their undergraduate studies. Participants were each offered a $20 Westfield voucher as a koha (gift) for participating. Monetary incentives can increase the response rate due to the principle of reciprocation where a sense of obligation is created to potential respondents (Toepoel, 2012). Participating in Phase 2 also required students to contribute their own time, so relying on altruistic behaviour of respondents may have been impacted by perceived inconvenience. However, some respondents demonstrated they had a strong interest in participating, supporting the notion that leverage theory can also increase response rates (Albaum & Smith, 2012).

Four groups were designed based on two-way combinations of the identifying factors: non-use of hints and low achieving (NUH/LA), non-use of hints and high achieving (NUH/HA), use of hints and low achieving (UH/LA), and use of hints and high achieving (UH/HA). In focus group design, there should be enough diversity within groups to stimulate discussion (Barbour, 2005); however, the scope of diversity among participants for this phase of the research was limited as I was dependent on the willingness of first population of participants to self-select into the second phase. Table 5 summarises the demographic information for Phase 2 participants. Homogeneity between groups is also an important consideration to afford comparisons during data analysis (Barbour, 2005). To facilitate drawing out similarities and differences in experiences and opinions of participants, pairings of groups enabled comparative analysis where each pair of groups was homogenous for one factor and heterogeneous for the other.

Table 5
Demographic Information: Phase 2 Participants

	Group			
	1	2	3	4
Number of students attended	4/6 (6 confirmed, 4 of these attended session)	4/6 (6 confirmed, 4 of these attended session)	4/6 (6 confirmed, 4 of these attended session)	7/6 (student from Group 2 turned up unexpectedly)
Type of group	Low hint use/low achievement	Low hint use/ high achievement	High hint use/low achievement	High hint use/ high achievement
Gender	F; F; M; M	F; F; F; M	F; F; M; M	F; F; M; M; M; M; M; M
Ethnicity	Tongan; Māori; Māori; Dutch	NZ/Pākehā; Indian; Chinese; NZ/Pākehā	Other European; Chinese; Māori; Other Asian	Other European; NZ/Pākehā; NZ/Pākehā; Middle Eastern; NZ/Pākehā; Other Asian; Other European
Achievement in first-year biology course	D+; C+; D+; C+	A; A–; A–; A	C-; D; C–; C+	A–; A–; A–; A–; A; B+; A–
Programme in first semester at university	Science; BSc/BCom; Biology; Food Science	Biomedical Sci Science; Biomedical Sci Biology;	Biology; Psychology; Biology; Chemistry	Biomedical Sci; Biomedical Sci; Engineering; Biomedical Sci; BA/BSc; Biomedical Sci; Biomedical Sci

Note. Pākehā is a Māori-language term for New Zealanders of European descent.

Piloting the focus groups sessions

A trial was undertaken prior to data collection to test out the logistics of collecting data and to determine if any changes were required to the proposed focus group session plan. A group of three students from a foundation programme generously gave their time to participate in the session and then provide feedback about their experience. All students had experience using the MasteringBiology system. A change was made to the stimulus material in the first part of the session. Originally it was intended to show each student a record of their own interaction with the system, in particular if they had used hints. The students considered this to be

confronting and preferred this to be anonymous. The stimulus material was changed to be representative of how each group interacted with the system. The data generated from this session was not analysed.

Conducting the focus groups

The focus groups were conducted at a time that was the most convenient for the participants. The research setting for conducting the focus groups was selected on the basis of availability, familiarity and ease of access by participants who already had established transport routines to this location. The location was on the main campus of the university where the study took place, in a seminar room that also contains many biological museum exhibits familiar to the students. Most students were in their third year of study and, as biology students, were used to the room and displays. The room was relatively large, designed to accommodate three times the number of participants, and seating was arranged around one large table so that participants could view each other unimpeded, to encourage interpersonal interaction. The circular arrangement was intended to reduce the likelihood of one participant dominating the discussion. Participants' views were directed away from the room displays, as the room was not "non-descript" as recommended by Stewart et al. (2007), in order to minimise distractions (Stewart et al., 2007). Influence of location on the discussion was intended to be minimised by student familiarity and sense of comfort with this room as it is not possible to find a neutral or ideal location for all participants (Barbour, 2007).

Sessions were 60 to 80 minutes duration. Groups 1, 2 and 3 were 60 minutes but Group 4, which had seven participants, continued for an additional 20 minutes with the agreement of the participants. Students had read and signed a participant information sheet on the rationale of the study prior to beginning the session. Although protection of identity could not be provided within the group, it was maintained as part of presentation of results. Confidentiality, including their responsibility for non-disclosure, was discussed with the participants and I reminded the students that the session was recorded. I indicated to students they could request at any time that recording be stopped if they wanted to say something that was not to be recorded and used in the data analysis.

Initial introductions between the students were handled informally and they were given time to chat before the session was started. Once the session began, students introduced themselves to the group in order to provide an opportunity to be identified by voice for transcribing and analysis. The overall plan developed for the focus group sessions is in Appendix B.

Facilitator/moderator

For this part of the study, my role changed from research practitioner to facilitator. In this research, as the moderator, it is likely I affected the participants as a Pākehā woman, one generation earlier than the participants. There was also a historical relationship as I was their course coordinator 2 years prior, so residual power differences between me and the participants could not be completely eliminated; although, as I was no longer involved in their learning and assessment, at the time the focus groups were conducted, this relationship had changed. Due to the numbers involved in focus group interactions, the participants had more control over the conversation than in a one-to-one interview (Belzile & Öberg, 2012). As the participants were each coming from a different position in learning and experiences, collectively the group had their own knowledge which I did not know about.

Group interaction is considered a distinct difference in focus group research compared to other methods such as interviews. Examples of interactions include direct and subtle challenges to opinions, and dominant voices.

Focus group session activities

In this research, the focus group sessions were conducted in two parts, defined by different activities for focus in the discussion. As there was a significant time lapse since the students had used the online feedback system, memory lapse was a concern. For this reason, focus groups included the technique of stimulated recall. Students were encouraged to re-engage with the system as part of the focus group discussion in order to draw out their commentary regarding their actions and beliefs. Stimulated recall has been used in research into teaching and assessment (Tjeerdsma, 1997; Torrance & Pryor, 2001) in order to encourage teachers and students to relive an episode of learning by providing an account of how they think about their learning. In the second part of each session, students separately completed a diamond ranking activity, as part of the design to allow students time to crystallise their ideas and attitudes about the feedback statements which reflected the theoretical framework.

Stimulated recall activity design for focus group sessions

Visual stimuli and/or other activities may be used to provide a basis for discussion in a focus group session. The first activity involved viewing stimulus material. As 2 years had lapsed since the participants had used the online system in the first-year biology course, the printed stimulus material showed the participants an example of a task from MasteringBiology. The students were each given a printed handout of a task as it would appear on the computer screen. The task was one of many used during the time the students were enrolled in the course. The

students were shown the multiple sources of information associated with the task as feed forward in the format of text, diagrams and videos. I anticipated discussion among the students would stimulate recall of the system and provide a reference point for later discussions. The students were then given a second set of the same material but as it would appear in the system with the hints (feedback) opened up, as can be seen in Appendix C.

Data analysis

Bazeley (2009) suggested that qualitative analysis involves a close engagement with the data and the illumination of meaning and significance. In the analysis of focus group data, Barbour (2007) stated that there is no "one-size-fits-all" and there are potential benefits to being open to a range of strategies (Barbour, 2007). She said that the approach to analysis is "largely determined by the overarching aims of the research and the format and structure of the original focus group discussion" (p. 313). Inductive analysis is an approach that uses detailed readings of raw data to derive concepts or themes through interpretations made by the researcher (Thomas, 2006). Inductive thematic analysis was used in this thesis "because it works with a wide range of research questions, from those about people's experiences or understandings to … particular phenomena in particular contexts" (Clarke & Braun, 2013, p. 120). Thematic analysis in this study was an essentialist or realist method, which reported experience, meanings and the reality of the participants (Braun & Clarke, 2006), as a rich and detailed account of the data by identifying, analysing and reporting patterns (themes). The process of coding the data did not try to fit it to a pre-existing coding frame or the researcher's preconceptions. However, as it is not possible to be free of assumptions about the nature of the data, the analysis likely made some theoretical assumptions in relation to the "reality" of the participants (Braun & Clarke, 2006).

Analysing the focus groups

A theme captures something important about the data in relation to the research question (Braun & Clarke, 2006). In my practitioner context, relatively little was known about students' perceptions of feedback use, both online and in general, so it was my intention to provide a rich thematic description of students' perceptions. This required the identification and coding of themes across the entire data set. While themes are represented by patterns across the data, the prevalence of a particular theme was not critical to its inclusion in the analysis. Some researchers suggest it is helpful to know how often each code appears in the data (Huberman & Miles, 1994); however, others consider this conveys a quantitative orientation that is contrary to qualitative research (Creswell, 1998). Inductive analysis themes are connected to the data

themselves so, in the process of coding, a pre-existing code frame was not used. In the focus groups, data was collected after students used stimulus material to think about previous feedback experiences and then they when had participated in a diamond ranking activity. As part of their discussion with other group members, their responses to this material may have influenced the meaning in their comments. Thematic analysis was carried out manually according to the phases recommended by Braun and Clarke (2013).

Coding facilitates new connections and alternative ways of framing and interpreting a situation and is essentially a recursive process that builds understanding (Bazeley, 2009; Thomas, 2006). The data from the audio-recorded focus groups was transcribed by an independent person into written format. As transcription is recognised as an interpretative act where meanings are created (Lapadat & Lindsay, 1999), I familiarised myself with the data by listening to the recordings. All the transcripts were checked back against the original audio recordings for accuracy and were "verbatim" accounts of all verbal with some nonverbal expressions. An initial list of ideas in the data was generated from each focus group transcript and, from this, the initial codes were identified. Coding was done by working systematically through the entire data set for as many potential patterns or themes as possible. Two main approaches to coding are possible in pattern-based forms of qualitative analysis. Selective coding identifies "instances" of phenomenon the researcher is interested in (Braun & Clarke, 2013), which is essentially an analytical process. In this thesis study, a complete coding process was used where anything and everything of interest was identified. The codes were then collated and re-focused to develop broader themes. Many codes had links or relationships with other codes. Links are based on commonalities in meanings between codes or causal relationships (Thomas, 2006). An example of a visual representation of this sorting process is given in Appendix D. Relationships between codes and between themes were then considered in order to form main themes and subthemes. Refinement and review of these themes was done to ensure there was coherence in the data within themes and that the themes were distinct from one another (Braun & Clarke, 2013). Braun and Clarke (2006) outlined a number of potential issues in using thematic analysis, as it is important to make sense of the data and go beyond the content to indicate what it might mean.

In the initial coding, approximately 50 codes were identified that occurred in more than one focus group. Where there were relationships or links between codes, I used these to develop emergent themes and subthemes; some related to technology as feedback (five themes), and other themes related to multidimensionality in feedback use, that is how students receive and use feedback and the contextual aspects in which this occurs. Part of the focus group data

analysis involved identifying areas of agreement or similarity and controversy or differences, to better understand how perspectives arise (Carey & Smith, 1994). The participants in each group related to their peers based on shared experiences of undergraduate courses, in particular their first-year biology course experience. Group membership was determined by achievement levels and tendency to seek help. Each group was informed whether they shared the attribute for help seeking or not, hence providing a further common frame of reference. This implied a group perspective during discussion. The group data were analysed in terms of their multiple viewpoints about using technology as feedback, and then following a diamond ranking activity. The emergent themes were used to explore similarities and differences between groups based on achievement and the propensity for seeking help during feedback use. These emergent themes are reported in the findings of this and the next chapter.

Ethical considerations

Creswell (1998) noted that regardless of the approach to qualitative inquiry, many ethical issues need to be considered such as recruiting participants, data collection and the analysis and dissemination of reports. As this research was conducted in real-world circumstances, in the context of the researcher's workplace, attention to ethical considerations in the conduct of the research was paramount. "Taking one's own professional work as the site for research also disrupts many conventional norms regarding the ethics of educational research" (Cochran-Smith & Lytle, 2009, p. 101).

In order to maintain the overall integrity, quality and trustworthiness of the proposed research the following ethical issues were addressed in the research-planning process and managed accordingly.

Informed consent

Ethics approval was sought and received from the University of Auckland Human Participants Ethics Committee to conduct every aspect of this study. It is critical to make sure that the relevant persons, departments and faculties have been consulted, and that the principles guiding the work are accepted in advance by all. Site access was negotiated with the Director of the School of Biological Sciences. All participants were fully informed about all the relevant issues in a participant information sheet (Appendix E) and before providing their written consent. In each phase of the research, consent to participate was gained through a signed consent form.

As the metadata used in this research was associated with required coursework as part of a first-year biology course, the students were approached by an independent person, not involved with the course, seeking their interest to participate in this project. The independent

person was available to answer questions about the proposed study to enable an informed decision about participation to be made. Assumed neutrality and impartiality of the researcher is one of the goals of educational research, as is the freedom from coercion for the human subjects who are participants (Cochran-Smith & Lytle, 2009). If a student did not want their data included in the analysis, they could withdraw from the research up to 1 month after signing the consent form. No students withdrew their data. The students were aware their data was archived and analysis carried out after the completion of the course, ensuring their participation had had no impact on any assessments or grades.

Anonymity and confidentiality

All data relating to participants was coded, by assigning numbers to individuals, so as to retain privacy and confidentiality. The coding was done by a third party before any analysis was undertaken. The person undertaking coding signed a confidentiality agreement (Appendix E). Further, Phase 1 data was not accessed for analysis until after the coursework and grading were completed. Because the data was coded, the researcher did not know who participants were during the purposive sampling of participants for Phase 2 of the research. At this stage, an independent person identified the students from the code to invite them to sign a release from anonymity and participate in the focus group sessions. At this point the researcher could identify focus group participants who had agreed to participate. Pseudonyms were used to ensure that students cannot be identified in any way in any reports, publications or presentations resulting from this research.

Minimisation of risk

The potential risks that participating students may have perceived included emotional stress, embarrassment, threat to self-image and judgements of performance. As the researcher was also the coordinator of the first-year biology course, students may have felt pressured to participate. To avoid this situation during Phase 1, access to data was delayed until after the coursework and grading was completed. Students were advised about this before consenting to participate, in order to address any perceived power differential within the project. Because the data collected was from an online system it was not connected directly to any persons involved in the course. As such, the voluntary participants were informed about the research procedures in advance, while their identity was safeguarded.

As the researcher and the moderator for the focus groups, I was aware that my persona and position could have an impact on the data elicited in the focus groups. At the time the focus groups were conducted, I was in my role as a teaching staff member, although I had not been

involved with any of the students in a teaching capacity for 2 years. However, as the coordinator of the first-year course the students were discussing in each group, for the purpose of discussion I was familiar with tacit knowledge and organisational aspects the students had experienced while enrolled in the course.

Trustworthiness

In my role as a practitioner, I have diverse responsibilities coordinating a large first-year biology course that includes designing curriculum and assessment, and teaching smaller groups within the course. An important part of this role includes pastoral care of students, where many conversations give me an insider's perspective of what it means to be learning in a mass education model. It is this perspective that I bring to this thesis study, as a researcher. M. J. Greene (2014) suggested that "'insider research' is that which is conducted within a social group, organisation or culture of which the researcher is also a member" (p. 1). Merton (1972) stated that the insider possesses intimate knowledge of the community and its members. As the research site is within a university, my knowledge extends beyond the course, to my school and faculty systems and processes involved in teaching and learning, as well as the wider university support structures available to students. My knowledge and experience within the institution certainly influenced the project's planning and preparation, organisation, analyses and reporting of results. Koch (2006) discussed how practitioner researchers approach their work with pre-existing understanding that contributes to the construction of the research design and context by fusing all sources of data. Further, she suggested credibility of a study is enhanced when researchers have self-awareness of their experience as a researcher and maintain notes that can be used for reflection.

Evidence suggests that teachers build their professional expertise by becoming researchers of their own practice (Cochran-Smith & Lytle, 2009). In carrying out studies, teachers' motivations are related to ensuring the learning needs of students are met and using the evidence, where appropriate, to transform teaching practice. In the evaluation of qualitative research, establishing validity and trustworthiness is important, whether it is intended to produce new knowledge or transform practice. Creswell and Miller (2000), in discussing the notion of validity, suggested qualitative inquirers engage in one or more common procedures such as member checking, triangulation, thick description, peer reviews and external audits. Cochran-Smith and Lytle (2009) states that "an important feature shared by many forms of practitioner inquiry is that notions of validity and generalisability are quite different from the traditional criteria" (p. 43). From Mishler (1990), they asserted that validity rests on concrete

examples that the relevant community can judge for trustworthiness and usefulness. A procedure for establishing validity is thick rich description in which participants and themes are described in rich detail (Elo et al., 2014). Braun and Clarke (2013) defined 'thick descriptions" as detailed and complex accounts for each participant. The purpose of this procedure is to create verisimilitude, where the readers feel they could experience the setting or situation (Creswell & Miller, 2000). This procedure is appropriate where other practitioners may also want to consider whether the findings support transformation in their setting.

For focus group research, Elo et al. (2014) stated that it is important to scrutinise the trustworthiness of every phase of the analysis process including preparation, organisation and reporting of results. Focus groups are social contexts that involve discussions between a number of participants in which they construct their own reality and truth through dialogue (Kvale & Brinkman, 2009). As such, participants may modify statements based on discussion processes, raising concerns about the trustworthiness of findings (Kidd & Parshall, 2000). In this thesis study, during discussions, participants had a "quiet time" to distil their own ideas before sharing and discussing. A debrief process, at the end of each session, was used to determine if participants felt the need to change their perspectives during or after the discussion. Chioncel, Van Der Veen, Wildemeersch, and Jarvis (2003) noted that for focus groups, applying concepts of validity and reliability rests in the realistic tradition and requires features such as documentation of procedure for replicability and clear time schedule to ensure attention to all questions. Participants' competence to answer a range of questions is also important for validity (Chioncel et al., 2003).

In this study, data from the quasi-experimental approach in Phase 1, and students' ranking of feedback, facilitated triangulation, in terms of students' real and reported feedback use. Other tools included researcher notes to support self-awareness during the stages of analysis and peer review. After each focus group, during a de-briefing session, participants were able to provide responses and thoughts about their experience. Finally, thick rich description took into account reflections of both researcher and participants, enabling the relevant community to judge trustworthiness and usefulness. However, transferability is dependent on the degree of similarity between the context of this research to other contexts (Guba & Lincoln, 1989).

Findings: Students perceptions on the use of the online feedback system

Seven themes emerged from the four focus group discussions about their use of the online system. One theme was common for all students: the belief that online systems have positive

aspects for informing learning. All students in all groups agreed with this common theme. A number of themes emerged that drew attention to the differences among students, namely the belief that it is strategic to not seek help or feedback in the online system. Two subthemes about system interaction emerged, firstly those students who were just-in-time obligatory and minimal users and those who maximised efficiencies in using feedback systems while maximising their achievement.

The analysis of the discussion among the system-hint users also revealed that there is a willingness and openness to fully engage with the online system. Further themes about system interaction emerged, namely the paradox where there is awareness of the value of help seeking but being reluctant to fully use online systems and, finally, being amenable to using online systems extensively with a view to long-term benefits.

Some students made brief comments about this, but others gave more detailed descriptions and explanations. However, an array of actions and strategies in the use of online systems underscored differences derived from students' individual interpretations.

Online systems support learning

While all students in all groups were positive about the online system supporting their learning, there was variation in the aspects of online systems that led to these positive views. The course design required students to access and complete online activities for homework blended into the course structure; however, the low-achieving students needed to be confident the system was relevant to their first-year biology course and of a reasonable quality, if they were to make a time commitment. The students had confidence in the system as they believed it was endorsed by teaching staff who provided the customised activities as part of coursework. This external validation and reassurance was critical for these low-achieving students, as they were not sure of their own ability to appraise the quality of the system for a first-year biology course:

> *I think also because it was organised by the university, I knew that those animations will give a level of details that we needed, the details in the tests and exams rather than some new video* (Focus Group 1, NUH/LA)

Other low-achieving students were more confident of their evaluation of the system and showed surety in their appraisal that the animations made it easier for them to learn the course material from lectures:

> *I liked the animation and the introduction because it covered what you learned in class and that was helpful – I liked that part.* (Focus Group 3, UH/LA)

And also, with the animation, you can get a visual representation which helps you to work easier – I really like using that. (Focus Group 3, UH/LA)

The students believed the animation format helped them to review content from lectures efficiently and enabled them to complete the tasks. The students had less inclination to use other formats such as text books that required time sorting the relevant content:

I'd rather get this than a lot of readings – a lot of words and pages that would kind of put me off a bit. (Focus Group 3, UH/LA)

I think they are kind of visual which is how I learn the best. And how it stimulates my brain and the diagram that explain a little bit which help me like okay it makes sense, I can choose based on what I see to answer. (Focus Group 3, UH/LA)

The high-achieving students who did not seek help were keen users of the MasteringBiology system as they recognised it provided alternative support for learning in constructive ways that were easily accessible given the large number of students in their class. These students considered the video and animation format provided a different perspective for learning from the lecture experience:

I remember them [animations] being really helpful like they were really good animations to help to explain the content. (Focus Group 2, NUH/HA)

The students also believed the associated activities allowed them to interact with course material after the lecture in a structured and guided way:

I like MasteringBio… it actually gives you a chance to get your hands dirty and actually get the material yourself rather than just sitting there listening. (Focus Group 2, NUH/HA)

Here the students considered they could add value to their understanding and learning by doing online work outside structured course time, which they perceived as more active involvement than the lecture experience in their first year at university.

The high-achieving and help-seeker students were complimentary about the quality of the online system, and expressed how the system supported them to improve their understanding and learning:

I thought the videos were awesome like they really helping me just watching the videos will be able to usually make you answer all the questions pretty easy, so I found that useful and interesting. (Focus Group 4, UH/HA)

Overall, the students' positive views about using online systems were determined from different needs and expectations as learners, as they transitioned into a traditional lecture approach to learning. In this new context, opportunities for interaction with teaching staff were noticeably reduced when compared to their previous education experiences.

Not seeking help ("feed forward") in the online system is strategic

The participants in Focus Groups 1 and 2 were the students who did not use the hints in the online MasteringBiology system and they are referred to as the non-help seekers. While the students were similar with respect to not seeking help via the hints, their reasons for not using the information more extensively were different. These students, irrespective of their achievement level in the first-year biology course, did not access further feedback information (hints) that provided an opportunity for students to develop their tacit knowledge from online information. Where students were unable to correctly complete activities, the information behind the hints allowed for deeper learning by providing guidance to the key aspects of knowledge and processes essential for problem solving and successful completion of the activity. Although both Focus Groups 1 and 2 had positive comments about the system, there were differences in their perceptions about the benefits to online learning and reasons for not accessing and using the feedback in the MasteringBiology system. The low-achieving students had less enthusiasm for the system and disliked the time taken, but were motivated to keep using it as marks were awarded for participation as part of the course assessment. The system was seen as an obligation rather than a productive learning environment. The students' minimal engagement approach influenced to their reluctance to seek help to support deeper learning. The high-achieving students were strategic non-users of hint information who recognised the benefits of the online system but made calculated decisions about the level of engagement with the system, as part of efficient use of their time while believing they were gaining as many benefits as possible in their learning.

Using the online system is an obligation

The students who were reluctant users and gave minimal effort in the online system were also among the low achievers in the first-year biology course. Their effort did not extend to the use of the feedback information in the hint system, i.e., they did not seek help in the online system. Although they saw merit in the online system, the students in this group used the MasteringBiology system because it was coupled with gaining coursework marks. The students were clear that without the requirement of activity completion as part of grading, they would not have done any independent coursework on a regular basis. The effort the students gave for

task completion was driven by reward rather than the identification and attainment of goals in learning:

> *As long as you do it, you get [a] mark for it, so why wouldn't you?* (Focus Group 1, NUH/LA)

Given the incentive to gain marks based on participation and successful completion, the students also strategised by spending the time necessary in the system until the questions were correct:

> *It meant that I had one quick run through to see how quickly I can get [it] and if I got some wrong… I have to stick around longer.* (Focus Group 1, NUH/LA)

The students preferred time on task to be kept to a minimum. Their strategy of minimal engagement in using the system precluded them accessing potential benefits of more detailed feedback available in the system's hints. The students' attention to the activity tasks appeared to be out of a sense of obligation as a completion requirement and less about the value of the assessment for learning key concepts and content:

> *I know that I did not engage with this. I did it because we had to do it and I just want to get it out of the way and do pretty well because this is hard and I didn't understand it.* (Focus Group 1, NUH/LA)

> *I didn't want to do this. So it just ended up I would miss doing it and sometimes I just clicked any answer because I had to hurry up and so I go "yep," this one, whatever sounds right for me.* (Focus Group 1, NUH/LA)

> *I guess it's because we have a limited time, we were forced to do this, it is a weekly thing we needed to do for marks and just complete to get out of the way. But I wouldn't have done anything like copy down this if it wasn't forced on us – it's good that we have it.* (Focus Group 1, NUH/LA)

The students saw efficiency gains from accessing course material in multimedia formats and they believed the animation or visual resources were valuable and enabled them to become familiar and comfortable with course material from the online experience:

> *probably the only part of MasteringBiology that I liked because I think … you could see the whole picture because I'm very visual, and you could see it happening and where it's happening, and that's what I liked about MasteringBiology.* (Focus Group 1, NUH/LA)

In particular, the students thought the system was helpful for rote learning of material in preparation for summative assessments and reviewing the resources for exam preparation but they were reluctant to use the opportunities for learning in general, which underpinned a surface-learning approach:

> *I think, I mean for test in the exam I read back and watch the animation again.* (Focus Group 1, NUH/LA)

While the system provided regular opportunities for homework to learn course content, these students viewed the online system as a mechanism for keeping them on task, rather than a resource they could plan how to use to meet their learning needs. The students believed they could gain a sense of the scope of the course from the weekly structure set up in the system:

> *Keeping up with the whole course kind of slacks when you don't have activities to do. I might not even look at the course for a month at a time. I would have no idea what's going on until I get, you know, close to a test or something, I have to cram everything so the weekly activities like that might let you have a better idea the scope of the course overall.* (Focus Group 1, NUH/LA)

Although the low-achieving students were comfortable in accessing the feed up aspect of the system, they did not seek the additional help available (feed forward), and they did not necessarily understand that acting on feedback could improve performance by allowing them to check their progress in learning.

> *I didn't really find that helpful for me…. When it came down to things like this, I had to try like figure out where does this happen?* (Focus Group 1, NUH/LA)

> *I just remember it being like an easy mark every week – that's what I want… The fact that you get multiple goes with the question like couldn't really make it any better for me.* (Focus Group 1, NUH/LA)

The students did not have a positive view about the hints. They did not like having more questions embedded in the help section as part of feedback. In the focus group discussion, the students recognised that the hints were useful, but still said they were unlikely to engage with the information because of the amount of text and additional work. The students were resistant toward using the system more deeply. A passive approach to using the online system was a characteristic of the low-achieving students:

> *I think with the hints I think I felt like not more words! Even though words are definitely important but writing is not my strength – I think that's why, as soon as I saw more*

words, I'm thinking oh no here we go! Block that out, I just need a picture and just somebody tell me what it's all about and that's it. I don't want to read. (Focus Group 1, NUH/LA)

The students also believed that needing further help reinforced their inadequacy or incompetency to successfully complete the activities in the time available. Using a hint was seen as equivalent to giving up on been able to complete tasks and this led to a reluctance to engage with detailed information that could progress their learning:

That's pretty negative I reckon. … I've been raised for 20 years to never give up, (Focus Group 1, NUH/LA)

In summary, the students were not motivated to fully engage with the system. Their efforts were minimal and they used the system with the understanding it was a compulsory aspect of their first-year biology course; they did not allow themselves to be open to discovering learning opportunities or the development of skills such as self-regulation. Rather their focus was on the grading outcome, leading to an obligation approach without attention to the process or gains to be made along the way.

Maximum efficiency is strategic in online systems

A goal of the high-achieving students who were strategic non-users of hints was the accumulation of marks toward final grades. Although mark accumulation caught the attention of the students and encouraged them to engage with the online system, they also did not use the system more comprehensively. These students viewed time as a valuable commodity and engaging further with feedback that did not lift achievement in the short term was seen as not necessary:

And you don't want to add to it – I've done it! I don't want really to go back but I couldn't, I don't have enough grade. Sometimes you like I don't really care but there's enough to get a good grade and I can just move on. (Focus Group 2, NUH/HA)

The students who took a more strategic approach had a different awareness about the automated online feedback after they attempted questions in the activities. Although the activities provided feedback about the task, these students were more aware of the productive aspect of the system that provided information in a step-wise process toward a goal. Their attention was drawn to the feed up information in the system that allowed them to revisit content in an efficient way. The students recognised they could make a shift in their

achievement level through taking action to check their understanding (feed back) and build an understanding of the key aspects of knowledge that relate to a concept or content:

> *I think it is really effective and again sort of leading you in to a question sort of giving you a little bit more information if you need it. I did really enjoy it, working through it and eventually work yourself up to answer the question. I thought it was good.* (Focus Group 2, NUH/HA)

> *What I like about this format: you do one thing, question, another thing, question. Although it seems like you are sitting there forever answering question, and after each section you're kind of building up as well and you knew how to pass on whereas if you're passively reading something – ah yeah I get it and after a couple of pages later, I don't want to read anymore.* (Focus Group 2, NUH/HA)

The students also believed the system provided guidance and direction about the appropriate goals in learning or where they are going:

> *Also, when you get like questions just to practice I think they often put in the main things that you need to know so it's like good for directing our studies.* (Focus Group 2, NUH/HA)

Previous experiences of assessment from their high school education influenced students' understanding of the system design and how they worked with the system. The students interpreted specific criteria indicated by the feedback information in the system as equivalent to levels of understanding and competency:

> *It kind of reminds me of NCEA when you're asking questions. You like have answers that are "achievement" level, and then merit level [answers], and … leading up [to the] kind of answers that you're doing in NCEA [at excellence level]… like the final answers [in the system]. I guess it kind of builds up your knowledge.* (Focus Group 2, NUH/HA)

Here, the students used the electronic system as external feedback for self-monitoring, or minimal self-regulation.

The opportunity to practice answering questions that were relevant to the course was highlighted by the students in this group, and they emphasised getting corrective information, including definitive explanations about answers, was important. The students liked knowing where they went wrong if this occurred:

I just liked the fact that you know it's more practice questions for you to do and you actually get the answers because all our practice like past papers you don't get the answers so I guess you do have to figure out you know how some of them are quite tricky. And even if we did past exam papers as a massive group sometimes you wouldn't be able to figure what the actual answer was – there will be a lot of controversy, so they have definitive answers which is really helpful. (Focus Group 2, NUH/HA)

These high-achieving students identified that the system provided a closed loop in their learning by confirming how they were going, where this involved expert or tacit knowledge from the electronic system. For these students, the electronic system allowed them to have control over their learning in a large class environment where it was difficult to access corrective feedback from expert teachers.

The students were aware the hints provided information about how to approach answering a question, acknowledging this help was particularly important when they had gone wrong; however, they had opted to not use the information in the hints during their first-year biology course. They had a working knowledge of the hints, they did not use this part of the system because they were challenged by the format:

Occasionally, I found the hints quite frustrating because I couldn't answer the question. (Focus Group 2, NUH/HA)

The hints above that are all questions as well. I don't know… I think if I just got to that massive text and if I didn't know the question or the answer and I just had to read all these questions it is not really telling me any extra information. Oh no, I have to think for myself! I'll be like kind of how am I going to do this? (Focus Group 2, NUH/HA)

However, the students found the hints had challenged them and this experience meant they were averse to exploring learning possibilities. The students' frustration when they could not answer these questions was exacerbated by their awareness that the hint structure was designed to develop their thinking, which is an important skill expected at university.

The students believed that using hints would detract from their sense of competence in being able to do the work, and be an indication of weakness. They felt their reputation was at stake and they needed to prove they could achieve without help:

I think if you are used to hints…even though we don't get penalised for hints, you still got that mentality like I should try to do without the hints because maybe like it will look better or whatever. (Focus Group 2, NUH/HA)

The students' concern with their reputation as a competent learner in an electronic system further challenged their development of incipient self-regulation strategies, as they limited their engagement with the help aspects of the system. Also, the students believed the format was user-friendly comparative to a text-only format and great for students who did not have a background in the subject, but they did not see opportunities for enhancing their own learning. Given the system is effectively self-help, the students viewed the feed up and feed back parts as having a remedial purpose but did not necessarily understand the purpose of the hints. Help seeking was seen as more relevant to students who were not so knowledgeable in the discipline and needed help to make up ground:

> *I think that's really, really helpful especially for first year, again people from different backgrounds so people would have barely knowledge of jargon used.* (Focus Group 2, NUH/HA)

> *I think it is particularly important for the first year because where people come in from all sorts of different backgrounds. You know they have different approaches from high schools and so a lot of people don't actually know sort of how to study, how to interact with each other and this sort of gives them a focal point.* (Focus Group 2, NUH/HA)

Other reasons were given by this group for not using the hints; in particular, they used the system summatively first as a way to check their understanding. The students also believed they were unable to use it more extensively because of workload and time pressure and they had done enough to get a good grade:

> *I think the other thing is like when I think it through like that's a good way to go about it probably at the time I have so much stuff on and I'm like studying all the time and you kind of, I don't know. Overwhelmed.* (Focus Group 2, NUH/HA)

> *Well, I think maybe it would have been good to read through but you know like when you're doing it, oh I just want to get this homework done real quick so I can move on to study or something else.* (Focus Group 2, NUH/HA)

Their perception of workload precluded seeking help even when students had an awareness of the value of accessing the help in the system:

> *I think it is a good way to try to answer all the questions using the knowledge I already have and then go back and open up all the hints and see if there's something I have missed even I have got the question right, use it to help me to work the answer, I probably wouldn't have done at the time because of time.* (Focus Group 2, NUH/HA)

For these students, who achieved high grades in the course, not seeking help was strategic. They weighed up the time commitment in relation to benefits they might gain in their learning. Effectively, they made a judgement call about the hint information in relation to learning strategies for summative assessments and the question format. The students assumed they needed less preparation for achieving high grades in multiple-choice-type questions and the further information about processes and details was not essential:

> *Sometimes I feel like even if we don't go back through all the hints and we don't know every exact detail, we don't need to know it to get a really, really, good mark because it's just MCQ you need to know the general idea all that, should know what the keyword so it didn't make a difference but later on when you need to know everything really, really, well, the second year and third year then it would have mattered but you wouldn't have known that in first year.* (Focus Group 2, NUH/HA)

The strategy to not use hints was "successful" in the first-year biology course for this group, confirmed by them being high achievers at final grading. However, on reflection, they viewed the hints as positive strategies for first-year students, despite not having used the hints themselves in first year. At the time they participated in focus groups, with hindsight, the students articulated how hints could support understanding processes in learning. The students had developed in their awareness of how to use feedback in their learning:

> *I think the hints are very helpful, they sort of cater to different levels of students I mean you've got like this first question here; ask you a question that if you remember back the lecture, you might be able to answer it but if you can't/don't remember parts of the lecture, maybe activate one of the hints to take you back.* (Focus Group 2, NUH/HA)

> *The fact that they explain why, like that "B" was the answer they said. This is why I would go back to this bit which is good. And the hints are helpful as well as you kind of figure like if you don't know. The first clue, you kind of see like how you kind of approach a problem in an exam as well because the hint is kind of like if you don't have it now here are some of the steps that will lead you to it, it kind of help you think about how to approach an exam question as well to figure out the answer.* (Focus Group 2, NUH/HA)

> *If you actually can't answer the question like some sections … need a hint for a lot of that, which is good because every person has their own different weaknesses, and the lecturer might stress something because people might struggle with that but some*

people might not so it's like it's fine for them but if you're going through [hints] yourself, you know you can figure out your own weaknesses and focus on it. (Focus Group 2, NUH/HA)

The students in this group had minimal self-regulatory skills while enrolled in their first-year biology course and they had used the electronic system to monitor their learning for accuracy. For these students, the system was a means to explore further the goals of learning outside the lecture format and compare their current performance with the desired performance for the group. However, they did not access the part of the system that helped them to close the gap toward the expected level for achievement. Some reasons for not seeking help behind the hints tab were similar to Focus Group 1 participants. Namely the contribution of workload to a sense of overwhelm during the semester so they strategised to reduce time invested, believing the marks gained were not impacted. Where these students differed from the previous group was in their awareness of the processes in the system which provided a greater sense of control over their learning environment through the access to feedback. However, they limited the opportunities to develop self-regulation skills by associating the seeking of help with a sign of their weakness as a student.

Resistant to online help seeking

Seeking further information for understanding occurred when the students used the hints in the online MasteringBiology system. The students were receptive to the full functionality of the online system as a means to build knowledge. In the system, the students could actively choose to access this information which provided the next stage in understanding (feed forward), leading to more complex knowledge for learning. The students were in control of monitoring this aspect of their online learning. As help seekers, these students had positive comments about the MasteringBiology system, although there were some differences between the low- and high-achieving students in their perceptions about using the feedback in the system.

Some of the students who achieved low grades in their first-year biology course used the feedback information in the hint system, i.e., they sought help in the online system other than the automated corrective information provided while completing activities. The terms of engagement with the online system for these students was influenced by their sense of how long it was taking, which sometimes detracted from their efforts to use the feedback.

[What] I found was, it takes too much time to do one block of questions. (Focus Group 3, UH/LA)

And like if you're sitting there for 30 minutes to an hour trying to figure out – it kind of drags on a bit much. (Focus Group 3, UH/LA)

Sometimes, it depends when you did it – it was at the last minute when I did it. …. Especially the last minute, you tried to click as much clicks until you get the right answer. So it's not that helpful in that sense. (Focus Group 3, UH/LA)

These help-seeking students had similar beliefs to the students who did not seek help and who also gained relatively low achievement levels in the first-year biology course. All the low-achieving students viewed the online system as structured around mandatory tasks. For these students, completing the tasks in the minimum time possible influenced their interactions. It seems the students, despite accessing the further help, were less concerned with deeper learning of key concepts and content, and were aware of their non-productive behaviour such as last-minute use of the system. The students were able to associate spending less time on their interactions in online learning with the consequences for their learning progress:

I normally do it [use hints] at the last minute so I don't find it that helpful. But for test and exam I do go through it so that's a little bit help. (Focus Group 3, UH/LA)

I agree, I only do it at the last minute so it's not too long for me, and I do find that during like for exam or test, I would use this as revision. (Focus Group 3, UH/LA)

To justify their approach, the students believed the system provided opportunities for low-risk testing for practice, prior to the course summative assessments, completing questions that confirmed and reinforced their learning. The students did not always realise they were bypassing regular opportunities to identify gaps in their understanding during the course.

However, the students were aware of how to make their learning productive by the use of the hints, although this was also not a constant in their interaction with the system:

I think I used the hint when I actually wanted to answer the question properly like not just guessing. (Focus Group 3, UH/LA)

Yeah. If you knew the answer with the hints then you understand the answer better rather than oh that's the answer because a lecturer told me. You understand why that is the correct answer. (Focus Group 3, UH/LA)

The students were able to distinguish between the different outcomes for their learning when receiving the automated feedback in the system and when they made the decision to seek extra

information. For the latter, they believed it was possible to add value and gain benefits for their learning:

> *The content was … pretty concise. Just the thing …the volume was big because there was actually a lot of questions* (Focus Group 3, UH/LA)

> *Took the guess-work out! Because even might see yourself test just go through and just keep on doing and after a while you know what the right answer. And if you get it wrong – enough!* (Focus Group 3, UH/LA)

> *It gives you that break like the understanding of why you choose that instead of you just picking one.* (Focus Group 3, UH/LA)

> *I thought that was more helpful cause then you knew why that was correct.* (Focus Group 3, UH/LA)

From their experience of using some hints, the students showed awareness of the purpose of the feedback was to facilitate their understanding on a deeper level, giving them control of their learning and a sense of less dependence on lecturers, although still dependent on external information:

> *[Using hints]…I think it helps you study smarter. Instead of trying to guess.* (Focus Group 3, UH/LA)

> *If you knew the answer with the hints then you understand the answer better rather than oh that's the answer because a lecturer told me. You understand why that is the correct answer.* (Focus Group 3, UH/LA)

> *I would look through all the hints if they gave a hint, look at it, understand it and then once I got the question right or wrong, check the green section that explains it. Use the screen shot as a study note. Pretty useful and good information.* (Focus Group 3, UH/LA)

These students, while engaging with help seeking in the online system, viewed the hints as assistance in gaining passes in the homework activities, which in turn contributed to the accrual of marks toward final grades. Although they believed the information was useful for supporting their understanding and as prompts for exam preparation, the students were less inclined to develop self-regulation strategies as they were also challenged by the demands of workload.

Open to online systems and mindful of long-term benefits

Some of the students were high achievers in the first-year biology course and used the feedback information in the hint system, i.e., they sought help in the online system other than automated corrective information provided while completing activities. From their discussion about the MasteringBiology system, these students were inclined to be more open and willing to explore the help provided in the system. Being comprehensive in their approach to the online system, the students were able to appreciate how the different parts of the system provided different types and levels of feedback.

In discussion, the students agreed there was a link from the animation information and explanations to the activities, enabling correct completion of tasks. Here the students have identified the feed up function of the animations as directing them to the relevant content and concepts. The students also understood that the online system was low-risk and that feedback works best in a low-risk world. Here, the students felt they could check their understanding through making mistakes in an environment with minimal consequences. Further, they changed their behaviour in a context that they perceived to be safer. The students talked about their interactions in a fluid and adaptable way, where the system worked multidimensionally as the "teacher":

> *I quite like that as well… the fact that we were allowed to get things wrong and then get it right, I found it really nice. It's not like a high risk that I need to make a decision. And I get feedback as soon as I get it wrong – I know I'm wrong and must be this one or I'm right and that confirmed my learning.* (Focus Group 4, UH/HA)

Providing feedback to students through dialogue is difficult in very large class, where one teacher to many students is the norm. These high-achieving students recognised that the online system provided access to a learning situation where dialogue was simulated by sequential questioning and feedback relevant to the discipline content of the course and that this could be done with anonymity:

> *I like online systems because if no one wants to ask questions, you go online everything is there.* (Focus Group 4, UH/HA)

The students believed the hint structure provided opportunities for learning that extended beyond the knowledge immediately applicable to an activity. The students talked about using hints strategically to improve and build their tacit knowledge. As high achievers, the students discussed accessing the hints to get a better understanding and saw the hints as a good resource or repository of information where they did not want to ask the lecturer directly. In the

following comment, the student was aware the learning gains would be helpful in subsequent lab classes where s/he could then participate in discussion:

> *If I can get good feedback using questions and activities in the online system then I probably won't need so much feedback [later]. Especially in biology I actually found that they [online tasks] build on each other – I get feedback from online system. I understand better and then go and talk to people in the lab. So it kind of worked logically I guess.* (Focus Group 4, UH/HA)

Here, the students saw hints as a more comprehensive way of receiving feedback other than indicating how they were going. The students saw the purpose of the hint information as extending and directing their learning. They preferred sequential questioning in the hint design that facilitated building a deeper and more detailed account of content and concepts. The students thought the explanations showed them how to be concise and accurate with the information, a skill that they identified as important in their summative assessments. For high-achieving students the hints were seen as additional to the information from their lecturers, which was considered a positive aspect:

> *So there were so many hints, we're learning more than just that question. So that's a good thing so obviously like if you think of our exam or test or just learning in general – if you like… there obviously will be a lot like that sort of questions or something related to that anyway so it's actually good to learn more about this entire topic.* (Focus Group 4, UH/HA)

Students had an appreciation of the value of making mistakes in the system which not only indicated where they had gaps but gave them access to information which contributed to tacit knowledge. The hints were a way for the students to self-manage their progress in learning when making errors:

> *I do remember that it would sort of tell you – try to give you a hint anyway if you get it wrong the first time, kind of try to push you in the right direction which I find helpful I think. Like seeing a question wrong and then it goes you know sort of to a point of clarification almost. It's helpful if you got the question wrong the first-time round I thought.* (Focus Group 4, UH/HA)

> *I usually use the hint if I got the question wrong the first-time round, and try to figure then what went wrong and that's kind of my way to study anyway which is if I feel that I am pretty confident on a certain question … but if I don't know I'll try to read around*

as much as possible. So this sort of hints, I think I remember being quite helpful for things like kind of questioning so it's good for that. (Focus Group 4, UH/HA)

Yes, hints were a really good thing just like I got questions that I guess, were a lot harder – I think hints were a really good thing just to help answer questions properly. (Focus Group 4, UH/HA)

One student indicated that s/he used hints to ensure s/he had a comprehensive understanding while managing fears around learning. In this case, the student used hints to support error correction as well as extending the current level of knowledge:

I remember actually with hints like when you only got a question wrong and you go to hints if you don't get it right to have a little look. I remember the first time I discover hints, I actually looked through all of them – every question whether right or wrong, I was scared to get anything wrong and I kind of read everything through. So definitely read them through. (Focus Group 4, UH/HA)

As for all the students, use of the online system for high-achieving students was also driven by summative assessment preparation:

I thought it reminds me of some of the tests that we did have because they were multi-choice that went along similar lines so I think they were really good revision for those sort of things as well. (Focus Group 4, UH/HA)

However, these high-achieving students also recognised extensive use of hints in activities contributed to preparation for summative assessments. The students were aware the additional help, as well as knowing the relevant content facilitated them to develop skills to craft answers:

I think it taught me quite well to be quite sceptical about what answers actually were and you have to read, very finely sometimes especially whilst you're sitting the end-of-year exam, you have to do the same thing, you have to be sure that what your answers is exactly right, it's like a no mistake words or no words it could make it more wrong than you answered actually. (Focus Group 4, UH/HA)

The students were reassured, when they were struggling in first-year biology, that they could access help in the online system, and saw the information behind the hints as extra information to extend their own knowledge beyond what may be needed for the summative assessment. Many of these students indicated they did not always use the hints in the online system during the course. Some students indicated they found the online system was tedious to use, boring

and that hints were not always useful. This experience led them to be reluctant to use the system:

> *I think it's also a good chance for almost compulsory learning and like we can easily put it off like till right before exams but since the deadlines kept coming, although I kind of felt like a chore, I remember now at the time it actually like forced my learning like without intending to which is quite helpful I think.* (Focus Group 4, UH/HA)

Although the students considered it "forced" learning they also believed the system design trained good habits, so their use of the online system was helpful in the long term which they linked to the development of minimal self-regulatory skills. The students acknowledged they struggled with the behaviours required for developing independent learning skills:

> *I mean forced learning would be nice I think we get more habits [if we were] able to do that ourselves – become more self-sufficient.* (Focus Group 4, UH/HA)

> *Feels like a chore at the time but it's helpful, to use the hints.* (Focus Group 4, UH/HA)

Chapter summary

At the time they used the system, the students recognised the online MasteringBiology as providing compulsory learning activities that required completion deadlines for marks to be awarded. All students indicated they believed the feed up (or where am I a going?) aspect of the system was valuable to their learning, in particular providing different presentation modes of lecture material that supported learning content and also reviewing, nearer summative assessments. There were differences between groups in terms of their use of feedback in the system. The system provided automated feedback (how am I going?) as part of assignments structure into course design; here there were differences between participants, although all were motivated to collect a "reward" or marks toward final grades. One group of high achievers used the system to support learning and extend this to identifying where the system's feed forward function enabled deeper learning. Another group of low achievers recognised the value of the feed forward functionality but struggled to use it effectively in the context of course assessment design. All students were also aware from their learning experiences post-first year and, on reflection, would have used the system more as they were not really aware how much help was provided.

The next chapter

The findings of the first part of the focus group discussions, in which students explored and discussed their use of the online system MasteringBiology, have been presented in Chapter 6. Participants in each focus group then carried out an individual activity where they considered statements that reflected the different levels and actions that contribute to the Hattie and Timperley (2007) model of feedback. Before discussing with their group, each student individually prioritised nine (out of 13) statements on a diamond template. Chapter 7 reports on the prioritisation of the statements as part of the structure of the Hattie and Timperley feedback model. The similarities and differences between the four focus groups is explored.

Chapter 7

Students' conceptions and use of feedback in a multidimensional context

In Chapter 6, students' reactions and perspectives on using feedback in an online system were reported. In that chapter, evidence was produced about the ways the higher and lower achieving students used or did not use feedback or seek help in the MasteringBiology online system, with respect to Hattie and Timperley's three questions: "where am I going?", "how am I going?", and "where to next?" Chapter 6 also highlighted that students' tendency to use the online system was variable with respect to actions at the feedback levels (task, process and self-regulatory) as detailed in Hattie and Timperley's model. Students' use of the system ranged from minimal engagement and limited learning to more strategic approaches as well as deeper learning. In this chapter, the focus of the analysis shifts to reporting on a diamond ranking exercise used in the focus group discussions. In this activity, the students as individuals prioritised the type of feedback important in their learning in terms of feed up, feedback and feed forward for the different levels. This indicated the students' prioritisation of feedback use was at task level. Following on from the diamond ranking exercise, the analysis explores the evidence in the focus group discussions regarding their beliefs and understanding about the use of feedback during their undergraduate learning experiences that led them to select and order the statements on the diamond. Their responses reflect their experiences of online, face-to-face and written feedback from the system and over 3 years in their university programmes. Informed by Hattie and Timperley's model of feedback at the task, process, self-regulation and self-levels, six themes were extracted from the data and are reported in this chapter.

Diamond ranking of feedback statements

As part of the focus group sessions in Phase 2, the participants individually completed a diamond ranking activity where they positioned feedback statements in order of highest importance to lowest with respect to their learning. As a group, the students then explored reasons for their prioritisation of statements during discussion.

Diamond ranking activity design for focus group sessions

Ranking is a common strategy used where participants are asked to indicate the importance of, or assign priority to, a particular attitudinal object (Gideon, 2012; Johnson & Christensen, 2008). The second part of the focus group session began with the students individually

completing a diamond ranking exercise. The diamond ranking exercise is an effective way to help participants formulate their own ideas about the topic they are about to discuss. Students were asked to rank 13 statements in priority order from those most important to them to those least important. Relative ranking enabled the least to most important statement (attitude) about feedback to be determined for the participants as a group.

As participant opinions can be shaped by the group discussion as the session progresses, this part of the activity allowed time for individual reflection on their perceptions of feedback. The phenomenon where opinions and reality can be developed in response to the psychosocial environment of the group has been referred to as the "groupthink" model, originally defined by Janis (1972), leading to conformity in decision making (Rose, 2011). In an empirical investigation of the relationships among the variables of the "groupthink" model, it was found the results partially supported Janis's model (Park, 2000). The influence from other participants can be ameliorated by providing an individual activity that facilitates distillation of an individual's own opinions, beliefs and perceptions prior to discussion. Individuals are more likely to retain stronger adherence to their written views even when no one else has seen them (Carey, 1995).

In a rank-order activity, participants are asked to identify priorities, which allows a relative degree of preference to be known about a list of factors (Cohen et al., 2007). In this thesis study, important considerations for the use of rank-ordering activity in the focus groups was to stimulate discussion about the qualitative variable (statements about the use of feedback). The statements reflected the possible actions with respect to feedback use from the theoretical framework, and the rank ordering allowed the participants to compare and discuss their priorities about feedback. Rankings are considered more effective than ratings (Visser, Krosnick, & Lavrakas, 2000), as rating each statement could lead participants to discuss feedback statements question by question. Although rating scales establish a degree of sensitivity and differentiation about a given question or statement, they are unidimensional, only measuring one item at a time, making it difficult to discern differences and level of importance between items. Where there are multiple constructs being rated, there can be problems of interpretation of the scale, leading to no differentiation (Cohen et al., 2007; Visser et al., 2000). One individual may vary in the interpretation of intensity of their responses from one item to the next. Likewise, between participants, there may also be differences of interpretation of the rating scale. When rating a large set of objects, most participants rate most of the items given in a similar or identical way, for example, as highly important or strongly agree, due to survey satisficing (Visser et al., 2000). This can result in difficulty separating

items of greatest importance from those of least importance (Bradburn, Sudman, & Wansink, 2004) and the researcher would then need to infer which items were more important (Visser et al., 2000). For this reason, the reliability and validity of ranking data are superior to those of rating data (Visser et al., 2000). Asking participants to rank items will resolve this problem.

However, rank ordering a long list or set of objects can take much longer than rating, causing participants to be challenged or overwhelmed (Cohen et al., 2007) and unable to make distinctions between statements (Visser et al., 2000). It is considered unrealistic to expect participants to arrange priorities where there are more than five ranks. Where the list is above 10, then the problem can be approached in one of two ways (Cohen et al., 2007). Cohen at al. (2007) suggested either reducing to five items, effectively reducing the range and comprehensiveness of the participants' responses, or alternatively retaining the list of 10 or more but requesting only the first five priorities be identified.

In this activity, the students were provided with a blank diamond template (nine positions) comprised of five layers and a prepared kit containing 13 short statements about feedback on sticky post-it-note pages. The statements are listed in Table 6. The diamond template and an example of a student's completed diamond is given in Appendix F. The students were asked to rank the short statements onto their diamond shape in order of priority of what they find effective for their learning, or what is most helpful through to least helpful for their learning. One statement to be placed on the first layer and two on the second layer, three on the third, two on the fourth and one on the fifth. The statements reflected the feedback typology of Hattie and Timperley (2007). The statements used are shown in Table 6.

The use of post-it statements was intended as a prompt to encourage the students to contribute their perspectives about feedback by giving them a common set of statements to debate in discussion. The use of post-it notes in focus groups has been shown to stimulate discussion and involvement of all students so as to gain an understanding of participants' views and also generate a shared outcome for the group (Peterson & Barron, 2007). Students could leave out the statements that were not relevant to them and alternatively author their own statements on the blank post-its provided. I encouraged the students to use these blank post-its to write down any ideas triggered while sorting, that were not captured in the statements already provided. Students could move the sticky statements on post-it-notes around as they decided on prioritisation and they were encouraged to write on their diamond the reason(s) for placing a statement in a particular position. Each student's individual diamond and positioning of statements was captured digitally for the purposes of analysis; examples of diamonds from

each focus group can be found in Appendix F. Each group's statements were on different colour post-it notes to identify different groups during analysis.

Previous studies have also utilised focus group methods where statements are sorted hierarchically and then provide the basic structure for the topic of discussion by participants (Akar, 2007; Glassey & Haile, 2012). However, a disadvantage of relative ranking is often experienced when participants are given a list of "objects" to prioritise: the order of the factors on the list influences how a participant may respond, with the items first on the list often given higher priority (Gideon, 2012). The use of the diamond and statements provided as separate items, which the participant could then move around, was a design feature to manage this influence. In addition, the "blank" statements allowed the participants to write their own response about feedback where they considered this was missing from the options. Placement on the diamond represents a form of numerical ranking, enabling statistical analysis of participants' prioritisation of statements within and between focus groups.

The individual ranking exercise was followed by discussion between participants in which they were asked to explore their reasons for positioning the various statements. In particular, they were guided to explore where they had similar views and also where their ideas were different. Participants were given an opportunity to change their ranking after the discussion if their perspectives had changed and if they had found other participants had ideas or reasons that they hadn't considered before. I was interested in the influence from others' views and if participants conformed to these ideas or if the ideas enriched their own understanding. The perspectives gained are specific to the unique group of people and the dynamic they establish through interactions with each other. The collection of the data and findings may not be replicable in a different mix of people and generalisation requires caution.

Table 6

Frequency at Each Importance Rank Position for 'Feedback' Statements and Weighted Mean for Each Statement for All Participants.

No.	Type of feedback	Importance Rank				Weighted mean
		Top	Medium	Low	None	
		1–3	4–5	7–9	0	
4	Receiving feedback during a discussion where I can ask questions to help me understand the feedback	9	7	2	1	7.17
5	Receiving information about how to correct my work	8	5	6	0	6.67
7	Receiving information about how to complete a task or activity and make better progress	8	7	2	2	6.67
11	Knowing what a successful piece of work looks like (the level I am working towards)	9	3	6	1	6.5
6	Receiving feedback after I have completed an assessment activity	8	6	2	3	6.33
1	Checking how I am going as I complete my work (if it is correct)	3	7	3	6	4.33
12	Receiving feedback about how well I understand my work using questions and/or activities in online system	4	4	4	7	4
3	After successfully completing my work, I try to use what I have learned in similar situations	3	3	7	6	3.67
8	Knowing I have made a mistake, I seek feedback if needed	2	5	6	6	3.67
9	Receiving feedback that confirms I already know what I need to do and what this is	1	6	4	8	3.17
2	Feedback provided by a teacher/lecturer to everyone during a class or group situation	0	3	5	11	1.83
13	Receiving feedback about how well I understand my work from another student in the course	0	1	7	11	1.5
10	Receiving information about myself e.g., "You are a great student."	0	0	3	16	0.5

Note. Weighted mean determined by multiplying the frequency of selection at each score point by a weight for each rank (3=high, 2=medium, 1=low, 0=not selected) and then taking average across participants.

Ranking of statements

Each student selected nine of the 13 statements provided and placed the statement on the diamond as three "high-ranked" statements, three "medium-ranked" statements, and three "low-ranked" statements. Where a student did not place a statement on the diamond, it was assigned "no rank." For each statement, the frequency at each rank level and the weighted mean is given in Table 6. The statements are listed from highest to lowest weighted mean. The weighted mean for each statement was determined in order to find the overall ranking of statements by the focus group participants. In the table, the statements fall into three clusters by importance for learning level (high, medium and low).

The high-rank statements in order include statements 4, 5, 7, 11, and 6. The statements are characteristically task-related except statement 4 (top rank) which is dialogic and a behaviour associated with self-regulation. The next tranche of the medium-ranked statements include 1, 12, 3, and 8. Statement 1 is process-type feedback whereas the other feedback statements reflect self-regulation behaviours. Finally, the low-ranked statements include statements 9, 2, 13 and 10 and task, process and feedback about self.

The use of hierarchical cluster analysis to determine grouping of feedback statements

The grouping of the statements from the diamond ranking exercise was done using cluster analysis to corroborate the rank level determined from weighted means analysis in Table 6. IBM SPSS version 23 was used to conduct hierarchical cluster analysis where the number of clusters was not specified. The hierarchical agglomerative method was used where each object (statement) is represented as a separate cluster and sequentially merged based on similarity. It was anticipated in the hierarchical cluster analysis, the statements would align with three groups: high, medium, or low rank, as determined from weighted means of frequencies for each statement. Hierarchical cluster analysis requires specification of how similar or dissimilar objects (statements) are in order to identify the clusters derived from the data. The similarity measure used to estimate distance between pairs of objects was squared Euclidean distance to identify both levels of homogeneity and separation of groups. The procedure used to determine the number of clusters was Ward's method, as similar sized clusters were anticipated and the data set did not include outliers (Ward, 1963). In this approach, the objects which have a minimal effect on increasing the overall within-cluster variance are combined at each step. The cluster analysis is presented as a dendrogram (Figure 6), a visual display of the distance level at which the objects (statements) and clusters were combined.

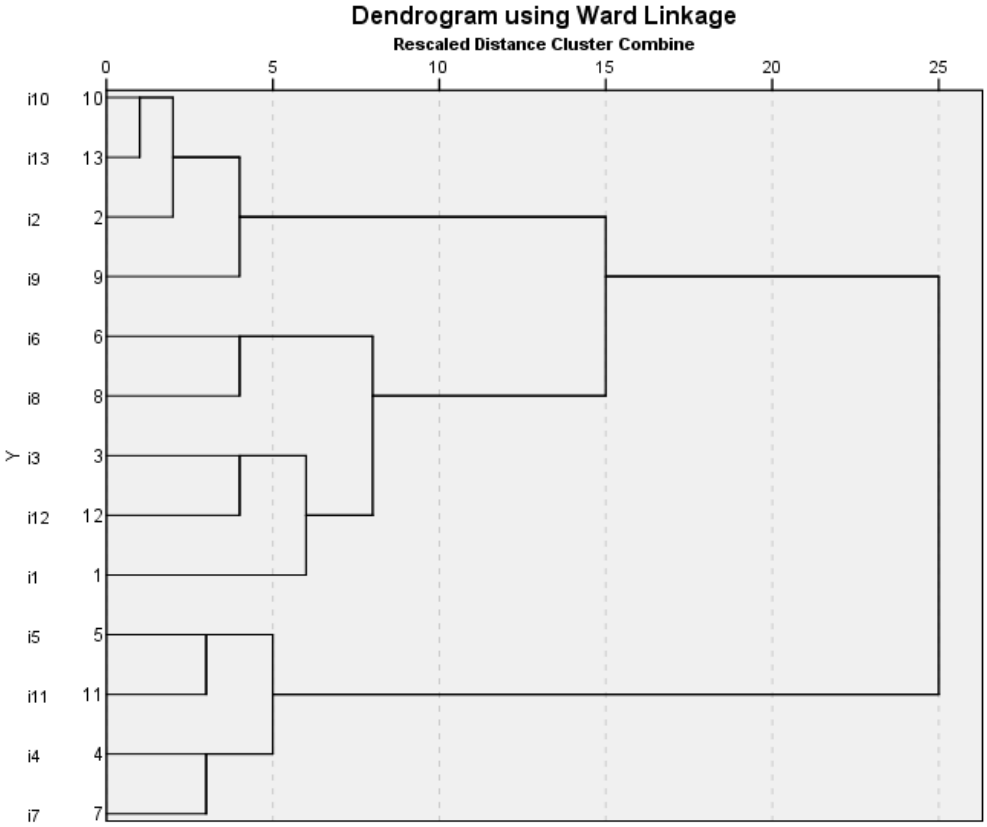

Figure 6. Dendrogram indicating grouping of statements by hierarchical cluster analysis.

The dendrogram was inspected to assess the number of clusters formed and supports the initial assessments of high, medium and low-ranked statements listed in Table 6, indicating three main cluster groups. Within cluster 1 (high level) students have included feedback statements 4, 5, 7 and 11. The cluster that corresponds to medium rank contains feedback statements 1, 3, 6, 8 and 12. The low-ranked statements appear in the third cluster and these are statements 2, 9, 10 and 13.

Validity of clusters: Predictive discriminant analysis

As hierarchical cluster analysis is an exploratory process, results were considered tentative and predictive discriminant analysis was conducted to examine the validity of the cluster solution using IBM SPSS version 23. The existing variables (participant rank scores for each statement) were used to predict which statements contribute to the membership of each of the three groups. All observations in the dataset were valid.

Canonical discriminant functions. Table 7 indicates the first two canonical linear discriminant functions used in the analysis. The number of functions is equal to the number of discriminating variables. The proportion of variance explained by the eigenvalue (between-

groups sum of squares divided by within-group sums of squares) indicates function 1 is strongly discriminating. In this analysis, the first function accounts for 91.5% of the discriminating ability of the discriminating variables and the second function accounts for 8.5%. The canonical correlation (0.988) between the discriminant scores and the levels of the dependent variable indicates the function discriminates well. Wilks' lambda indicates the proportion of the total variance in the discriminant scores that is not explained by differences among groups. The lambda of 0.05 has a significant value (Sig.= 0.000), thus the group means appear to differ. The chi-square statistic has a significant value (Sig.= 0.000), and allowed rejection of the null hypothesis that the canonical correlation of the given function is equal to zero i.e., no discriminating ability.

Table 7
Summary of Canonical Discriminant Functions

Eigenvalues

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	41.762[a]	91.5	91.5	.988
2	3.874[a]	8.5	100.0	.892

a. First 2 canonical discriminant functions used in the analysis.

Wilks' Lambda

Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1 through 2	.005	45.386	8	.000
2	.205	13.463	3	.004

Figure 7 shows the predicted cluster (high, medium and low importance of feedback) as the relationship between two discriminant functions and the group means or centroids of the predictor variables. The map indicates function 1 separated the clusters with the maximum difference between group membership.

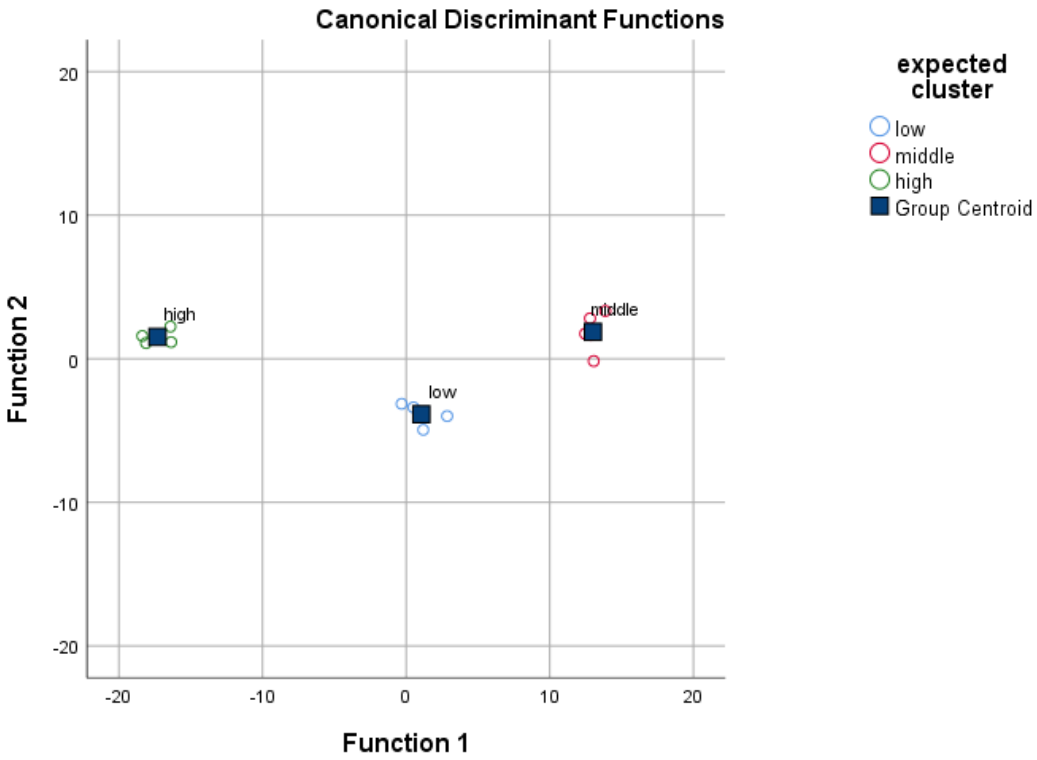

Figure 7. Functions at group centroids.

Predicted classifications. All observations in the dataset were successfully classified. The classification results (Table 8) provide a summary of the number and percent of statements classified correctly and incorrectly. From the Original section of the table, the row totals indicate four statements fell into cluster 3, five statements into cluster 2, and four statements into cluster 1.

The cross-validation method followed in SPSS was the “leave-one-out classification” for which the results are also presented. Overall, 100% of the statements were correctly classified.

Table 8
Classification Results Table.

Classification Results[a,c]

			Predicted Group Membership			
		expected cluster	low	middle	high	total
Original	Count	low	4	0	0	4
		middle	0	5	0	5
		high	0	0	4	4
	%	low	100.0	.0	.0	100.0
		middle	.0	100.0	.0	100.0
		high	.0	.0	100.0	100.0
Cross-validated[b]	Count	low	4	0	0	4
		middle	0	5	0	5
		high	0	0	4	4
	%	low	100.0	.0	.0	100.0
		middle	.0	100.0	.0	100.0
		high	.0	.0	100.0	100.0

a. 100.0% of original grouped cases correctly classified.

b. Cross validation is done only for those cases in the analysis. In cross validation, each case is classified by the functions derived from all cases other than that case.

c. 100.0% of cross-validated grouped cases correctly classified.

Differences by groups and student attributes

In order to determine if the clustering of statements by students in the diamond was affected by the students' attributes of hint-seeking behaviour and achievement, the nonparametric Kruskal-Wallis test was used as an alternative to the ANOVA. The Kruskal-Wallis test does not have the assumptions of normal distribution with approximately equal variance on the scores for each group. The Kruskal-Wallis test was used to investigate differences between the four groups; high and low achievers; help-seeking behaviour and non-help-seeking behaviour.

The null hypothesis and alternative hypothesis for each investigation are:

H_0: the groups have the same median for each of the feedback statements.

H_1: the groups are different for each of the feedback statements.

Table 9

Kruskal-Wallis Test for Differences Between Four Focus Groups

	Statement Number												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Chi-square	2.151	.321	7.542	2.830	4.375	2.718	3.881	2.695	6.404	1.205	10.400	9.528	1.920
df	3	3	3	3	3	3	3	3	3	3	3	3	3
Asymp. Sig	.542	.956	.056	.419	.224	.437	.275	.441	.094	.752	.015	.023	.589

a. Kruskal-Wallis Test

b. Grouping Variable: Focus Groups

The results of the analysis indicated that there is no significant difference in the medians for the rankings of each statement between the four groups (see Table 9). Therefore, the null hypothesis was accepted and it was assumed the samples are from the same population and the rankings of the statements do not differ by focus group.

Table 10

Kruskal-Wallis Test for Differences Between High and Low Achievers

	Statement Number												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Chi-square	1.570	.000	.987	.099	1.027	.690	2.251	1.780	3.390	.107	.008	2.804	.225
df	1	1	1	1	1	1	1	1	1	1	1	1	1
Asymp. Sig	.210	1.000	.320	.753	.311	.406	.134	.182	.066	.744	.929	.094	.635

a. Kruskal-Wallis Test

b. Grouping Variable: Achievement level.

The results of the analysis indicated that there is no significant difference in the medians for the rankings of each statement between high and low achievers (see Table 10). Therefore, the null hypothesis was accepted and it was assumed the samples are from the same population and the rankings of the statements do not differ by participant achievement level.

Table 11

Kruskal-Wallis Test for Differences Between Help-Seeking and Non-Help-Seeking Behaviour

	Statement Number												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Chi-square	.747	.139	3.780	2.333	.002	.231	.000	.017	1.847	.835	9.159	7.317	1.763
df	1	1	1	1	1	1	1	1	1	1	1	1	1
Asymp. Sig	.388	.709	.052	.127	.965	.630	1.000	.897	.174	.361	.002	.007	.184

a. Kruskal-Wallis test

b. Grouping variable: Help-seeking behaviour.

The results of the analysis indicated that there is a significant difference in the medians for the rankings of two statements between students showing help-seeking behaviour and those who do not (see Table 11):

Statement 11 (χ^2 = 9.159, Sig. = .002). "*Knowing what a successful piece of work looks like (the level I am working towards)*"

Statement 12 (χ^2 = 7.317, Sig. = .007). "*Receiving feedback about how well I understand my work using questions and/or activities in online system*"

Therefore, the null hypothesis was rejected for both as the obtained value is greater than the critical value for χ^2 (3.84). The alternative hypothesis supports there is a difference in the rankings of the statements between participants who demonstrate help-seeking behaviour and those who do not.

Table 12

Descriptive Statistics for Rank Score of Feedback Statements 11 and 12 by Hint Users and Non-Hint Users

	Usage	N	Mean	Std. Deviation	Effect size
Statement 11	Hints	11	3.2727	1.67874	1.28
	No Hints	8	1.5	.75593	95% CI for *Cohen's d*:
	Total	19	2.5263	1.61136	0.29, 2.28
Statement 12	Hints	11	2.1818	1.25045	0.42
	No Hints	8	1.5	2.0702	95% CI for *Cohen's d*:
	Total	19	1.8947	1.62941	-0.51, 1.34

The clustering of the feedback statements from high to medium to low importance is universal across the focus group participants. The characteristics of the items, in the main, are consistent for all groups. There is a significant difference for the focus group characteristic associated with help-seeking behaviour for statement 11, "*Knowing what a successful piece of*

work looks like (the level I am working towards)," from the students who do not seek help in the system. In this situation, feed up, in the form of an exemplar, is important for help-seeking students in clarifying the learning intentions. Similarly, statement 12, "*Receiving feedback about how well I understand my work using questions and/or activities in online system*," was significant for help-seeking students in the online context (see Table 12).

Summary of findings from diamond ranking of statements

The diamond ranking exercise allowed each participant to work individually to prioritise statements on feedback use. Across all achievement levels, the students ranked feedback statements about how to improve their understanding or "where to next" as most important for their learning, with an emphasis at task level for specific problems in terms of this feedback information from external sources or agents. The students next ranked feedback about monitoring their own progress at the process level for learning, where feedback enables generalisation or transference to other contexts. They assigned lower importance to feedback that a teacher provides to a group or class and feedback from peers. The students placed feedback about self as least important, although they could not dismiss receiving this type of feedback for affective reasons. There was no significant difference in ranking of statements between focus groups or when the students were grouped by achievement levels. However, differences were found between groups characterised by help-seeking behaviour. A significant difference was found in the medians for the ranking of two statements with the online help seekers having a higher mean compared to the online non-help seekers. One statement was about knowing what a successful piece of work looks like or the expected goal and the second statement was about receiving feedback about their level of understanding in an online system. The difference between the help-seeking and non-help-seeking groups is not surprising given the latter statement reflects the behavioural differences that were used to categorise the students related to self-regulatory skills. Likewise, having a sense of the expected goal is an important benchmark where a student is using help to improve or progress their learning. However, irrespective of achievement level, students all prioritised feedback that facilitates successful task completion and gave lower priority to feedback that facilitates transferability to multiple contexts, which has implications for the development of self-regulation skills at university.

Having individually deliberated on and prioritised statements about feedback in a diamond ranking exercise, the students participated in discussion about the statements, and reasons for order of ranking of statements across the group. A number of findings emerged from the analysis of this discussion. Individual experiences may differ from one another, supporting the assertion that there is a multiplicity of narratives about the use of feedback in

learning in large classes at university. Next, this study explores student perspectives on their understanding about feedback use and reasons for their level of engagement, and, as such, sheds further light on the results from the pathway analysis of hint use and the ranking of statements about feedback.

Findings: Students' beliefs and understandings about using feedback

Students' focus group discussions were examined iteratively utilising Hattie and Timperley's feedback model to search for different approaches to using feedback information. In perusing the data, similarities and differences between students were revealed in regard to the level at which they applied effort in using the feedback information, and how this related to their short- or long-term goals. All students were focused on working at task level, and less so at process level and self-regulation level, in order to attain short-term examination goals.

Prevailing feedback use is at task level

All students talked about working at task level. This is also evident in their prioritisation of task-related statements from the diamond ranking exercise. In particular, information related to feed up (where and I going?) and feedback (how am I going?) was emphasised as part of their learning strategies.

A clear view of task goal (feed up) is a priority

The high-achieving students identified that the feed up question (Where am I going?) at a task level, was a means to fine-tune their performance for impending summative assessments. From their experience of a range of assessments, including the online system, the students recognised the value of this type of feedback as directing them to keep track of relevant concepts and content, and believed this was explicit information about the outcomes they were expected to achieve in examinations:

> *I find that having some kind of exemplars for the course is really helpful otherwise you have got nowhere to focus on. And if you know what a good answer should look like then you can either attempt to learn or understand how they phrased it or work through that answer.* (Focus Group 2, NUH/HA)

> *Probably most important just to know the content and then once you're going to exam to backup with how the lecturers like it to be answered because that depends on how well you can say, how they want to hear it.* (Focus Group 4, UH/HA)

For the students, worked examples and clear instructions were appropriate formats for feed up information. They expected this information would enable them to complete work in a

relatively straightforward manner. The students discussed that feed up at task level was important for learning about the standard of work or performance required for summative assessments and being able to check the requirements of marking or success criteria. Less important to the students was how to deepen their understanding or adapt feed up information to other situations.

Task goal (feed up) information is not always useful

The low-achieving students were less positive about their experiences of feed up. The low-achiever group who did not seek help in the online system viewed the purpose of feed up as indicating the minimal effort required to work toward a goal:

> *Because it gives you bare minimum! Like let me do the least amount of grade – lets me know exactly what kind of stuff the markers are looking so I can just kind of tailor it to that and not have to extend or overshoot how much I have to put in….Irrelevant stuff they don't really mark on, you know not in the marking schedule things like that.* (Focus Group 1, NUH/LA)

The low-achieving non-help-seeking students expressed frustration about the instructions or the information about outcomes that did not directly allow them to attain their goals:

> *If we got really clear instructions, we don't even need a template or anything but a lot of the time, instructions weren't really that great.* (Focus Group 1, NUH/LA)

These low-achieving non-help-seeking students identified that not all feedback is useful. The students in this low-achieving group recognised feed up information could vary in quality with respect to outlining the goals or outcomes the task required and they were concerned that this had the potential to be detrimental to their learning, leading them to sometimes avoid using it.

The low-achieving help seekers were similarly not convinced how effective feed up information would be in supporting their learning. These students also articulated that sometimes the information could impact on their confidence to continue the task:

> *Like you know how sometimes oh this is what an A+ essay looks like, I always get freaked out. That so smart, I could never write something like that. So I don't like looking at that. I rather write my own piece and get my grade and then compare it.* (Focus Group 3, UH/LA)

> *I find sometimes like the guidelines you get for a piece of work aren't very clear like very vague. You want to see what to work towards, but it's kind of off-putting, you can't do that so it's just better to do your own work.* (Focus Group 3, UH/LA)

Some students found feed up information was a challenge, suggesting they may not have had the preparedness for the level at which they were working in a content-rich curriculum. In this regard, they were having difficulty in finding meaning in the information and the feed up was not providing what they needed to take action. While the gap may be significant, in some cases, it also been discouraged the students from making an effort.

Corrective task information needs to be timely

Students from both the low-achieving and high-achieving groups talked about feedback information or "how am I going" at task level. For the low-achieving, non-help-seeking group, this information was not necessarily used when the information was received at the end of the task:

> *I also usually don't like looking at feedback because if I have already handed something in, I also usually know what I've done wrong or what could have gone better and I don't need to see it again. It was what I did with the time I had.* (Focus Group 1, NUH/LA)

However, in the online system these low-achieving students, who did not use hints, were using the corrective information as they had the opportunity to redo the assessment. Their goal was to ensure they were maximising the marks gained for an activity, and feedback information is about confirming marks are accumulating:

> *The fact that you get multiple attempts with a question means it couldn't really make it any better for me…It meant that I had one quick run through to see how quickly I can get it and if I got something wrong, I have to stick around to repeat it and it takes longer.* (Focus Group 1, NUH/LA)

For the students in the other groups (all the high achievers and low achievers who use hints) feedback was important in identifying issues with their work. Implicit in the feedback was a means to seek reassurance they were on the right track. In other words, they were seeking corrective feedback. Thus, the students were working at task level, checking their acquisition of knowledge:

> *Just imperative to you know where you can improve, what went wrong.* (Focus Group 3, UH/LA)

> *In fact, relating to the questions if you can get specifically back which questions were right and which were wrong then you know like what you really understood and what*

you have no clue what you're talking about even if you think you know what you're talking but it turns out that you don't. (Focus Group 2, NUH/HA)

Sometimes when you know something is right – you know it's right. And you know you didn't need to have any more information but if you're guessing and getting it right. (Focus Group 2, NUH/HA)

Students had an awareness that feedback is an important confirmation of where they are in their learning; however, some students understood further value could be obtained from the information for taking corrective action. Here the students were beginning to develop a notion of the purpose of feed forward. The students were aware that this information, if aligned with feedback, could allow them to improve but only if they received this in time to make adjustments for final grading.

Corrective task information is not enough

Low-achieving and high-achieving students alike, identified that making progress and lifting their achievement, was more complex than simply knowing where they had gone wrong. Two years after the opportunity to use the MasteringBiology system, they knew that they needed more detailed and complex explanations that related to their work:

Specific feedback is good rather than the general like "I like the tone", "good essay". I mean you can tell it's a good essay if you get a good mark. A bad essay you get a bad mark. (Focus Group 2, NUH/HA)

Individualised feedback which is what I feel really helps you learn. (Focus Group 4, UH/HA)

So it's like fully understanding what you need to do before you continue. (Focus Group 1, NUH/LA)

More typically, the students appreciated the feedback on their work that helped them to know if their work was meeting the expectations of the course.

How much depth is needed in my work. (Focus Group 1, NUH/LA)

Something that I find helpful as well is if you get a mark back that they actually put on a marking rubric so you can see what the criteria and things they are looking for. (Focus Group 2, NUH/HA)

Looking back on their university study to date, all students had an appreciation of the different levels at which feedback can operate. They also understood that task-level corrective

information could be insufficient for them to take action. For these students, feedback was more than error detection, it was also about the process that could cue them to construct meaning and understanding:

> *So I guess if you get feedback to say "this is actually what you are meant to do" that would be helpful.* (Focus Group 3, UH/LA)

> *I think the best thing is if they could give us an explanation for the answer because in the second or third year, sometime you don't even know why your answer was incorrect as there was no explanation.* (Focus Group 4, UH/HA)

The students talked about their overarching goals in relation to their tendency to use feedback. Their attention was attuned to their expectations of summative assessment goals. Students talked about how their achievement levels were impeded without external feedback in relation to this goal. Feedback was viewed as a key strategic element for passing exams:

> *I think it's important because if you don't know it, you need to learn it to pass the exam. If you don't understand, find someone to help you.* (Focus Group 3, UH/LA)

> *Like when you receive feedback from tests and things like that and how they marked it as well would be really helpful.* (Focus Group 2, NUH/HA)

Although students recognised that, when receiving corrective feedback, it was helpful to have information about how to improve, they were also focused on information that confirmed specifically what was important to learn for tests and/or exams and techniques to learn for achieving marks.

Feedback after the completion of work has less impact

In discussion, the low-achieving and non-help-seeking students explored situations where they were disinclined to use the feedback they received during coursework. The students connected learning from feedback with a gain in their achievement. To engage with feedback, they stated that they needed to see an explicit and immediate chance to gain extra marks in their assessment task. The students who used this strategy did not have a sense of engaging with feedback in the long term as beneficial. Rather, they regarded their learning in discrete amounts and aligned with working at task level without generalising to other learning situations or building more effective strategies:

> *I say that's helpful but not necessarily useful if you are not assessed in that part of that subject or that format again like it's good to know where it went wrong but it's not helpful for the rest of the course.* (Focus Group 1, NUH/LA)

These low-achieving and non-help-seeking students also made reference to external pressures influencing how much of their time they spent using feedback. They made a conscious decision to not make use of feedback where there was no opportunity to increase the assessment mark. While students were aware of the value in using feedback to understand their faults, effort to do this was seen as at the expense of keeping up-to-date with other work:

> *For me, like once I get the assignment at the end, I would love to find out where I went wrong but you've got to keep going and so like you said so it becomes like what's the point because you've to hurry up and keep up.* (Focus Group 1, NUH/LA)

In the group of high achievers and non-help seekers, feedback after completion was seen as important:

> *Even if you don't have similar assessments I do feel that we are here not to just pass assessments. It's actually meant to teach us knowledge that adds meaning to our degree as well as passing assessments.* (Focus Group 2, NUH/HA)

This highlights that some students retain personal goals about building knowledge and believe university study is more than working through a series of milestone assessments. However, feed up and feedback at task level were not always viewed as transferable to other learning contexts. Here the focus on an endpoint (grade) minimises the extent and level at which students engage with information that has the potential to enhance their learning and be useful in other contexts.

Student use of feedback at the process level is limited

In order to become more proficient learners, students need to move to a process-level approach where they develop an understanding about the underlying processes used when solving problems. Building process knowledge enables students to transfer their understanding about how to go about completing related or similar pieces of work (Hattie & Timperley, 2007).

The use of process-level feedback is variable

Students in every group were keen on feedback on how to go about developing goals and they recognised that understanding the processes they used is a key strategy for success. They had a sense that knowing how to work at process would enable them to use their learning in other learning contexts, particularly where they could understand what to do to avoid repeating similar errors in other challenging situations. In this way, the students were talking about being able to move from immediate task completion to related tasks, and develop a strategy that would be useful in future learning; that is, it would lead to future self-regulation:

If I made a mistake, turn down the wrong road whatever, I need to know how to get back on track … learn how to get back. (Focus Group 1, NUH/LA)

I tried to make my own exemplar. It's kind of when you don't know how good that exemplar is. (Focus Group 2, NUH/HA)

If you've got a really bad mark then you kind of do really want to know what you need to do. "Why don't I know?" – it kind of makes it kind of harder. So I guess if you get feedback to say "this is actually what you meant to do" that would be helpful. (Focus Group 3, UH/LA)

But by looking at the successful piece of work and then like having your work next to it and then saying, okay I feel I'm good at this topic or stuff like that. And if you compare the two and then say, well this will come up like that, this will get that mark, this will get either better or worse mark, and then understand where those differences come from – I don't just mean looking at the good piece of work in isolation, I mean sort of comparing to yours, and saying, what are the discrepancies? (Focus Group 4, UH/HA)

If I got the question wrong the first-time round, and try to figure then what went wrong and that's kind of my way to study. (Focus Group 4, UH/HA)

In these cases, the students are aware they need to seek out information that allows them to determine or work out the underlying process, in some cases using their experience of errors they have made. The low-achieving students were looking externally to another agent for the information, whereas the high-achieving students commented about how to work out the process themselves after sourcing information to help them understand errors or make comparisons to expected standards. This demonstrates the latter students moved between levels as they were attempting to self-regulate. In this capacity, the high-achieving students considered it was important to know what the work should look like so they could determine the underlying processes to make gains in their achievement.

Feed up (*where am I going?)* was also an important question when working at process level for the low-achieving students. However, the students were distracted by other information determining how they were going (feedback) when working at process level. The low-achieving students judged their work quality by benchmarking their marks or grades relative to other students or other students' goals, not just their own. For these students the effort made, or the level of work achieved, to reach their learning goals was not just about their

individual gains, but was also where their grade might be based on rank position or relative to the other students in the course:

> *All quite scary when the lecturer tells you that your marks might be released after this lecture but the class average is 88%, and you think like oh my goodness, and you think am I above or below that average? It can be quite bad.* (Focus Group 3, UH/LA)

> *Like after exams and sometimes it says "class average" I found that feedback pretty cool especially if you're higher up. Like yes, I got more than the class average.* (Focus Group 3, UH/LA)

Where students were concerned about their position in relation to others in the course, they shifted their focus on the feed up and feedback at process level away from their goals of achieving learning outcomes and reverted to their perceived position relative to peers.

Getting started at process level is a difficult

Working at process level and regulating learning requires self-assessment and seeking further information when it is needed. Students were aware of needing to seek out such information, but were not always clear about how to go about getting help:

> *It's [feedback] the most helpful thing at uni but be able to do that is a different story. Like even in tutorials and stuff you can sometimes tell that people just don't get it but they do not ask for help and so it is hard to admit that you're needing help.* (Focus Group 1, NUH/LA)

> *I find that having some kind of exemplars for the course is really helpful otherwise you got nowhere to focus on. And if you know what a good answer should look like then you can either attempt to learn or understand how they phrased it or work through that answer.* (Focus Group 2, NUH/HA)

In discussion, students had a keen awareness of the value of feed up and feedback at process level but they were not always able to use information at this level in order to make learning gains. For these students, operating at process level was more complex and challenging to their confidence. This led to the need for external corroboration about their actions, which was not always possible within the course structure. In some cases, the students were frustrated by these challenges as they were aware understanding and using feedback at process level could lead to comprehensive development of knowledge and understanding. It is also less likely the students developed transferable strategies that led to successful performance in summative assessments.

Students challenged by feedback at the level of self-regulation

In the four focus groups, there was less discussion about self-regulating learning where students monitored their own learning and success. Given proficient learners are more likely to work at the self-regulation level, it was mostly the high-achieving students who talked about monitoring their learning.

Firstly, the high-achieving, help-seeking students talked about the challenges of learning where they were monitoring their own progress:

> *When you get to later years, sometimes you have a question, and you look up information on it, and there's all information around out there, and you have to search for quite a while.* (Focus Group 4, UH/HA)

The high-achieving non-help-seeking students were aware of the benefits of deeper learning and extending the use of feedback information to develop their learning strategies. However, these students monitored their progress and sought further feedback with the intention that they could adjust their approach to learning for success in the next cycle of summative assessments:

> *Something that would be quite good is feedback after exams.… I know the paper is over and it's sort of done but I mean you can build up for other papers so you sort of know where you've gone wrong in your study.* (Focus Group 2, NUH/HA)

Here, the students recognised a feedback aspect of information contained in exam results as confirming the processes they had undertaken as preparation were effective. Where the specific purpose of using feedback was to enable success in short-term summative assessments, learning that is more likely to lead to the development of tacit knowledge became less important.

> *If we are talking about what's helpful to learning… if we separate that in some cases from what helps for assessment, you know sometimes not always be the same thing.* (Focus Group 4, UH/HA)

> *I really echo that statement like it's not that important but sometimes focusing on assessment for the grade is kind of counterintuitive to actually getting there, and going through the process of using feedback can be that much better than looking at the "exemplar" which can sometimes be more daunting.* (Focus Group 4, UH/HA)

These comments indicate the students were aware of this tension in their learning approaches and the use of feedback.

Desire for feedback at self-level

Students from all groups expressed a view about feedback operating at the level of self or about them as a person. However, for some students, feedback at self-level was more important than for others and some comments revealed that their thoughts were contradictory.

Some of the low-achieving students expressed an explicit understanding that feedback at self-level was not that helpful to their learning, yet they also talked about their emotional responses associated with this type of feedback and whether they liked it or not:

> *I feel it's kind of weird when I didn't get a good mark back but it is like a positive reinforcement that it is quite motivating. Like if you get a good mark like cool, you're on the right track, I'm doing the right things.* (Focus Group 1, NUH/LA)

> *Yes, it doesn't seem academic kind of thing but it is important to get that feedback. It will give me the confidence to know that I'm a great student.* (Focus Group 1, NUH/LA)

> *Because it's no good for me you know. I just spend so much time trying to break the ego.* (Focus Group 1, NUH/LA)

> *Praise - It's good for like for a pat on the back!* (Focus Group 3, UH/LA)

Other low-achieving students recognised feedback about self or a sense of themselves as a learner, could be sourced from class performance information with a possible outcome of both positive and negative feelings about themselves as learners. If there was constructive support linked to feedback about self that was about difficulties in learning, however, then the students were more receptive:

> *I heard from other people they received email from the department like when they done the test, they didn't pass and they like ask "what's wrong – how can we help you to improve?" things like that. I thought that was quite good.* (Focus Group 3, UH/LA)

The high-achieving students in the group who were the non-help seekers, were also aware feedback at self-level contributed to their affective needs, although the impact was relatively low-key:

> *Praise - whilst it's not hugely helpful, what it does is gives you sort of motivational and confidence that you're on the right track. I find that I mean if you are in the 6 weeks before the exam, you get that kind of feedback even if it's just a throw-away comment by the lecturer or something, saying "good work" – it does gives you a bit of confidence and it does make you feel maybe I am not going to fail this exam or… so it does calm you down a bit.* (Focus Group 2, NUH/HA)

The help-seeking and high-achieving students, however, placed the least importance on feedback about self:

> *I think of it [praise] as irrelevant.* (Focus Group 4, UH/HA)

> *I thought it's [praise] interesting. I think everything is important.* (Focus Group 4, UH/HA)

Feedback about self is important to students, particularly as a means to help them with building confidence in their learning. The students who were the more proficient learners felt less of a need for this type of information.

Context matters when using feedback

All of the students talked about using feedback in learning at tertiary level where their expectation of success was dependent on the environment being conducive to their learning needs. The belief that the use of feedback was limited by some aspects within the context of learning at university was a key influencer on the achievement of their goals.

Focus is on assessments that contribute marks to grades

Students in both high- and low-achieving groups alike, talked about their time at university as a gradual progression toward their goal of a tertiary qualification. Students were also keenly aware that summative assessments such as examinations were the interim checkpoints toward this goal which could lead to or limit their future options. Gaining passes in courses was the focus for many students. This was particularly relevant in first year and students experienced further pressure to achieve high-grade averages to gain entry to many professional programmes. As such, summative assessment design within their courses was the predominant lens through which they viewed all content and activities. Students talked about engaging with course material only if it was directly relevant to summative assessments, yet they were aware these decisions were not necessarily productive for their learning.

Obtaining enough marks to pass a course was a clear goal for the low-achieving students. The group who did not use hints/feedback in the online system, talked about how they focused on accumulating marks toward a passing grade as they engaged with the electronic system and during other coursework that contributed to final grades. These students saw learning separately from the goal of passing to gain a degree:

> *Learning for me wasn't really my goal at university like I'm not necessarily here to learn; I was here to get a degree so it's something that I'm not even that interested in so when you asked question like something helpful for my learning I really like assume*

that means something that will help me to pass the paper rather than actually like making it useful learning. (Focus Group 1, NUH/LA)

Like I totally have that study smart not hard… so I can do the best I possibly can and try to get the marks, and also put in that little effort before that. (Focus Group 1, NUH/LA)

It basically reflects my whole studies, smart not hard and I want to do well. I guess try to manage my time and where it's not going to help me. And I guess knowing what is helpful but not necessary always picking those right choices. (Focus Group 1, NUH/LA)

Thus, these low-achieving students did not associate completing the online activities with facilitating improvement in their performance. Rather, their expectations were that any input in the learning environment should relate directly to meeting a target (output) of the qualification, their goal. The students did not identify longer term value or potential gains to achievement if they spend more time on comprehensive approaches.

In contrast, the low-achieving students who sought help in the electronic system, while also focused on aggregating marks, recognised the particular way they were engaging with the activities was not helpful for their learning. Despite this awareness, they maintained the same routines in their coursework:

I see it as a 3–5% – like I normally do it last minute so I don't find it that helpful. (Focus Group 3, UH/LA)

From their descriptions of completing coursework, all the low-achieving students appeared to not to know what strategies were effective for them to achieve their goals. Absent from these students' understanding of the learning process was the interactive use of feedback on their part that could be useful if they encountered similar problems in later summative assessments.

Limited time impacts students' learning

Students talked about managing the challenges and needs of studying at tertiary level in terms of the time available for their coursework. Many students had a perception of a condensed period for learning, which created demands on and limited the time available to do all their university work. All students talked about the challenges of a compact course design, where they had a sense of shorter time periods to meet their commitments for some coursework and considered this influenced how they engaged with work:

At the beginning we all start with really good intentions – we're going to learn and have a complete understanding, and then you get all these assignments, you just like, want to do well. And then [you] just move on because too much is piling up and so when I start using this [the online activities] I intend to go through all the things and towards the end, I think I have got this many marks that's enough. I have to move on now and I'm tired. (Focus Group 2, NUH/HA)

Yes there's like some of the ones that I really want to know, [but I think] like "oh man," I have to hurry up and keep up with other assignments and the exam will be up – so I probably look at it later but I never did. (Focus Group 1, NUH/LA)

While the low-achieving students indicated their initial intentions were to embark on a comprehensive learning experience, they considered time was a definite constraint. The students saw ongoing deadlines as problematic and difficult. This belief impacted on their behaviour managing multiple assessment contexts. Moreover, the low-achieving students did not have a sense of control over their learning:

Because we have a limited time, we were forced to do this. (Focus Group 1, NUH/LA)

The students articulated that the sense of being *forced* to do assessments was related to gaining marks:

We needed to do [this] for marks and just come to get out of the way. But I wouldn't have done anything…if it wasn't forced on us – it's good that we have it. Because I would never have done it otherwise. (Focus Group 1, NUH/LA)

Thus, the students felt controlled in their learning, rather than having the ability to take responsibility for planning when they would complete assessments. They believed a consequence was a negative impact on learning gains:

Always have to set aside the time to do it I find that a bit annoying. Again, I left things to the last minute. (Focus Group 3, UH/LA)

Sometimes, it depends when you did it – it was at the last minute when I did it. (Focus Group 3, UH/LA)

I normally do it last minute so I don't find it that helpful. (Focus Group 3, UH/LA)

In an online context, given such time constraints, the low-achieving students talked about how they engaged with activities randomly and made a quick or last-minute judgement in some cases:

I just click because I have to hurry up and so I go yep this, this, this whatever it sounds right for me. (Focus Group 1, NUH/LA)

Especially the last minute, you tried to click as much clicks until you get the right answer. So it's not that helpful in that sense. (Focus Group 3, UH/LA)

In contrast, the high-achieving students, although they recognised their behaviour was controlled or forced in terms of engagement, were aware of the gains when they worked to deadlines:

I think it's also a good chance for almost compulsory learning and like we can easily put it off like till right before exams but since the deadlines kept coming, although I kind of felt it was like a chore, I remember now at the time it actually like forced my learning like without intending to which is quite helpful I think. (Focus Group 4, UH/HA)

Further, high-achieving students recognised that not all learning situations had the same time pressures and it was possible to engage more fully with their learning when the context was low-stakes:

I actually felt like I learned more from Mastering because I had the time to think it through. There wasn't as much time pressure. I know I can make a mistake and see where I have done wrong. (Focus Group 4, UH/HA)

The high-achieving students considered limited time was a negative aspect of the lecture structure and made it difficult to address gaps in their understanding. Further, their concerns about the consequences for their learning were ongoing and cumulative:

I go to the lecture and I will listen to the lecture but don't often understand all of the content, and once I've gone home and studied all of them like I open up my textbook to figure out what I don't understand. And then by that time I have a new lecturer or I have to email the lecturer to organise some time to meet up and ask questions. So I often don't ask questions straight after the lecture because I don't understand after the lecture because I don't have time to process it. (Focus Group 2, NUH/HA)

Most of the time people…after they just had their lectures so they don't have the time to revisit the content and you don't actually find out until later what you don't understand. (Focus Group 2, NUH/HA)

For some of the high-achieving students, time spent on work was related to the output in terms of the grade, with time period equivalent to weighted grade contribution. This behavioural strategy created a sense of urgency and frustration around their learning as they felt they had spent more time on a task than was required:

> *We had this one little module I think normally it would take 30 minutes. But for most of them it took 2 hours, and everyone had that problem and we had to complete this in the lab. We all thought how could this tiny thing worth a tiny amount take so much time. I think I remember us making a diagram and we hadn't been taught the diagram up to that level which was as complex as our lectures. We had to figure out that one question of that whole entire section that just took so much time.* (Focus Group 2, NUH/HA)

Although the high-achieving students were focused on the marks gained in an assessment, they also had a sense that there were further gains in learning possible that could benefit the understanding required for achievement at another time. They recognised the benefit of engaging fully with the work so they understood concepts which were valuable for other courses and subsequent years of learning. Further, they believed a competent student makes good use of time for learning and prioritises time on key aspects of the course:

> *There is one thing that is really good is if you're really struggling with a question, it's so nice to have that exact information right there because maybe first year like the general topic, it's alright. But definitely when you get to later years, sometimes you have a question, and you look up information on it, and there's all information around out there, and you have to search for quite a while. So having information that's really about the question up there [in the online system], it can give you the concrete understanding and is really helpful.* (Focus Group 4, UH/HA)

The high-achieving students' reflections on their experience in the online system, MasteringBiology, also highlighted to them how delaying the start time for working affected learning gains. These students were also able to recognise that they were not always taking full advantage of the system to support their understanding. Here, a student reflects on a strategy for seeking help in the online system, which they had not done at the time they used the system:

> *I think a good way might be to try to answer all the questions using the knowledge I already have and then go back and open up all the hints and see if there's something I have missed even I have got the question right, use it to help me to work the answer, I probably wouldn't have done at the time because of time.* (Focus Group 2, NUH/HA)

All students articulated a self-awareness about responsibility for their actions and that using time effectively for learning was a struggle, often leading to working in high-stress situations:

> *I have noticed that in third year, you are kind of keeping up with the whole course kind of slacks when they don't have activities to do. I might not even look at the course for a month at a time. I would have no idea what's going on until I get you know close to a test or something, I have to cram everything.* (Focus Group 1, NUH/LA)

As part of this struggle, the students discussed how time issues made it difficult to complete the aspects they were aware were important to their learning. There was a sense of pressure requiring the ability to decide about what they spent their time working on for greatest benefit, as this was critical to passing courses. However, they were not confident in making these decisions about effective use of their time:

> *I guess I try to manage my time where it's not going to help me. And I guess also reflects like knowing what is helpful but not necessary; always picking those right choices.* (Focus Group 1, NUH/LA)

> *I think... at the time I have so much stuff on and I'm like studying all the time and you kind of, I don't know, [You're] overwhelmed.…Like so much stuff to get through.* (Focus Group 2, NUH/HA)

> *And you don't want to add to it – I've done it! I don't want really to go back but I don't have enough marks. Sometimes you like I don't really care but there's enough to get a good grade and I can just move on.* (Focus Group 2, NUH/HA)

> *Yes, that was good but the thing is that I found was it takes too much time to do one block of questions.* (Focus Group 3, UH/LA)

A safe learning environment is reliant on relationships with peers and teachers

Students believe their relationships with peers and teachers are linked to learning in a safe environment. Time constraints during the learning period compounded other aspects of the learning environment and students talked about their vulnerability as a learner when they were unable to build relationships with peers and teachers. An important aspect of adapting to the university as a new context was the establishment of new learning behaviours and new relationships with other students in their classes. In addition to adapting to the university environment, students were learning in classes on a much larger scale than previously experienced. In this context, the students articulated the challenge of trusting others, both students and teachers.

Peers cannot be relied on

Both low-achieving and high-achieving students expressed concerns about the reliability of their peers taking the same courses as them and this was a persistent issue during the entire semester. The theme captures two facets about working with peers. First, the students perceived a non-friendly learning environment that was competitive due to the high-stakes outcomes. The students were aware that a large proportion of students in the class had significant career goals that depended on the grades they achieved. These goals would be met or not by the end of the year when many of the students applied for highly competitive programmes that educated them for high-paying professions. Second, due to the competitive environment, the students questioned the reliability of peers when working in groups as part of class activities. They found there was insufficient time to build relationships and establish trust their peers. Whether other peers could be relied on in terms of their knowledge or understanding was a cause for concern for many students. The low-achieving students were suspicious of peers' knowledge and understanding and the risk associated with learning inaccurate information:

> *And often they don't really know what they're talking about.* (Focus Group 1, NUH/LA)

> *No one knows what they are talking about. And it's better to get information and stuff from your lecturer/teacher rather than from people in your class.* (Focus Group 1, NUH/LA)

> *Why would other students know better than me? I won't consider their feedback valid – it's just like you don't know what you are talking there.* (Focus Group 1, NUH/LA)

> *Yes, I agree with that and that's quite dangerous because if you go off learning something not even right and we as learners are worse, it's harder. So why would you go to the wrong source when you can just go straight to the source.* (Focus Group 1, NUH/LA)

> *Some students are just way too confident when they have the complete wrong idea.* (Focus Group 1, NUH/LA)

> *I've seen it, I don't get involved. Like no you should go and read – it's just like well I'm just going to the lecturer.* (Focus Group 1, NUH/LA)

While the low-achieving students were not confident in being assessed or critiqued on the basis of their peers work or their contributions during learning, the high-achieving students took a cautious approach. As they were aware that peers may not be knowledgeable, they considered

it more important to check from reliable sources in terms of literature and teaching staff. Thus, they managed the inconsistencies in peers' contributions and potential issues of unreliability:

> *Unless you've got a friend that you know is super-smart, when someone else corrects your work, sometimes you like, are you sure like I kind of sometimes doubt them unlike tutor or lecturers then you know it's definitely right.* (Focus Group 2, NUH/HA)

> *Sometimes, if I was going to ask a friend or someone a question, I don't know a hundred percent if they're going to get the answer right so I'd rather look in the textbook or look at the lecture content again because I could get the right answer there. Whereas, sometimes I don't believe a hundred percent without doubt, especially with like Bio there is a lot of content but it's not sort of open-interpretation and you need sort of facts … you know.* (Focus Group 2, NUH/HA)

> *I remember sometimes I like telling the tutor whatever exactly I think because if I tell my friend and I'm wrong but I think I'm right and I don't get corrected but I have to tell the teacher and then they like wait "that bit is wrong" and you have to go back and think about it. Because I remember doing that in some tutorials before, teach you guys research this bit, another group researches this bit, and then you just teach each other. Some of the quality of the works that were presented from the other group was not as good.* (Focus Group 2, NUH/HA)

For all students, working with peers introduced new issues into an already tight schedule of learning. The low-achieving students were concerned about their own competence in assessing whether peers were reliable and accurate in their work, bringing trust issues into the learning context. Time availability also impacted on relationship building in the class as students had minimal interactive experience in class where they can get to know peers. In contrast, the high-achieving students, who had similar concerns to the low-achieving students, were aware this could be remedied by checking other sources, indicating self-regulation skills.

Students believe teachers' expectations are variable and difficult to manage

The high-achieving students talked about the frustrations they experienced by not knowing what teachers expected of them in terms of assessments. The students perceived variability in their teachers' expectations and criteria for completing tasks and processes as part of assessment:

> *The difference at uni I feel like there's so many more lecturers for that one paper. So all of them kind of have a different idea of how you should be writing essay or whatever.*

> *Some of them will give you marks for style if you put an introduction or a double space. But you don't know what their internal criteria is. And you also have your own internal criteria because you know when you study you only try to beat how you did last time but you don't really know where you stand with the other 500 people like "am I doing well" amongst these people or "am I in the lower half?"* (Focus Group 2, NUH/HA)

While these students were aware of the knowledge skill set of their teachers, it was not always possible to build relationships with their teachers to facilitate discussion or seek help. Faced with large-scale classes and managing in a condensed-time period, the students had difficulty gauging the range of expectations. With limited opportunities to establish a connection, the students talked about how participation was challenging. Implicit in their comments was the lack of opportunity to resolve problems which impacted on their learning, and not having their needs met:

> *I guess what I noticed in [a large course] specifically, I didn't find it that helpful because as mentioned in a big classroom, it was awkward tension sort of thing. And it wasn't effectively done perhaps.* (Focus Group 4, UH/HA)

> *But then I actually didn't ask single question of any of the lecturers or after the lectures or anything like that. It was just too daunting you know for people. I mean there was one time I didn't want to go down, there was this huge line of people.* (Focus Group 4, UH/HA)

Here, the students talked about feeling restrained in making connections with teachers. This was compounded by their apprehension at discussing freely and openly with their peers in a competitive context. The students' reticence to communicate had the potential to limit their development of skills to regulate their learning as they had little trust when working with their peers and teachers. With few opportunities for dialogue, which can help students to monitor their progress, the students were more dependent on print, online sources and their own judgements about their work.

Students need to maintain their reputation

The students expressed a reticence to interact with other peers and teachers in these large competitive classroom cultures. They did not want to put their reputation at risk and so they behaved in a way to protect their self-efficacy:

I guess being lazy and short of time so maybe like I wouldn't want to admit like I was too embarrassed to admit if I wasn't able or couldn't do so many things I guess. (Focus Group 1, NUH/LA)

I don't like seeking feedback normally because I don't want people to see what I've done wrong. (Focus Group 1, NUH/LA)

First year I don't think I asked that many questions. (Focus Group 3, UH/LA)

Once there are too many people, I find don't feel like asking. (Focus Group 3, UH/LA)

The high-achieving students also referred to a spectrum of behaviours, from adapting and reconfirming their self-efficacy to withdrawing from [not getting involved] class dynamics. Implicit in these behaviours is that all the students felt challenged by interactions with people in their tertiary courses. The students rationalised their reactions and behaviours as maintaining and protecting their individual reputation and personal characters.

I got feedback from answering questions online on my activities because you can do it in your own time. You don't have to be dependent on the lecturer's reply and little work getting contact with one and usually get multiple teams. It's not stressful like asking somebody in class and be embarrassed – like it's just on your computer. You get feedback straightaway and usually relevant. It's not just like the lecturer might just say read this page such in your textbook and this will be right. You get the feedback and it will probably give you the direct information about how to correct your work. (Focus Group 4, UH/HA)

Because I kind of felt like in first year, we spend a year in these huge classes when like you arrive in uni and especially in an environment where there is quite a lot of competition and people aiming for very high marks, no one really wants to get anything wrong so when the lecturer asks a question, and there will be dead silence. And no one wants to break that silence. And maybe some lecturers will get something going but it's usually quite quiet. And I think spending a year like that, it kind of gets like ingrained in you and then it takes a while to break that in second and third year in tutorials. (Focus Group 4, UH/HA)

The high-achieving students had insight that this impacted their learning progress when they tried to sort out the gaps and misunderstandings:

> *That's why I want to talk because I really think that changing the atmosphere… I think that if you're able to sort of break the sort of competitive nature of the course.* (Focus Group 4, UH/HA)

The low-achieving students' concerns were expressed as feelings about themselves. They rationalised their behaviour or limited interaction with other students in terms of their own inadequacies or limited competence that they did not want peers to observe:

> *I feel embarrassed if I have asked a stupid question. What if everyone else already know the answer so I found my own way to approach the lecturer by myself so I don't get embarrassed.* (Focus Group 3, UH/LA)

Chapter summary

To summarise, students viewed feedback as a natural part of their learning and articulated receiving it and responding to it in different ways. Students' descriptions revealed that they understood not all feedback was the same, and they used it for different purposes demonstrating the multidimensionality aspect of using information to support learning. They viewed feedback as providing for different needs during learning, with some students emphasising distinct approaches in their learning and completion of assessment tasks. Most students focused on using feedback at task level as this was type of information they recognised and believed was readily available. All students used feed up to know the key content and standard required; however, the extent of use varied depending on intended outcomes with the low achievers using this information to help them pass assessments to gain marks for summative assessments. The limited use occurred when they had difficulty finding meaning in the information which may not have been at the level they needed. The high achievers appreciated that feed up information enriched their understanding of the material. Students were keen users of corrective feedback

All students had knowledge of the purpose of corrective feedback and considered this was important to ensure they could move forward. However, the information to extend their understanding was not always clear to the students and, in many situations, they believed it was not available. Further, students were more challenged by feedback at process level and believed they were less likely to receive this and be effective. They also found feedback at self-regulation level was constrained by the focus on summative assessment and the need to streamline their effort toward these goals.

Students believed many aspects of the context in higher education affected how they used feedback and influenced the way they worked and approached their learning. Where the

course assessment design was high risk and summative assessment predominated, there was less attention to feedback opportunities despite students' awareness of the benefit to learning. Further constraints such as limited time created a sense of urgency leading to the need to make decisions about what and how they engaged with various aspects of a course. There was also less time to build relationships with peers and teachers, which they knew was important to facilitating their learning and becoming confident in their interactions.

The next chapter

A discussion of the research findings follows, in the next chapter, and is structured around the overarching themes that emerged from the data: students' understanding of feedback in an online and undergraduate context, how and why students use feedback or not in this context, and some of the reasons that constrain or impact students' use of feedback. Discussion also considers how students' achievement levels and skills as proficient learners may influence the learner's experience. Relevant formative and summative assessment and feedback literature, as well as literature drawn from the fields of transitioning to university, informs the discussion.

Chapter 8
Discussion, implications, conclusions and recommendations

Introduction

This thesis has explored students' understanding and choices made with respect to their feedback use in different learning contexts during their undergraduate biology courses. In the first phase, a quasi-experimental study investigated students' interactions with feedback delivered via online activities blended into a traditional campus course as an approach for formative assessment to support independent learning in a large first-year biology class. In the second phase, qualitative approaches provided a richer insight into students' perceptions about their use and level of engagement with feedback across their undergraduate experience. Situated in a higher education context, the thesis has examined the influence of students' perceptions and understandings of feedback on their engagement with feedback.

This final chapter brings together the findings of the two phases of research to discuss how students engage with feedback in the context of higher education biological science courses and, how their understanding of, and engagement with, feedback influences and is influenced by these experiences and perceptions. The chapter begins with a brief summary of the study results before discussing the theoretical and policy implications of the findings. As the work presented here is part of an education doctorate, the practical implications for feedback provision and use in undergraduate courses are emphasised. The limitations of this study are discussed and possible future research studies that may further support and inform teaching and learning are recommended.

Summary of findings

Phase 1 of this study used structural equation modelling to identify who used the MasteringBiology hint system and to discover the relationship of such usage to learning achievement (Chapter 3). In the first half of the semester, usage was more common among lower achieving students, with greater usage predicting further usage in the second half of the semester. Unfortunately, usage in the first half did not contribute to achievement on the mid-term test, but by the end-of-course exam, continued usage had a small positive contribution to

test performance. Thus, this study showed that hint usage could help students with weaker starting competence to do better.

Phase 2 selected students from the Study 1 data according to whether they were high or low users and high or low achievers. This allowed the creation of four focus groups in a 2*2 framework (usage vs achievement). Each focus group began with stimulus material to facilitate recall of the online system, followed by an individual activity in which they ranked, in terms of importance, different kinds of feedback (Chapter 4). Then a semi-structured group discussion took place in which students retrospectively explained how they used the hint system, why they used it as they did, and how it made them feel, both at the time and subsequently (Chapter 4). The ranking procedure showed that task-level feedback was important, while feedback at process and self-regulated learning level was less so. The discussion groups revealed the students used the system feedback for building domain knowledge in preference to using feedback to support their learning process and progress to a deeper understanding. Feedback use by students depended on their personal experience and the learning context; their emotions and feelings influenced the extent to which they used feedback as part of different learning strategies.

Discussion of the findings

The central question addressed in this project was: "How is feedback conceptualised and used to support learning by tertiary biology students?" The findings are discussed thematically around the role of technology, feedback itself, features of time constraints, and emotional responses that contribute to different contexts existing in the same learning environment.

Technology as feedback system

Universities are increasingly turning to technology systems to assist with important processes (e.g., assessment and feedback) to overcome the challenge of large classes. In higher education, online formative assessment is increasingly provided as part of blended learning contexts using tools such as self-test quiz tools, discussion forums and e-portfolios (Gikandi, Morrow, & Davis, 2011; Rowe, 2011). As the use of technology in large-sized classes in higher education settings is becoming commonplace as a means of addressing the challenge of providing adequate feedback (Ferrell & Sheppard, 2013; Ferrell & Stewart, 2014; Fyfe et al., 2014; Gikandi et al., 2011), efficacy of the technology for improved learning outcomes is an important concern for course design. A key challenge, in using technology for instructional feedback and learning, is determining the extent to which students engage with learning

opportunities that deepen their understanding as they work toward a learning target (Stiggins, 2005).

The first phase of this project investigated the efficacy of online feedback, and used interaction traces from student activity in the automated tutoring system MasteringBiology. MasteringBiology is one educational technology that promises support to students through its extensive hint system. The students were able to gain a small number of marks for timely completion as an incentive to complete online activities incorporating feedback, and they could take multiple attempts, in which they were able to make mistakes without penalty, in the online system. This system provides structured feedback in accordance with good feedback principles (Nicol & Macfarlane-Dick, 2006), especially around task and process (Hattie & Timperley, 2007). Unsurprisingly, the system provided limited opportunities for teacher and peer dialogue around learning. Deliberative practice accompanied by success confirmation feedback, and support as needed, facilitates mastery in learning (Hattie, 2014). MasteringBiology delivers feedback for practice, and also provides opportunities for students to operate autonomously because they have to self-regulate their own access and use of relevant feedback. While the system oriented the students to work at the task and process level, metacognitive engagement via self-regulation was supported only if students opted to use the hint system to extend their learning and strive for improvement. In effect, the students could take responsibility for "where to next?" When students used the optional feed forward hint information, they were provided with help to clarify the procedural aspects of an activity and learn any disciplinary knowledge that was required to successfully complete tasks.

The pathway analysis indicated that the students who were academically weaker at the start of the semester tended to use the hints more. These students engaged more extensively with feedback in the hint system beyond the basic incentive related to mark accrual. This confirms that the technology supported feed forward actions enabling students to seek explanatory and directive information about how to take action and improve performance. The somewhat greater initial usage by low-achieving students ($\beta = -.34$ from entry GPE) suggested there was a tendency for students to have some self-awareness of their need for additional help and manage this help seeking themselves. Unfortunately, hint usage did not pay off quickly in improved test performance, and this may have contributed to reduced usage in the second half of the semester. This lack of rapid achievement increase following hint use could come about because the time taken to engage with hints during activities impacted on preparation time needed for formal assessments. Furthermore, a lack of rapid results may have contributed to a belief that the time taken to get hints was counterproductive.

Unfortunately, few students overall used the online feedback opportunities in the system, and thus were not taking advantage of all the opportunities for learning. Hence, this study provided evidence about the relative low attractiveness of online feedback delivery for formative assessment in a first-year biology course. Naturally, one would expect students who believe they are coping to not make use of a hint system designed to teach how to do a task that they believed they knew how to do. However, because not all students who interacted with the online system achieved well on the assessments, the findings could be viewed as disappointing for teachers in the course and the developers of the system, and certainly led to questions about the benefits of online formats for the provision of feedback.

Phase 1 results differ from other studies investigating the efficacy of online feedback delivery. In their review, Gikandi et al. (2011) highlighted that online formative assessment can provide the means to align assessment with teaching and learning and like Hattie and Timperley (2007) concluded that there was an effect size similar to d=0.52 for "computer-assisted instructional feedback" (p.84). While some studies have reported that using online systems provides feedback opportunities for student learning and results in gains in achievement (Carnegie, 2015; Hodgson & Pang, 2012; Sly, 1999; Wang, 2007), other studies have found mixed outcomes for students. While access to online learning opportunities has been demonstrated to be well received by students (V. Crisp & Ward, 2008; Herrington, Reeves, & Oliver, 2006), use of these formative assessment activities does not necessarily lead to an improvement in grades (Henly, 2003; Miller, 2009). This study can show that usage of the hint systems does pay off for greater learning but that it requires persistence, which can be problematic as time-pressured students may prefer to see quick results.

Nonetheless, the technology system did bring benefit, especially to lower achieving students who used the hints. Relative to human resources, it would be expected that the technology is comparatively cheap and this may justify continuing to provide the resource.

Students' perceptions about the utility of technology as feedback

The inconsistency in reported outcomes, across multiple studies on feedback use, highlights why checking with the students themselves is critical to gauge the effectiveness of the assessment tasks in terms of their learning approach (Sadler, 2015). More importantly, it is critical to gauge whether online feedback systems are able to provide competent learners with feedback that they can use as a means to engage productively and improve their achievement. The second phase of this thesis explored students' perceptions about what they understood as feedback in an online context, whether they used the feedback if provided, how they used

feedback, and, in particular, if students used feedback to support their development of deeper understanding of their disciplinary knowledge and skills.

Students' retrospective reflections about using the system revealed more subtle differences in their reasons than was apparent from the frequency of use by achievement results index investigated in Phase 1. Facilitated discussions in focus groups, where participants were organised into four groups in a 2*2 framework (usage vs achievement), provided means to draw out differences and similarities between the groups.

All students emphasised the positive benefits of the instructional aspect of the system, reflecting their familiarity with other learning contexts where they were provided with learning goals and key content or concepts of disciplinary knowledge (Nicol & Macfarlane-Dick, 2006; Shute, 2008). In terms of Hattie and Timperley's model, the format of goals and content in the online system mapped to feed up, and was the first interaction in the system for completion prior to the activities that mapped to feedback and feed forward in the model (Chapter 3). Although student use of feed up for an activity was not time logged, the students valued the system feed up as they recognised there were knowledgeable and competent subject-matter experts involved in designing and preparing the content-rich activities. Sadler (2010) refers to this information as telling or disclosure; had the information been delivered didactically many students may not have understood the composition of the material (Sadler, 2010). Content delivered in online formats can sometimes scaffold understanding of difficult concepts by combining visual, textual and audio components that can be viewed a number of times. For the students, this aspect of the system represented an alternative asynchronous source of content and exemplars as feed up, or "where am I going?", thus communicating to students the required quality of work (Booth, Dixon, & Hill, 2016). Shute (2008) refers to this type of feedback as reducing the cognitive load, which is important for low-achieving students or novice learners. As a form of instruction, online feed up was important to the students for giving them a sense of agency in their learning, where they take the initial step in learning, as students genuinely want feedback that facilitates deep learning (Higgins et al., 2002). In Phase 2, the students shared a common perception of the utility of feed up, as providing the relevant discipline knowledge required to complete the online activities in which they used corrective feedback for confirmation of their understanding and knowledge. These students gained a sense of security in being able to access re-teaching when they needed to establish clarity about goals, and expected standards of performance (Butler & Winne, 1995; Nicol & Macfarlane-Dick, 2006).

Students paid attention to instructional information as there were consequences for tests and exams. Not all students, however, engaged with the optional feed forward information that had the potential to facilitate deeper learning. There was variability in how and why the students interacted with feedback and feed forward questions at different levels of task, process and self-regulation in the system, a finding consistent with the large body of research on feedback (Shute, 2008). Studies indicate that students find the culture of feedback different as they transition to higher education (Beaumont et al., 2011), and they arrive with a multiplicity of experiences reflecting the diversity inherent within a large student body (Harvey et al., 2006). In this thesis study, the prospect of identifying a weakness in their understanding, or following processes to overcome a gap in learning by using feedback, was less attractive to some students. The students were able to make meaning within their online learning context but their perceptions of the system's assessment processes influenced how they learned in the system, a finding that concurs with other studies (Biggs, 2003).

Students' wider experience appeared to influence their interactions with the online feedback system. While the intention of the online system, as part of the blended learning design, was to provide formative assessment and feedback to individuals, many of the students viewed the online activities as part of summative assessments, albeit with opportunities for rehearsal and practice. In the online activities, corrective feedback was automated and the students re-visited feed up if required to gain the pass mark threshold in an activity. Students, no matter how they achieved on the course, viewed the activities primarily as an opportunity to gain marks to contribute to final grades and therefore focused on completing the activities before each deadline to receive the associated mark reward. Their focus on marks indicates that summative assessment outcomes are a strong driver for student behaviour during learning as they reward their attention to particular material (Assor & Gordon, 1987; Ramsden, 2003). In the focus groups, the students were explicit about the fact that gaining marks took priority over using the feedback, underlining the difficulty of motivating students to use the feedback they receive. Other studies too have found that students acknowledged they did not always use or benefit from feedback in their large undergraduate class context (Price et al., 2010). In this thesis, the students discussed a range of beliefs and strategies from minimal interaction and actively ignoring feedback, through to proactively looking for feedback opportunities to improve their disciplinary knowledge.

Students, across the range of achievement levels, resisted using the hints (or feed forward). Students reported that they had evaluated the cost of investing time and effort to use the hints system and judged it too expensive in terms of any potential improvements to their

course grade. Student resistance to using online feed forward was multifaceted, with some low-achieving students viewing the system as primarily for the accrual of course marks or an external reward and they associated system use with grading purposes which compromised formative feedback opportunities (Shute, 2008). Other students, due to time pressure, deemed hint use as unnecessary in terms of the summative assessment goals and resisted using feed forward information in the hints or help that potentially deepened their understanding to a more comprehensive level. For this reason, students viewed online tasks as an obligatory part of coursework assessment and not for supporting learning, providing evidence that assessment design drives how students interact with tasks. The students' resistance compromised the potential of the online feedback, demonstrating the critical issue of assessment design and its effects on learning and teaching in university contexts (Carless, 2017). Students in this thesis project felt obligated to complete mandatory online activities and saw the potential for increasing their final grade by rehearsing/practising for summative assessment as justifying the time it took to complete activities; they did not, however, link the information back to goals and expected content and concepts (feed up) to improve the depth of their understanding. Although monitoring is pivotal to self-regulated task engagement (Butler & Winne, 1995), in this case it was part of a strategic approach to enhance summative outcomes. In reframing the purpose of the formative activities as rehearsal, these students developed a superficial focus on mark collecting as their preferred learning strategy. It was far less palatable for these students to request help, which in turn reinforced their sense of inadequacy or incompetency. The need to use feedback information and/or seek help was viewed by them as an indicator of low proficiency. They had expected that they would be able to absorb the knowledge on their first encounter without needing to strengthen or extend their understanding. This aligns with the notion of feedback as something that happens externally to them and mechanistically (Boud & Molloy, 2013). The students' perceptions indicated that underlying their expectations about feedback were more complex affective and/or emotional reasons that also limited their approach to using the full potential of the system. Rowe (2011) highlighted the need to take into account the emotional aspects (both positive and negative) of students' perceptions about feedback (Rowe, 2011).

The more proficient students who did not use hints, viewed help seeking as a sign of weakness in their knowledge and understanding and concluded the cost associated with investing time in seeking and using help resulted in little or no gain given the format of the summative assessments. This strategy was reinforced by their previous experience of academic success after minimal effort. For these students, the use of the feed up information was

sufficient effort to enable them to monitor their learning progress and reach their desired level. The students were cognisant of their limited monitoring approach, suggesting they were using self-regulation strategies, albeit incipient, deliberately. All the students interviewed in the focus groups stated that there was very limited time to complete the course content, that there were multiple demands on their time, the workload associated with this course (40 lectures in 12 weeks) was huge, and that their other courses were busy as well. Thus, they adopted a strongly strategic approach to learning, in which seeking learning-oriented feedback was seen as a counterproductive learning practice. For these more proficient students, seeking help also threatened their reputation as a competent student, but for different reasons. They believed it was important that any improvements in achievement came from their own individual cognitive effort and ability, as to do otherwise threatened their self-efficacy. These students held the view that feedback was a resource for remedial purposes for students without the background or study skills to succeed, and therefore for use by low-achieving students. On reflection, and removed from the pressure of the high-stakes assessment environment, these students recognised the value in using feed forward information as a positive strategy for deep learning, although this subsequent development of their metacognition meant early feedback use in their first year of university had been minimal. However, the findings suggest that due to the powerful messages built into the tests, and exam-based systems and extensive workloads, many of the students ignored the online system as a context for deep learning and used it only to secure a few extra marks by completing the assignments provided. Effective use of the system was predicated on students having self-regulation skills so that they would evaluate and monitor their learning as they transitioned to university. It is apparent that for some students, their self-regulation skills were countered by the influence of summative assessment that directs the students to the de facto agenda for learning (Boud, 2000).

Some students in this thesis project were receptive to fully using the system, as hint use was important when they were having difficulty completing a task, thus leading to a more formative perspective. For low-achieving students, this appeared to be a short-term gain providing them with just enough information about procedural aspects required and disciplinary knowledge to complete a task correctly for marks. These students kept their help-seeking interactions in the system for when feed up had not provided sufficient information. The findings from pathway analysis in the structural equation model indicated their use of hints resulted in a gain in achievement, i.e., a small increase in summative assessment grading. Hence, these students' use of feed forward benefited their academic outcomes, but their minimal engagement may account for the small gain in achievement.

Comprehensive help seekers were high achievers who understood the interconnectedness of the system in providing support to identify learning goals, learn from errors, check understanding, and practise, and, where they recognised the need for further extension of understanding, seek help. These students recognised that feed forward opportunities enabled them to develop more in-depth knowledge that could be transferable to other assessment contexts, in particular summative assessments. This finding is consistent with other studies that have found successful learners are able to generate and use feedback (Brown, Peterson, & Yao, 2016). The high-achieving students valued a low-stakes assessment experience to build their tacit knowledge and understanding for subsequent high-stakes situations. In this context, some students perceived efficiencies in extending knowledge beyond immediate needs for assessment and demonstrated metacognitive skills about learning processes, supporting the contention that success in university is more likely when students are autonomous learners taking individual responsibility for their outcomes (Brinkworth et al., 2009). The students' reflections revealed that they adapted their interactions with the system as they monitored and regulated their learning. Key skills of autonomous learners include the ability to create internal feedback and self-regulation mechanisms that allow them to monitor their progress in learning (Zimmerman, 2008). Hence, some students demonstrated strong self-regulatory skills, although this did not necessarily enhance their grade level. Skills that enable effective feedback use are critical in facilitating the transition between school and university (Kift, 2015; Poulos & Mahony, 2008). Some high-achieving students in this thesis study have used these skills in the online system, further supporting other studies that have found a relationship between approaches to learning and academic achievement (Lizzio, Wilson, & Simons, 2002). More recently, for students in a school environment, it has been found cognitive abilities act as a predictor of self-regulating capability when coping with school demands (Brown & Eklöf, 2018). In this thesis study, the students who had responded to and used feedback in the online system more comprehensively than others, while managing similar time pressures, were also the high achievers on summative assessments. These students recognised the system acted as a surrogate teacher that simulated questions and responses while maintaining a certain level of anonymity, allowing them to cope with a transition to a learning environment with minimal dialogic feedback. Current directions in assessment for learning in higher education point to the importance of dialogic feedback, even delivered by video or audio, as an effective approach to ensuring feedback is understood and implemented by students (Carless, 2016). It could be argued that for the proficient students, the hint system may have provided insufficient knowledge-limiting opportunities to extend their understanding. The

online experience also retained a level of student dependence on the system as a surrogate teacher, and it is likely an "artificial performance ceiling" affected the rate of learning by these students (Sadler, 1989). In other words, they were proficient beyond the level that the system could support in terms of their self-regulation behaviour, although they still appreciated that hint design facilitated building a deeper and more comprehensive knowledge of content and concepts that provided an advantage for later summative assessments where the risk level increased. The learning behaviour demonstrated by these students integrated formative and summative assessment through self-monitoring and regulating performance. However, there is also evidence that when students learn about complex topics in computer-based environments, they are less able to regulate their learning (Azevedo & Cromley, 2004; B. A. Greene & Land, 2000). According to Azevedo and Hadwin (2005), computer-based learning environments can provide effective scaffolding for self-regulated learning and metacognition by assisting students when needed and then reducing the level of assistance as competence increases (Azevedo & Hadwin, 2005). The discourse surrounding effective self-regulation highlights the responsibility of the student as learner in taking action, while the teacher as expert and source of tacit knowledge is supportive and strategic but not so central (Sadler, 1989). It could be argued that the "expertise" of the online system limited the high-achieving students from taking responsibility in self-regulation, by retaining student dependence on external support; however, the time-saving aspect attracted these students to use the system.

Although the findings from students' perceptions of feedback utilisation in MasteringBiology indicated the online learning system delivered a consistent and similar experience to all students, their responses and interactions varied. The efficacy of the feedback system was influenced by multiple aspects that can also be found in offline contexts. These include assessment design and purpose as well institutional parameters within which higher education courses are delivered, such as timelines for assessment and processes determined by policy requirements and the assessment decisions made by the teachers (Dawson et al., 2013). Each student's learning skill set and personal contexts also shaped his/her perceptions about using feedback and how he/she valued online learning.

Time constraints and the need to be strategic

For many students, beliefs about assessment from the online context persisted through their undergraduate experience. One of the main purposes of assessment in higher education courses is to provide a reliable measure of a student's achievement. Course assessment designs that contained a high number of summative assessment tasks (i.e., contributed to their final grade),

affected student agency. The students were aware that time pressure led to a tension between assessment requirements, affecting their ability to work effectively. Because of this tension, regular assessments, intended to support learning in a formative way, paradoxically resulted in feelings of urgency to meet constant deadlines and diminished deeper engagement. There have been many reviews concerning the impact of assessment practices on students (Bangert-Drowns, Kulik, Kulik, & Morgan, 1991; Black & Wiliam, 1998; Brookhart, 2007; Hattie & Timperley, 2007; Shute, 2008). These reviews point to the multiple ways in which assessments can be used, which are often in conflict and lead to different outcomes such as the less effective use of formative feedback. The students in this thesis study talked about being frustrated by the effects of limited time to effectively engage so they could use feedback in their learning. In particular, the students were aware of the expectation they would be independent and able to monitor their learning to build in-depth tacit knowledge, and, at the same time, demonstrate high-achievement levels by passing assessments under strict conditions. The students found it difficult to use any feedback for deep learning despite wanting to take this approach, a finding that concurs with other research (Burke, 2009; Carless, 2006; Evans & Waring, 2011). Due to a short time period for course delivery, the high-achieving students prioritised their use of feedback and work effort during the course to focus on summative assessments. They did this by linking their preparation and practice directly to questions and problems that they believed would be part of summative tests and exams, demonstrating creativity in their learning strategies. This thesis study shows that despite efforts to support the use of feedback, the curriculum focus of some students was narrowed and focused on achievement outcomes (Au, 2007). Thus, effective formative assessment opportunities were ignored by students in the context of time pressure and high-stakes summative assessments (Yorke, 2003). In situations where students ignore the potential of feedback, multiple factors may be involved in the context of their learning environment (Winstone, Nash, Rowntree, & Parker, 2016), leading to diverse responses across a class/course, and this was demonstrated in this thesis study. Some students demonstrated strategic thinking under high-stakes situations as many were aiming for a highly desired goal such as access to medical training. Where assessment is high risk and consequences can be detrimental to an individual's personal life goals (Ecclestone & Pryor, 2003), students adjust learning approaches in the short term to avoid negative outcomes.

Constraints from time pressure were exacerbated by a competitive culture in the learning environment and it was evident from this study it affected students of all achievement levels. As part of high-stakes assessment, competition for high grades resulted in the students having a comparative or normative focus on assessment, checking their performance relative

to others, rather than achievement of standards or outcomes. In seeking outcomes that are available to a small proportion of individuals in a course, the competitive culture can intensify under pressure of limited time for learning. The washback effect of high-stakes assessment on the learning approach can be powerful (James, 2006). The students evaluate the work they need to do for "learning vs grade," in particular what is required for a high-grade type response in a summative assessment. This strategic approach emphasised the students' motivation in achievement was to achieve as well as possible by studying according to the assessment (Entwistle & McCune, 2004). Although the competitive culture was most intense in their first year, many students retained this normative mindset in other courses during their undergraduate education. The need to stand out from other students gave them a sense of having a competitive advantage over peers often found in courses with professional goals, such as medicine (Lempp & Seale, 2004).

For many low-achieving students, the plight of time constraints contributed to students operating in a survival mode for learning, including avoidance of feedback in formative assessment activities. The students became "trapped" at a lower level of achievement by limited engagement with formative assessment and foregoing comprehensive use of feedback, so they did not learn (Black & Wiliam, 1998). Sadler (1989) points to the importance of students gaining evaluative expertise as part of instruction to progress understanding. In this thesis study, for many students who did not use feedback it was a conscious decision rather than a lack of awareness about feedback. Reasons given by students related to being strategic in terms of time cost, whether there was a perceived impact on mastery and competency of the discipline material, and subsequent final grading. For many students, such decisions were part of a familiar well-tracked strategic pathway from their first year to final years of undergraduate study. By avoiding feedback, students restricted opportunities in learning and while these strategies allowed them to survive via step-wise progress through most of their university pathway, there were potential barriers to building a comprehensive tacit knowledge. This was evident in students' discussion about feedback, as they tended to focus on task-level preparation for summative assessments. Limited feedback use when students deliberately ignore formative assessment has consequences for development of self-regulation skills (Panadero, Andrade, & Brookhart, 2018). Productive feedback use is important, allowing incipient self-regulatory behaviours where students openly explore and build knowledge in their discipline (Dinsmore & Wilson, 2016). Summative assessments that dominate the learning approach had an inhibitory effect on low-achieving students who adopted a satisficing approach in which they lowered the bar and aimed to achieve satisfactory results.

Consequently, the assessment design, being primarily summative, may have led to marginalisation of formative feedback that could support learning. The students felt secure and more familiar with the "satisfactory" position. They believed there was an increased sense of risk with making more effort, as increasing their achievement level did not necessarily follow.

Where curriculum design mixes different purposes of assessment in a time-constrained learning environment, the effect can be counterproductive. A high-risk summative assessment context retains external motivation as the driver of student actions. In this thesis study, the students were aware their actions were resulting in surface-level learning and, in some cases, they were concerned about not engaging with self-regulation. As part of their strategies to manage time pressure, many students focused on working out what their lecturers wanted for a high-grade answer, highlighting the shortcomings of these experiences in early years in tertiary education. The findings indicated the students sought information about what the lecturer/teacher wanted for a high-quality response in summative assessments, in order to give this back. While this strategy provided a sense of security and lessened the stress of time pressure, it also contributed to a surface approach to learning their knowledge of content, further limiting the long-term value of their education. As such, students attended to a different type of feedback for shaping their knowledge, that is, feedback from individual teachers/lecturers who marked their summative assessments and made decisions on grading.

In the findings of this thesis project, summative assessment was uppermost in students' thoughts, shaping learning approaches and engagement with all assessments with a "grade focus." The impact of this approach limited the range of feedback accessed, as students refrained from deeper learning approaches if they were not required when preparing for a particular assessment type. These results are in line with studies of school students' behaviour (Black & Wiliam, 2005; Carless, 2011; Harlen, 2005), where ensuring formative outcomes within a summative assessment framework is difficult. Despite many of these students having prior experience with a standards-based assessment qualification in secondary school, their focus shifted to grading processes and to practising for the test instead of learning for understanding, thus illustrating how summative assessment practices drive what is learned (Boud, 2000). In this thesis study, the effect is exacerbated by time pressure, further limiting the attention students pay to feedback information. Instead of viewing assessment as an integral part of learning, students come to view assessment as a competition with, and external to, teaching (Heritage, 2007).

Students' perceptions about negotiating the different levels of feedback

In focus group discussions, students explored their views about what was effective for their learning situation and their expectations of teacher feedback provision during their undergraduate studies. Their views underpinned their decisions and actions about using feedback. Students demonstrated some awareness of the processes and skills associated with feedback use as being transferable to other learning contexts, indicating metacognitive skills. However, their learning approaches differed from each other, influenced by their academic and personal needs. In other words, students' individual needs in their learning led to variability in the extent to which they engaged with feedback opportunities (Lipnevich et al., 2016; Shute, 2008). In this regard, individuals working within their own context, in an educational setting, means, in a large course, there is a heterogeneous group of students with respect to learner agency. As Lipnevich et al. (2016) argued, the role of feedback in instruction is "nuanced and complex" (p. 173) and understanding how students respond to feedback is an important area of research.

In order to encourage discussion that explored the variability in students' engagement with feedback, the students in this thesis study participated in a diamond ranking exercise at the beginning of their focus group discussion, in which they individually deliberated on and prioritised statements about feedback. The findings of the diamond ranking exercise indicated students recognised and prioritised task-level feed up (*where am I going?*) and feedback (*how am I going?*) information (Chapter 4). By engaging in formative assessment feedback, students can regulate their learning (Panadero et al., 2018), as they set learning goals, and use information in relation to these goals to facilitate adjustments and revisions to make progress toward the goal. Hattie and Timperley (2007) encapsulated this process in their model of feedback with the three questions related to feed up, feedback and feed forward. By prioritising feed up and feedback questions at task level over feed forward (*where to next?*), the students organised their learning into discrete and manageable blocks. Their decisions to use or not to use feed forward depended on whether they recognised they needed to adjust their work to improve a mark. In some cases, this meant getting over the line to a pass mark. The students perceived most feedback as corrective and at the end of a discrete learning episode, or the point where further adjustment and crafting of work is not possible, and so did not pay attention to or use it anyway. In these situations, feedback is unlikely to influence learning and development (Jonsson, 2013; Price et al., 2010). For the low-achieving students, corrective feedback provided information about the minimal effort required to achieve goals, whereas high-achieving students were more focused on high-level goals, which was evident in the

prioritisation of statements in the diamond ranking exercise. For the low-achieving students, the sense of limited time from external pressures reduced their work effort on individual courses. These students often knew they had a gap in their understanding but were unsure how to manage this situation, which in turn contributed to their frustration if the feedback information was not clear or seemed too difficult.

Proficiency in learning skills is important for students to transition successfully to higher education (Kift, 2015), as was shown by some students' strategic help-seeking behaviour in the online low-risk context. In their subsequent learning experiences, the students directed their attention to managing the short-term goals of summative assessments and this influenced their approach to using feedback and strategies of self-regulation. The students monitored their performance at task level by receiving external information/advice about gaining comprehensive knowledge and understanding. In self-regulated learning, recursive phases of task definition: goal setting and planning, applying strategies for study and adapting study (Winne, 2011), can be enacted to different degrees. The criteria and standards used to set goals, monitor and evaluate, i.e., self-assessment, may vary according the context (Panadero, 2017). In this thesis, students were primarily focused on the goals of summative assessment, so their self-regulated actions were focused on using task-level feedback to support rehearsal and memorisation, precluding their use of other self-regulation strategies that can support an appraisal phase involving reflection and self-evaluation and progress toward their goals (Clark, 2012). Hence, feedback use focused at task level and was potentially a default position influenced by context, but had consequences for self-regulated learning strategies among the students. The students believed they were conflicted by other conditions such as the pressure of limited time to prepare for high-stakes assessments that caused tension, leaving them with a sense that deep learning and assessment are mutually exclusive.

Self-monitoring performance is a construct included in many self-regulation models (Winne, 1995; Zimmerman, 2013), and is facilitated by seeking information to adjust tactics to meet goals. Information can be from non-social sources, as shown in this thesis study, using technology where the students preferred an expert in the discipline as the source of knowledge when learning biology. However, the students were wary of seeking opportunities related to the socio-cognitive aspect of self-regulation by which they could acquire knowledge through social interaction. This has implications in terms of regulation of their learning. Social support has an important influence on self-regulated learning (Hadwin, Järvelä, & Miller, 2011). While essentially an internal process, self-regulation is supported by social interaction through processes such as modelling and scaffolding that can be provided by peers, teachers, and family

(Azevedo & Cromley, 2004; Zimmerman, 1990). In this thesis study, students believed it was difficult to establish these interactions, and related this to the culture of their courses and intense focus on superficial learning.

The findings indicated the low-achieving students were less adept, in terms of monitoring their learning, as they had low confidence in using feedback during learning. These students were aware that building confidence was important to becoming an effective learner by utilising feedback opportunities. Butler and Winne (1995) described feedback as an inherent catalyst for self-regulated activities. Yet, in this thesis study, the low-achieving students were frustrated when they could not use feedback information that they believed was not clear or seemed too difficult. These students resorted to lowering expectations in terms of their own performance, essentially operating in survival mode, and they used feedback to gauge their level of performance and effort needed to pass.

All the students found discussing or using feedback at process level to be more complex and challenging. The process-level feedback was identified as the "missing link" for many students. While students recognised understanding what to do and how to manage errors as key to helping themselves both in immediate and future situations, they believed feedback about procedural aspects was relatively rare in their learning environments. As process-level feedback is critical to evaluating processes underlying tasks, and students can gain understanding, interconnections and transference to other tasks (Hattie & Timperley, 2007), it is more likely to lead to deep learning. The students recognised that knowing how to re-strategise is critical to process-level feedback. However, they were unsure how they might action this in their learning. When they did receive information at process level, they believed they struggled to use the feedback, indicating they were less skilled at selecting strategies to renegotiate the task. While the high-achieving students were inclined to try to self-regulate at process level by working it out themselves, the low-achieving students needed external corroboration; however, they believed asking for help was difficult for them, leading to a sense of frustration.

An important aspect of most self-regulation models is students monitoring their work for progress (Panadero, 2017). This may involve managing errors. In this study, students were not comfortable with being wrong and were averse to showing their mistakes in front of peers and teachers. These negative responses to feedback have critical implications for developing skills in self-assessment where students need to describe their performance or assign merit to their work and check against standards (Panadero, Brown, & Strijbos, 2016). Therefore, the students focused on getting it right and avoided making mistakes as part of learning even in a

low-risk context. The feed up question 'Where am I going?' was prioritised, giving high importance to instruction rehearsal approaches to check the "correct" body of knowledge, precluding opportunities for using feedback and feed forward to manage and deepen understanding of disciplinary knowledge by self-regulation.

Influence of emotional responses on feedback utilisation

Students, particularly in first year as they transition to university, are managing a number of emotional pressures such as anxiety and loneliness (Larose & Boivin, 1998). In this thesis study, students referred to their emotions as they discussed aspects of using feedback. Emotions associated with testing or assessment have been documented as influencing achievement outcomes such that an assessment no longer reflects a student's competency or ability (Vogl & Pekrun, 2016). In this study, students were aware of their emotions in the context of learning issues, including how their emotions influenced their attention to using feedback. Starting out with high hopes and enthusiasm for intellectual challenges, they became aware of emotional pressures during university courses, which they attributed to features of the context and structure of their courses. Negative emotions associated with feedback use were predominantly frustration, anxiety, embarrassment and hopelessness. Vogl and Pekrun (2016) suggested where outcome emotions such as anxiety are experienced, a person perceives they have minimal control of their situation and so become focused on failure. Many students in this study described feeling perplexed, and finding it difficult to manage feedback use in their learning. These emotions affected their sense of competency, and belief in their potential for achievement success. In a review about the impact of testing on students' motivation, Harlen and Deakin Crick (2003) highlighted that affective and conative outcomes of assessment associated with summative assessment had detrimental effects on learning. In this study, where some students experienced a predominance of negative emotion such as fear, shame and anxiety, the students struggled to control their emotions in a high-stakes setting, influencing students to resist using feedback. Ironically, feedback use requires managing actions that can also illicit negative emotions, for example making errors in work can lead to discomfort and even embarrassment. In this context, therefore, feedback use could exacerbate the emotional state of some students.

Changes in higher education over recent decades such as increasing student-to-staff ratios means students' level of contact with teaching staff is reduced and supportive social environments for students are less effective (Rowe, 2011). Most students in this study wanted the opportunity to interact with others, albeit teachers or peers, indicating their interest in

interactive learning, and pointing to a strong connection between feedback and students' social needs (Rowe, 2011). Responses of individuals at a particular moment are usually determined by their strongest need. In a classic model of human needs, developed initially by Abraham Maslow and then further refined by Clayton Alderfer (Hersey, Blanchard, & Johnson, 2001), Alderfer described three core needs: existence (physiological and safety needs), relatedness and growth. Relatedness corresponds to social needs; in an educational context, this involves students building relationships with teachers and peers. The lack of a sense of community can have a negative impact, leading to a sense of isolation and exclusion from the learning process (Sadera, Robertson, Song, & Midon, 2009). Negative emotions associated with lack of social connections have the potential to affect the learning environment. The findings indicated relationships with peers and teaching staff were profoundly important to students, accentuated by their experience of the absence of constructive and productive associations during the short period of their courses. Given the highly competitive context with high-stakes outcomes in their courses, peer reliability was an issue for the students and affected situations where they needed to work collaboratively. Building trust was key to their concerns. While trust is a positive emotion, the students perceived there was neither time nor opportunity to develop a working relationship and build trust with their peers. The low-achieving students were particularly affected by lack of trust in peer relationships, having no confidence in peers, and fearing they could learn inaccuracies.

Relationships with teachers were seen as important for dialogue and resolving problems, situations that are likely to have opportunities for feedback tailored to the student's specific needs. However, the students experienced frustration in variability between teachers with respect to expectations and criteria in assessments which meant the students found it difficult to manage and establish criteria for self-assessment, leading to negative emotions of hopelessness where they perceived a lack of control (Vogl & Pekrun, 2016).

The findings indicated that although the low-achieving students were strongly motivated to interact with teachers they were reticent, as they did not feel comfortable about revealing their perceived inadequacies. Higgins et al. (2001) identified problems derived from the teacher-student relationship where the student can receive assistance and, within the same interaction, a judgement on their competence, which may have an emotional response (Higgins, et al., 2001). The use of technology for feedback has value in managing the emotional responses of students during feedback use. The high-achieving students recognised an online learning context could bypass the dilemma of face-to-face interaction, which brings the risk of embarrassment of being wrong and dialogue that is not helpful or constructive.

The final core need, growth, corresponds to esteem and self-actualisation and in education influences motivation and satisfaction in learning (McLeod, 2007; Milheim, 2012; Poston, 2009). Needs change depending on where the individual is in his or her life and in this study in the context of undergraduate biology, many students had high-stakes goals, where emotions experienced during assessment can affect cognitive ability and motivation (Vogl & Pekrun, 2016). While positive emotions can be beneficial to academic performance, negative emotions can have effects that are more complex. In this thesis study, students were reluctant to seek help out of concern it could indicate weakness or lower competency. Emotions of shame, anxiety, hopelessness and anger led to avoidance of feedback use, possibly because they did not want to threaten their sense of wellbeing. The role of emotions is emphasised in some self-regulation models that consider collaborative learning situations present significant emotional challenges (Panadero, 2017). Boekaerts (2011) pointed to three different purposes of self-regulation during the learning process, two of which are influenced by students' emotions: protecting one's commitment to the learning activity, and preventing threat and harm. Where students perceive a task may be a threat to their wellbeing, negative emotions are triggered and students implement strategies to protect their ego from damage by moving away from tasks where they might not be successful (Boekaerts, 2011).

Finally, students' emotions are, in turn, influenced by feedback, as some students related feedback about self to their emotional responses during learning and for this reason did not view feedback about self as trivial. Approbation was less important to the high achievers, even viewed as ego building, but still enhanced confidence and motivation. However, the low achievers considered constructive feedback about self as important to their emotional wellbeing, which was critical to their motivation to engage and use feedback. Feedback that functions on a personal level can be perceived as caring and act to mitigate the effects of other emotional responses (Rowe, 2011).

Adapting to the culture of university was challenging for some students in this research. Their need to build self-esteem in the university context depended on establishing reputation, recognition and self-respect. An individual with low self-esteem can be affected on a social level, as is their ability to build relationships, particularly in a high-risk context where there is a perceived level of challenge or threat with respect to trusting peers.

Limitations

Somekh (1995) points out that action research (practitioner research) is influenced by the culture of the participants and their institutions and is sensitive to context, which brings some

constraints and limitations. It is important that participants are recognised and considered when interpreting the meaning of research findings. This thesis study was conducted in a biological sciences educational context and is thus somewhat limited in scope. The study participants were undergraduate students enrolled at the University of Auckland who were relatively uniform in age. All participants were enrolled initially in the same large first-year biology course and used the same technology for feedback. The demographics at some other universities in New Zealand are likely to be similar. Likewise, contexts in other institutions may also have a predominantly transmission instructional design situated in competitive learning environments as students take high-stakes assessments for access to professional programmes. Generalising the results of this part of the study to a wider population should be approached with caution.

The use of technology for feedback, part of a normal learning experience in a blended course, contributed to the robustness of the findings. However, as part of this blended approach, and to provide an incentive to use online feedback, students were given a small contribution to their final grade for using the system, which may have resulted in students having a perfunctory level of engagement. It is possible these students were rushed when using the system in order to meet deadlines for activities and they perceived a more summative assessment purpose for using the system. However, information obtained in the focus group discussions that corroborated this approach were important in providing rich insight into this behaviour.

The feedback processes used in the online system were limited to the task and process cognitive levels. Where self-regulation may have occurred, it could not be monitored by the system except when the students sought help after corrective feedback. Similarly, feedback about self was not gathered in the system. Information about both of these levels was obtained during the qualitative phase, which was reflective in nature, and possibly limited by students' recall of specific learning situations.

One of the goals of educational research is the assumed neutrality and impartiality of the researcher, as is freedom from coercion for the human participants (Cochran-Smith & Lytle, 2009). As the researcher, I was also the coordinator of the first-year biology course, so the students may have perceived power differences and felt pressured to participate. In Phase 1, my access to anonymised data (system interaction terraces) was delayed until after the coursework and grading was completed. At the beginning of the course, an independent person advised the students about the data-collection process before they gave consent. The notion of researcher positionality can shift at various times during a study (Thomson & Gunter, 2011), as occurred in the subsequent phase, when I was no longer directly involved in teaching or

grading the students. However, given the time since the students had completed the first-year course, many had come to know me in my position in undergraduate teaching.

As a practitioner I had tacit knowledge of the study site and this raises logistical and epistemological issues (Herr & Anderson, 2014). Logistically, my knowledge of the study site could be considered an advantage when facilitating students' discussions. However, I also acknowledge I have impressions and unconscious biases as a practitioner that may have influenced students' disclosures and my interpretations during analysis. In order for the students to engage with each other about their ideas on feedback, I used stimulus materials and a diamond ranking exercise as a framework for their discussion.

After completion of the course that used technology for feedback, the students progressed to a range of courses under different programmes where they experienced different learning environments. In Phase 2, focus groups were used to gain insights about their perceptions of feedback use in these contexts. According to Eisenhardt (2002) case study research can have important strengths that arise from the possibility of linkage with empirical evidence. The participants in Phase 2 were a small group purposively selected from the same population of first-year biology students who were still enrolled at university. While this research strategy allowed for understanding the dynamics present within the learning context of these students in this study, applicability to other learning environments may be limited. Phase 2 was essentially a small-scale study, so one of the issues with this approach is the problem of generalisability.

As the participants were from one course within one university, when Phase 2 focus groups were being conducted many of the students were well known to each other. Hence, there was some potential for contamination or influence between students' accounts in focus groups, although this is unlikely given less than 2% participated in the focus group discussions. The sampling process did not capture participants from the original course who had left university prior to degree completion. Where these students left for academic reasons (Krause, 2005; Tinto, 1975), their stories were not captured in the rich information about students' perceptions of feedback use and whether this may have contributed to their decisions to discontinue with university studies. Although all the original participants were invited to participate in focus groups, formation of the groups was effectively a self-selection process. Hence, their decision to participate may reflect something about their disposition toward feedback in learning and this process is likely to have produced a disproportionate number of students with a "story to tell." As it was more challenging to recruit students who were low achievers, these students may have perceived participation in the focus groups as a difficult

emotional experience while they were still at university and only the "bravest" of these students became focus groups participants, despite reassurance about the processes for recruitment and reporting being confidential and anonymous.

Implications

A number of implications can be drawn from the findings presented in this thesis, related to the design of biology undergraduate courses at university, specifically in facilitating students' use of feedback and the mitigation of circumstances that impede the development of self-regulatory skills. Self-regulation theory claims there are multiple variables operating within a holistic experience, for example self-efficacy and cognitive strategies, that influence learning (Panadero, 2017). Idiosyncratic features in courses further complicate the potential for complexity under the extraordinary umbrella of self-regulation. There are implications from the current study in a science context that the metacognition associated with feedback use is important in facilitating self-regulation skills. Establishing a "best fit" learning environment is challenging given the fluid and holistic nature of learning and is dependent on exploring different perspectives held by students to avoid a mismatch in learning approach adopted by a teacher. Institutional policy and processes can add a further layering of constraints.

Implications for theoretical frameworks in education

Yorke (2003) argued there is a need for further theoretical development of formative assessment particularly in higher education. Yorke directed these efforts to include aspects such as accounting for disciplinary epistemology and the psychology of giving and receiving feedback. More recent literature has indicated the importance of emotions in students' responses to feedback (Lipnevich et al., 2016) and achievement (Vogl & Pekrun, 2016). This thesis used Hattie and Timperley's model of feedback to provide the interpretive frame for students' feedback use and explanations of their actions in undergraduate biology courses. As the research design was praxis-orientated and conducted from inside the "field site" by a practitioner, it has the potential to point out there are "people" beneath education theories and categories (Cochran-Smith & Lytle, 2009). While the research process was intended to explore and analyse conditions that allow students to flourish, it has the potential to support and improvise on existing theories.

As the findings in this thesis demonstrate, further texture and granularity to understanding the conditions in which students respond to feedback and self-regulate is revealed through this practitioner investigation. These insights are of great value to practitioners in improving teaching and learning. For example, undertaking this investigation

led to redesigning formative assessment underpinned by education theory that is more targeted to the needs of the students.

The research reported in this thesis was conducted in a research-intensive university in a faculty where empirical research is most commonly experimental. Biology is a popular choice for study at university and there has been substantial growth in the body of knowledge given global issues in human survival and welfare. The teaching approach in biology courses is often content rich and objective in nature and the science is learned as non-contestable knowledge. Thus students were more likely to operate at task level and take a superficial learning approach where feedback operated as a mechanism to support knowledge acquisition by providing corrective information. This was in contrast to the goals and practices of formative assessment that require active and metacognitive involvement in the learning process (Black & Wiliam, 2009; Clark, 2012). In this thesis study, students developed coping strategies as part of their feedback use (or not) during this acquisition of a large body of knowledge. This implies there is very limited scope to activate learning beyond memorising facts and recalling information. As such, working with a theoretical framework that is sociocultural, where the actions of peers, teachers, family etc. are critical, may be at odds with learning within a positivist discipline where students are conditioned to the importance of empirical evidence as having high validity and reliability. The findings in this thesis suggest students behave as if the acquisition of (biological science) knowledge is mutually exclusive from the processes and progress of learning, implying that sociocultural aspects of learning contexts need to be considered during feedback use.

Hattie and Timperley (2007) developed a comprehensive framework for the provision of feedback to students at different levels of cognition and metacognition. Within these levels, students' use of feedback is related to goals of what they need to know, where they are in relation to these goals and what they need to do to get there. The findings of this thesis have shown these goals can compete leading to different outcomes from variable feedback use. For example, in a context where students are under time pressure, many strategise to use feed up and feedback to ensure they meet short-term assessment outcomes but are less inclined to attend to developing long-term learning skills.

To further develop this notion of learning contexts, students' academic and personal attributes should be thought of as integral to the feedback process in terms of students becoming proactive receivers and seekers of feedback (Winstone et al., 2017). Table 13 indicates four different contexts that have been derived from the findings, each context illustrating multiple aspects influencing student use of feedback. The context descriptions include features that

influence feedback use and are similar to previous findings about preparedness in terms of key disciplinary knowledge (Bone & Reid, 2011; Buntting, 2006), and academic emotions associated with tests (Vogl & Pekrun, 2016). However, from the findings of this thesis, the features are shown to have a composite effect suggesting there is a complex multidimensional influence on students' use of feedback and development of self-regulated learning. Contextual aspects leading to low feedback use include lack of preparedness in key disciplinary concepts, limited interaction with peers and teachers and negative emotions about their situation. In this context, low levels of both confidence and commitment manifest in avoidance or resistance strategies suggesting that these features result in discord and counterproductivity in the learning environment. While this context highlights the need to ensure students are ready for courses both cognitively and metacognitively, this is not always pragmatic where there are no requisites for admission to courses. Other contexts indicate that as students increase in skill level, improve disciplinary knowledge and experience some positive emotions about their learning environment, then they are more inclined to act productively in terms of feed up, feedback and feed forward information. The findings support Hattie and Timperley's assertion that receiving and using feedback requires much skill by the students. In their review, Winstone et al. (2017) proposed a taxonomy of features that may promote or inhibit students' proactive recipience of feedback, and suggested that educational context has the potential to play a role. Multiple contexts have been revealed in this study of a large course with a high-stakes assessment design and competitive culture and these influence students to respond to feedback delivery, accounting for the observed and reported variability in feedback use (Table 14).

Table 13

Different Contexts of Feedback Use: Learner Characteristics and Outcomes

Context	Context 1	Context 2	Context 3	Context 4
	Limited background and preparation to be at this level in the discipline. Avoids feedback use, gives minimal effort and has low self-responsibility. Goals are task focused and grade focused. Cautious of competitive class culture and untrustworthy relationships. Low confidence and commitment. Insecure and resistant to formative assessment. Uses cost/benefit strategy.	Able and well-prepared for level of learning in discipline. Goals are task focused and grade focused. Avoids feedback use, and focuses on rehearsal for summative assessment. Cautious of competitive class culture and untrustworthy relationships. Uses cost/benefit strategy.	Low confidence. Limited background and preparation to be at this level in the discipline. Goals focus on regulation and process levels. Engages in feedback use, to assist task completion. Accepts making errors in low-stakes environment helps learning. Low confidence.	Able and well-prepared for level of learning in discipline. Goals highly focused on regulation and process levels. Engages in feedback use, and focuses on extending learning beyond requirements for summative assessment. Welcomes making errors in low-stakes environment. Not so concerned with class culture and untrustworthy relationships. Secure and achieves goals.
Emotions present or absent	**Emotions present:** *Fear* *Anger* *Shame* *Disgust* *Anxiety* **Emotions absent:** *Happiness* *Hope* *Pride* *Gratitude* *Trust*	**Emotions present:** *Happiness* *Hope* *Pride* *Gratitude* **Emotions absent:** *Shame* *Sadness* *Disgust* *Trust* **? Emotions:** *Fear* *Anxiety*	**Emotions present:** *Fear* *Anxiety* *Gratitude* **Emotions absent:** *Hope* *Pride* *Trust* **? Emotions:** *Anger* *Shame* *Disgust* *Happiness*	**Emotions present:** *Happiness* *Hope* *Pride* *Gratitude* **Emotions absent:** *Fear* *Anger* *Shame* *Disgust* *Anxiety*
Readiness to use feedback	Limited background and experience. Insecure and defensive. Exhibits resistance.	Able with appropriate background and experience. Insecure and defensive. Exhibits resistance.	Limited background and experience. Confident and willing. Exhibits openness.	Able with appropriate background and experience. Confident and willing. Exhibits openness.
Responsibility level in feedback use	Limited self-direction and monitoring. Dependent on external cues to signal learning. Procrastinates.	Medium skills in self-direction, monitoring learning and self-assessment. Dependent on some external cues to signal learning tasks.	Medium skills in self-monitoring learning. Dependent on external cues to signal learning tasks.	Highly skilled in self-direction, monitoring learning and self-assessment. Independent of external cues to signal learning instructions.
Relationships with teachers / peers	Limited interactions. Insecure and defensive. Trust of peers and teacher absent.	Recognises importance of interactions to support learning. Open to building relationships. Relationships must be trustworthy. Self-secure but not able to always discern what is correct.	Recognises importance of interactions to support learning. Desires relationships. Relationships must be trustworthy. Insecure and not able to discern what is correct.	Recognises importance of interactions to support learning. Open to building relationships. Relationships must be trustworthy. Self-secure and able to self-assess.

Table 14

Different Contexts of Feedback Use: Learner Characteristics and Learner Responses

Context	Context 1	Context 2	Context 3	Context 4
	Limited background and preparation to be at this level in the discipline. Avoids feedback use, gives minimal effort and has low self-responsibility. Task focused and grade focused. Cautious of competitive class culture and untrustworthy relationships. Low confidence and commitment. Insecure and resistant to formative assessment. Uses cost/benefit strategy.	Able and well-prepared for level of learning in discipline. Task focused and grade focused. Avoids feedback use, and focuses on rehearsal for summative assessment. Cautious of competitive class culture and untrustworthy relationships. Uses cost/benefit strategy.	Low confidence. Limited background and preparation to be at this level in the discipline. Can focus on regulation and process levels. Engages in feedback use, to assist task completion. Accepts making errors in low-stakes environment helps learning. Low confidence.	Able and well-prepared for level of learning in discipline. Highly focused on regulation and process levels. Engages in feedback use, and focuses on extending learning beyond requirements for summative assessment. Welcomes making errors in low-stakes environment. Not so concerned with class culture and untrustworthy relationships. Secure and achieves goals.
Frequency of feedback use	(Low) ⟵		Uses Feedback ⟶	(High)
Level of feedback use	Task level		Process level	Self-regulation level
Approach to goal setting	(Short-term goals) ⟵		Time perspective ⟶	(Long-term goals)
Inclination for making errors	Uncomfortable / avoids ⟵		Error making ⟶	Comfortable / accepts
Need for praise	Needed ⟵		Feedback about self ⟶	Not needed

Implications for policy in higher education institutions

Within a higher education institution, assessment policies generally guide assessment practice and, as such, practitioners' aims and values may be constrained by institutional structures thus impacting decisions and judgements exercised as part of their practice (Carr & Kemmis, 2003). Given university graduate profiles are increasingly including competences related to higher order learning skills such as self-regulation that enable graduates to continue as competent lifelong learners, it is important that assessment policy and practices align with manifesting these expectations. The finding that students focus their learning on exam preparation to gain a certain grade level, is similar to that of previous research, which found what is assessed summatively drives the curriculum areas attended to by the students (Snyder, 1970). The findings from this project suggest that it is challenging to implement formative assessment, critical to engaging students in self-regulated learning, in a traditional summative assessment environment that encourages a competitive culture in learning. However, as this research has also shown, students respond to assessment in different ways and are influenced by a range of experiences, motives and perspectives (Sambell & McDowell, 1998), and the influence of assessment on learning is nuanced (Joughin, 2010). Whereas expected outcomes of a graduate profile may speak to skills that are relevant to future employers, policy that focuses more on accountability and certification may diminish the ability of practitioners to implement balanced quality assessments.

Policy has the power to shape an environment that is conducive to developing self-regulating leaners in higher education (Chickering & Gamson, 1987; Pascarella & Terenzini, 2005), where students are able to reflect on what they have learned, what they still have to learn and how to assess themselves. The findings imply that incentivising teachers/practitioners to include formative assessment in the curriculum as part of course design could be productive for students, a finding that concurs with the literature (Knight, 2000; Yorke, 2003). Formative assessment as part of coursework is often a better predictor of long-term learning of course content than exams (Gibbs & Simpson, 2004). An important implication from these findings is the provision of practitioner professional development in assessment design to enable contexts for productive use of feedback. While the development of skills in assessment design is the first step, it is also appropriate that there is realistic time allowance built into workloads for teachers/practitioners to implement and maintain in their practice.

Likewise, students may benefit from radical changes to policy around summative assessment outcomes where options are available to students to determine their own readiness

to demonstrate their proficiency. This allows students to take responsibility in determining how much time they require to build competence and reach learning goals. The feasibility of changes of this tenor would be enhanced by practitioner action research as part of testing and improving alternative educational practices that enhance an individual's progression in a sociocultural learning environment. A change in summative assessment processes would be challenging to an institution with massive enrolments that scale up to an even larger number of exam instances, which are currently managed by traditional examination periods.

Students learn asynchronously, which is a feature familiar to many practitioners working with a diverse student population in their courses and classrooms. However, assessment of learning is synchronous. The findings in this project indicate that not all students progress their learning at the same rate, as contextual aspects play a role in each learner's experience. Inevitably, some students, as shown by the current study, become trapped into learning behaviours associated with low achievement, potentially leaving them at risk of becoming subject to attrition. For many students, their low achievement is self-fulfilling as negative emotions activate non-productive behaviours during formative assessment. This implies that if students had more involvement in decisions about when they complete summative assessment, then they would potentially pay attention to their readiness and preparation for high-stakes academic assessments. However, challenges to formative assessment in higher education depend on changes to an assessment culture, which is concerned with attainment standards. Other issues also put pressure on maintaining the status quo such as increasing student/staff ratios, which limit opportunities for interactions with students; and changing curriculum structures such as modularisation that increase the frequency of assessments (Yorke, 2003).

In summary, policy that supports and promotes educationally trained practitioners to implement and then maintain formative assessment within realistic workload norms would be conducive to supporting students to develop lifelong learning skills such as the effective use of feedback for self-regulation. A key aspect is enabling students to recognise their role in the assessment process as integral to their learning and empowering them to do this.

Implications for teaching practice

In discussing education research and the profession, Carr and Kemmis (2003) suggested action research, a form of practitioner research, provides a method for testing and improving educational practices by engaging, extending and transforming the self-understandings of practitioners as they are involved in the research process. A practitioner's self-understanding

is formulated from theoretical or interpretive frameworks and their own theorising drawn from their practice and its consequences (Carr & Kemmis, 2003). This project suggests implications that have direct relevance for the practice of a large first-year biology course. In summary, these are making informed decisions in the implementation and evaluation of technologies used to deliver feedback, ensuring students understand how to use technology as feedback in terms of functionality of the system and that they have the metacognitive skills to use the system. Finally, creating a safe environment in which students can explore and use feedback without constraints of time pressure and negative consequences.

With increased access to higher education in recent decades, the size of classes at university has challenged the sustainability of individual feedback practices (Hounsell, 2007). As a result, technology solutions, particularly in the first year, have been sought. Online and blended teaching has become an important educational strategy in higher education, where assessment activities with interactive formative feedback can foster a learner- and assessment-centred focus (Gikandi et al., 2011). Hattie and Timperley (2007) in their meta-analyses, suggested feedback can have a powerful effect on achievement with an average effect size of 0.79 standard deviations. Further, computer-assisted instruction is more effective when feedback is optimised (Hattie, 2009). The findings in the current research on the effect of feedback in the online system were not encouraging in terms of student progress across the class. Certainly, the practitioner needs to take into account the diversity of students with respect to current knowledge, learning skills, current level of competency as well as their inclination to work independently in such a system. A practitioner will be cognisant of the experience students are gaining from the feedback structured into learning activities, and researching how the students use online materials is key information or feedback to the practitioner about course design and the sustained use of the system. The focus group findings from this study also suggest the variability in student use of online feedback help has implications for whether students themselves find value in the system for their learning. This implies the traditional course as a unit of learning may impose artificial boundaries when evaluating the effect of some interventions, as benefits from feedback may not be discernible in the short term, i.e., grading at the end of a course. An important implication is determining the criteria to be used in making decisions about discontinuation of an online system, as these may be short-sighted without a deeper insight into how students are interacting with the system, by listening to the student voice. Given such systems are often part of blended course designs then value can be added by supporting students to be competent end-users in terms of learning approach and metacognition.

The use of technology also requires learner competence to navigate new software systems. Technology has the capacity to support learners at university; however, this thesis study indicated some students may not make full use of systems in their learning. Incorporating machine/online components into courses, while helpful, has mixed outcomes as shown in this research. Scaffolding the technology, to help students gain a stronger understanding of functionality, may help improve outcomes for more students when incorporating technology into courses. First, metacognition should be demonstrated to learners to improve the formative assessment literacy of students. In order to induct students to university, teachers may need to provide opportunities for students to develop metacognition about feedback use by providing explanations of the thought processes embedded in an assessment experience specific to their discipline – effectively a model or exemplar of the metacognitive processes that lead to a learning target. The demonstration and practice of decisions and actions that ensure formative assessment is productive can enable a student to understand how taking individual responsibility leads to productive learning. Enabling metacognition that facilitates teachers and learners to build a shared understanding of what is happening, and why courses are designed the way they are, allows students to become partners and be more involved in their learning (Hughes, 2010). Where students can articulate clearly what steps they are taking and why they are following particular processes and steps they are challenged to think about their actions or lack thereof and begin to monitor and reflect on their own performance.

Second, the findings indicated that a significant barrier for students is their fear or dislike of being wrong, particularly in front of peers and teachers, a finding that relates to preventing any perceived threats to self during regulation of learning (Boekaerts, 2011). This implies there is a need to consider interventions that reframe feedback in order to mitigate the effects of humiliation that lead to student reluctance or avoidance of feedback use. Actions that privilege error and misunderstandings are valuable opportunities for learning and providing appropriate challenges that foster deep learning and skills associated with self-regulation. There are implications for teachers interested in providing “safe” learning experiences where students can try out ideas and different skills. Initial considerations could involve providing collaborative activities and supporting students to build relationships with peers and teachers. A situation where they feel secure in themselves to participate without fear or anxiety is a key step. While not all kinds of feedback are equally effective (Andrade, 2013), encouraging students to use feedback within a learning-centred approach is important for the teacher/practitioner to be mindful of even where it may require more time in the course design.

The research also revealed the drivers for task-level focus came from a strong emphasis on summative assessments through rehearsal, exacerbated by time pressure and a competitive learning culture. Summative assessment was a strong deterrent to feedback use, implying there is a need to design activities and assessments that reward feedback use during courses.

Although feedback at self-level does not necessarily contribute to student achievement (Hattie & Timperley, 2007), the findings in this research indicated low-achieving or less-proficient students recognised it was valuable in building their confidence and self-efficacy as learners, influencing their motivation. In order to mitigate the risk of failure for these students, interactions that confirm positive learning behaviours are important, implying that this is a key part of the learning process (Hughes, 2010). However, the integrity of the feedback about self is key to the learners, who did not appreciate hollow comments from brief encounters with teachers. This implies there is an underlying influence of feedback about self and, in building relationships, trust is important, as the students want meaningful encounters in their learning. However, this is challenging in large university classes with high student/staff ratios.

Recommendations for future research

The thesis has investigated the multidimensional nature of feedback use by students in a higher education setting. With increasing emphasis on active learning in science at university (Bradforth et al., 2015), more research is needed to inform effective feedback use in courses.

This first phase of this study relied on traces of student use of the MasteringBiology system. Future research could obtain data directly from students during the process of using the system; for example, through talk-aloud protocols (Mayring, 2000) to gain a deeper understanding of how and why students choose to use the hints or not. Such a study could provide insights into the use of computers to scaffold student-regulated learning and support practitioners to tailor interventions and learning environments.

As the MasteringBiology system is available in other science subjects, investigating use of feedback within the same system across multiple disciplines allows for quasi-experimental approaches that control for system design. This investigation could further explore whether students respond or adapt to feedback use in different disciplines.

Attrition, particularly in the early years of higher education, is costly to both the individual and the institution (McInnis, 2001). Investigating the skill sets such as the propensity for feedback use, as students arrive at a higher education institution, could be informative about some of the academic causes of attrition. Further, provision of interventions for mitigating attrition could be addressed at the point of entry to courses.

Independent learning skills are included in many graduate profiles to signal students are ready for the workplace. Investigation into the development of self-regulation skills as students progress through university, as part of a longitudinal study of their university experience, would provide rich insights to contextual aspects of learning. Data could be used to test self-regulation learning models, by focusing on particular stages, for example first year and at higher level courses. Informing and facilitating transitions between these education levels could provide valuable evidence to the institution for quality teaching and learning measures, in particular, mapping how this speaks to the needs of the workplace after graduation. A study of this nature would provide explicit information about long-term goals to support motivation and endurance while at university.

Concluding comments

This study emphasises the importance of supporting student use of feedback by addressing the contextual aspects within which formative assessment is delivered. By gaining insight to students' perspectives about how and why they decide to use, or not use, feedback, the teacher/practitioner can mitigate features of the learning environment that counter effective engagement. Hence, moving toward a student-centred approach requires understanding what it means for a student to be positioned in a particular curriculum and assessment design context in terms of their holistic experience. The findings of this thesis contribute to our understanding of the contexts that enable and empower students to be proactive users of feedback, as an essential competence in higher education.

A corollary from the findings in this thesis study is an implication that in science education at tertiary level there are components of passive learning that continue to constrain students taking a more active role in their learning. Over 50 years ago, Karl Popper was concerned that passive approaches neglected the essential parts of learning and impacted students' experiences. "In a way the educational system is based on natural selection – only those with first class minds and bodies survive complete damage" (Popper 1945, quoted in Penny, 2012, p. 22).

However, Popper did identify the way forward: "The proper method (for teaching science) is that everything depends on the degree of activity and not on passivity… i.e., students posing questions and looking for answers" (p. 22). Supporting students to be proactive in using and applying feedback is another step in this direction.

Appendices

Appendix A Phase 2 invitation and consent form

THE UNIVERSITY OF AUCKLAND
FACULTY OF EDUCATION
Te Kura Akoranga o Tāmaki Makaurau
Incorporating the Auckland College of Education

School of Teacher Education Practice
Epsom Campus

Telephone 64 9 6238899
Facsimile 64 9 6238853
www.education.auckland.ac.nz

The University of Auckland
Private Bag 92601, Symonds Street
Auckland 1150, New Zealand

PARTICIPANT INFORMATION SHEET
(Students)

TITLE: The Utility of Online Homework in Learning Acquisition in First Year Biological Science Courses.
PRINCIPAL RESEARCHER: *Mandy Harper*
RESEARCHERS: *Assoc. Prof Mary Hill, Mandy Harper, Assoc. Prof Gavin Brown, Dr Rasil Warnakulasooriya and William Galen*

Dear Students
Assoc. Prof Mary Hill and Assoc. Prof Gavin Brown are teachers and researchers in the Faculty of Education. Dr Rasil Warnakulasooriya and William Galen are members of the Learning Technologies Group, Pearson Education, Boston MA, USA. As an Education Doctoral student in the Faculty of Education and Director of stage one teaching in the School of Biological Sciences in the Faculty of Science, I am the researcher in this project.
You may remember you agreed to participate in doctoral research I am currently conducting when you were a student in BIOSCI 101, semester one, 2012. The research is assessing the effects of online homework in learning gains in first year biological science courses. Pearson Education Mastering products were used to provide online formative assessment with feedback opportunities. In March 2012, you agreed to the inclusion of data generated as a natural outcome when you completed online activities for homework for analysis in this study. Data from your homework was archived and we analysed this anonymised data after the completion of the course. The results of this phase of the study indicate different levels of feedback use which we would like to investigate further.
You are invited to participate further in this study. If you agree, you would be invited to take part in a focus group discussion with several peers about the use of the online system and experiences about the use feedback in your undergraduate studies. These discussion groups would occur at a place and time negotiated with you. It is anticipated this would not take more than two hours of your time. I will be facilitating the discussion and with your permission, I would audio record the discussion, transcribe the recording but not return to you for emendation. Due to the nature of focus group discussions, confidentiality will be requested from all participants.
As a focus group participant, you will be provided with materials to enhance discussion with your peers. The materials will include a set of cards which list the different ways students are known to use feedback (e.g., did not use; just looked at mark/grade); you will be asked to undertake a diamond sorting process to rank different feedback practices in order of priority; drawing activity about feedback and follow up questions.

I intend to make this discussion a positive experience and I hope reflections on your use of feedback and experience with MasteringBiology® will benefit you in your learning. It is anticipated the discussion analysis will assist us to improve the learning experience of future students. As a focus group participant, you will receive a $20 Westfield voucher as a thank you for your time.

Thank you for your previous participation in this research. For this previous phase of the investigation your confidentiality was preserved with respect to researchers through coding of participants by an independent person (Caroline Aspden). Selection for this next phase of the investigation about student experiences and use of feedback has preserved this confidentiality. Caroline Aspden is seeking your agreement to participate further in the focus group discussions. If you sign the consent form, Caroline will then release your contact details to the researchers.

If you have any queries please contact us or the Head of the School of Learning, Development and Professional Practice at the Faculty of Education.

Contact details if you require them are:

Associate Professor Christine Rubie-Davies
Head of School of Learning, Development and Professional Practice
Faculty of Education
The University of Auckland
Private Bag 92601
Auckland
c.rubie@auckland.ac.nz
Tel: 09 623 8899 ext 82874

Assoc. Prof Mary Hill
School of Learning,
Development and Professional Practice
Faculty of Education
The University of Auckland
Private Bag 92601
Auckland
mf.hill@auckland.ac.nz
Tel: 09 623 8899 ext 48630

Assoc. Prof Gavin Brown
School of Learning,
Development and Professional Practice
Faculty of Education
The University of Auckland
Private Bag 92601
Auckland
gt.brown@auckland.ac.nz
Tel: 09 623 8899 ext 48602

Mandy Harper
School of Biological Sciences
Faculty of Science
The University of Auckland
Private Bag 92019 Auckland
a.harper@auckland.ac.nz
Tel: 09 373 7599 ext 87794

Yours sincerely

Mandy Harper

For any queries regarding ethical concerns you may contact the Chair, The University of Auckland Human Participants Ethics Committee, The University of Auckland, Office of the Vice Chancellor, Private Bag 92019, Auckland 1142. Tel (09) 373 7599 ext 83711.

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS EHTICS COMMITTEE on 25/10/11 for (6) years.
Reference Number 2011/ 7641

THE UNIVERSITY OF AUCKLAND
FACULTY OF EDUCATION
Te Kura Akoranga o Tāmaki Makaurau
Incorporating the Auckland College of Education

School of Teacher Education Practice
Epsom Campus

Telephone 64 9 6238899
Facsimile 64 9 6238853
www.education.auckland.ac.nz

The University of Auckland
Private Bag 92601, Symonds Street
Auckland 1150, New Zealand

CONSENT FORM

(Student)

This form will be kept for a period of six years

TITLE: The Utility of Online Homework in Learning Acquisition in First Year Biological Science Courses.

PRINCIPAL RESEARCHER: *Mandy Harper*

RESEARCHERS: *Assoc. Prof Mary Hill, Mandy Harper, Assoc. Prof Gavin Brown, Dr Rasil Warnakulasooriya and William Galen*

I have read the Participant's Information Sheet and have understood the reasons for furthering this research and why I have been asked to take part.

I understand:

- The focus group discussions will occur at a time and place negotiated with me.
- I agree to confidentiality of contents of discussions that take place during the focus groups.
- That the discussions are audio- recorded for the purpose of analysis.
- That the recordings and data analysis of the focus group discussions are confidential and any reports or publications will not identify me individually.

I therefore agree to participate in focus group discussions about my use of feedback. The discussions will focus on the use of feedback in undergraduate assessment activities including the online activities analysed for the research project *The Utility of Online Homework in Learning Acquisition in First Year Biological Science Courses* that is being carried out in the School of Biological Sciences, The University of Auckland.

Name_____

_____

Email address: University: _____ Personal:

_____

Phone: Landline_____

Mobile_____

Signed_____ Dated:_____

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS EHTICS COMMITTEE on 25/10/11 for (6) years.
Reference Number 2011/ 7641

Appendix B: Focus group session plan

Activity	Activity detail	Script	Anticipated Time
1. Welcome / ground rules	**Confidentiality** – remind students session is recorded (turn on when no longer confidential – ask students) **Students introduce themselves** to the group – provides an opportunity to identify by voice for analysis.	-What is said within this session is confidential. (You may know each other so maintaining confidentiality means we do not talk to anyone else about anything that is said or done during this time.) – You have the right to request at any time that recording is stopped if want to say something that they do not what recorded.	5 minutes
2. Stimulated recall and initiation of discussion. Start with stimulated recall to remind them of the experience using MB so this can be a reference point during session: Prompts – A3 and laminated	Prompt 1: Each student can view copy of online item activity with questions that has hints (closed) to remind them of how Masteringbiology system works Discussion questions after showing prompt 1 about what system looked like.	• Tell me about how you found using the system? • Describe for me what is was like using system • How does an activity like this support your learning? • What do you think of these questions when you are doing a first year course like BIOSCI 101? (say compared to test and exam questions) • What were your impressions of this activity? • What was it like for you?	10 mins
	Prompt 2: = same Masteringbiology question but view with hints open (two groups will not have opened these) Discussion questions….mention whether this group used or did not open hints. – in pairs or threes look at hints)	• Do you think the information provided in the hints is useful or not useful for learning? Why? • How might this information change your experience while completing the questions? • I am interested in why in general you might use some hint information and not others. • Would you do anything differently now? Why?	10 mins

		• Would this have changed in any way how they continued with learning in subsequent courses?	
3. Diamond ranking exercise. a. Individual exercise:	Students provided with blank diamond and prepared kit containing statements about feedback on post-its. Blank post-its available for students to add anything they consider missing if not on prepared statements. Students move sticky statements around as prioritise and annotate on diamond sheet why each statement is in this position. For each group statements on different colours of post-it notes to identify different groups during analysis (At end - Capture - take photo of each individual's diamond rank).	• I'd like you to do this by yourself and then we are going to share and compare. • While you are sorting, you might find it triggers an idea). E.g., you think there is something that is not quite captured in the statements you have been provided. • Blanks are also provided so you write down these ideas if needed. • You can write on your diamond the reason(s) for placing a statement in a particular position. • order them according to criteria: What is "beneficial to my learning" e.g., from what you personally consider are most helpful to least helpful actions What kind of feedback works to help you learn? What works to help you learn? What is most important to least important? Indicated they need to be ready to explain why they have put in that order. (only use blanks here if needed)	Students complete diamond rank individually (10 minutes)
b. Students then work as a group.	Use individual diamond ranks to pitch questions back to group about why one statement might not have or have high priority. Look for trends, patterns to comment on.	• You will now share and compare with others – you will find you may think similarly or think differently. That is what we are going to discuss – how and why you are different and similar? I am interested in these patterns. There is no need to have a group consensus. • Before you share – can I take picture	<u>15 mins</u>

4. Debriefing exercise	First two – use only if discussion when sharing diamond ranks does not proceed. (capture changes)	• How difficult was it to rank the statements and what problems did you encounter if any? • Were you able to provide arguments to explain your diamond? Give reasons. <u>Final question</u>: Did you hear good reasons from others you hadn't considered before? If you have heard something from the discussion that has persuaded you enough to change your ranking in the diamond then do this now.	5 mins

Appendix C: Example of stimulus material used in focus group sessions

Cellular Respiration (4 of 5): Oxidative Phosphorylation (BioFlix tutorial)

Oxidative phosphorylation consists of two tightly linked processes - electron transport and ATP synthesis. In electron transport, the NADH and $FADH_2$ produced in the first three stages of cellular respiration are oxidized by O_2 (the *oxidative* part of this stage). These redox reactions also drive the pumping of protons across the inner mitochondrial membrane, creating a proton (H^+) gradient. This H^+ gradient is used to power the chemiosmotic synthesis of ATP from ADP and P_i (the *phosphorylation* part of this stage).

As you watch the Oxidative Phosphorylation animation, pay close attention to how electron transport is coupled to the formation of the H^+ gradient and ATP synthesis.

Part A - The role of O_2 in electron transport

In mitochondrial electron transport, what is the **direct** role of O_2?

You did not open hints for this part.

ANSWER:

- to provide the driving force for the production of a proton gradient
- to oxidize NADH and $FADH_2$ from glycolysis, acetyl CoA formation, and the citric acid cycle
- to function as the final electron acceptor in the electron transport chain
- to provide the driving force for the synthesis of ATP from ADP and P_i

Part B - The effects of anaerobic conditions

How would anaerobic conditions (when no O_2 is present) affect the rate of electron transport and ATP production during oxidative phosphorylation? (Note that you should *not* consider the effect on ATP synthesis in glycolysis or the citric acid cycle.)

You did not open hints for this part.

ANSWER:

- Both electron transport and ATP synthesis would stop.
- Electron transport would stop but ATP synthesis would be unaffected.
- Neither electron transport nor ATP synthesis would be affected.
- Electron transport would be unaffected but ATP synthesis would stop.

Part C - Comparing the amount of ATP synthesis from NADH and $FADH_2$

NADH and $FADH_2$ are both electron carriers that donate their electrons to the electron transport chain. The electrons ultimately reduce O_2 to water in the final step of electron transport. However, the amount of ATP made by electrons from an NADH molecule is greater than the amount made by electrons from an $FADH_2$ molecule.

Which statement best explains why more ATP is made per molecule of NADH than per molecule of $FADH_2$?

You did not open hints for this part.

ANSWER:

- Fewer protons are pumped across the inner mitochondrial membrane when $FADH_2$ is the electron donor than when NADH is the electron donor.
- The H^+ gradient made from electron transport using NADH is located in a different part of the mitochondrion than the H^+ gradient made using $FADH_2$.
- It takes more energy to make ATP from ADP and P_i using $FADH_2$ than using NADH.
- $FADH_2$ is made only in the citric acid cycle while NADH is made in glycolysis, acetyl CoA formation, and the citric acid cycle.
- There is more NADH than $FADH_2$ made for every glucose that enters cellular respiration.

Part D - The effect of gramicidin on oxidative phosphorylation

When the protein gramicidin is integrated into a membrane, an H^+ channel forms and the membrane becomes very permeable to protons (H^+ ions). If gramicidin is added to an actively respiring muscle cell, how would it affect the rates of electron transport, proton pumping, and ATP synthesis in oxidative phosphorylation? (Assume that gramicidin does not affect the production of NADH and $FADH_2$ during the early stages of cellular respiration.)

Sort the labels into the correct bin according to the effect that gramicidin would have on each process.

You did not open hints for this part.

ANSWER:

Appendix D: Coding map and codes

Candidate themes and sub-themes showing associated codes

Theme	Sub-themes	FG1 codes	FG2 codes	FG3 codes	FG4 codes
Time is valuable	Competing demands	hard to keep up with coursework if no regular activities to keep on task compromise quality of assignment based on time do exercises hurriedly	do enough to get a good grade time is a limiting factor do not use hints so can complete questions as quickly as possible	assignment takes too long to complete do assignments at last minute complete at last minute online requires additional time	
	Time well spent	Good to be given regular homework like to do the minimum effort for maximum gain repetition helpful for rote learning			
	Quality time	like application of learning in different contexts			
Reputation / feelings	Competitive/high stakes environments	like to be guided toward answer like clear instructions important knowing what is helpful I didn't do what I know is good for learning	having the answers it is important to get feedback from tests and exams to know where you went wrong practice questions at end of a lecture cannot trust feedback that is about previous cohort's achievement knowing what is expected for answering questions in tests and exams mcqs mask if you understand the concept well	feedback helps you learn what you need to pass exam	first year is competitive and students main goal is high grades Competitiveness is disincentive to ask questions like when online activities are similar to tests and exams
	Challenges of learning interactions	do not like being given answer dislike ambiguity people don't always know what they are talking about	do not understand everything in a lecture at uni you have to do things for yourself	small group discussion work for learning	Competitiveness is disincentive to ask questions in large classes, there is tension if discussion is attempted like to interact with other students School is more personal compared to university
	Trust is important	learning is about shared experience with students rely on discussions with students to check understanding facebook discussions or posted information unreliable	can learn new material in discussions with other students believe other students do not always give honest feedback cannot trust feedback that is about previous cohort's achievement		Facebook used for learning can mean getting information which is misleading

	Expectations	students can be confident but may be wrong tend to be lazy and short of time when learning	in first year you are helped with your learning in second and third year you are left on our own start courses with good intentions at high school everything is given to you		School is more personal compared to university
	Protection of self-efficacy	do not like to admit to 'teacher' when do not know something self-blame when do not know fear of people judging reluctant / self conscious to seek feedback if know work is incorrect personal feedback is ego building only ask questions in discussions if know content well	personal feedback helps confidence and motivation too shy to answer questions do not like to ask questions of lecturer if don't understand	don't like asking questions because of fear of embarrassment do not ask many questions in first year	discussions are hard to have in large classes believe more likely to ask questions in 2nd and 3rd year in first year do not like answering questions if get wrong reluctant to interact in first year it is overwhelming in first year lectures for answering questions
Summative Assessment domination (SAD)	Grade focus	feel forced to do online activities (as worth final marks) did activities because compulsory did activities to get marks strategise if multiple attempts available need to know what is required to pass	like practice questions when you get definitive answers practice questions without answers are tricky	like incentives to complete (e.g., marks for grades like feedback that indicates position in class	like when online activities are similar to tests and exams students are mark oriented online activties help understand the characteristics of MCQs like immediate access to explanations / information in hints
	Engagement vs passing	positive achievement is motivating / reinforcing / building of confidence general feedback is helpful for information you did not know	online systems help you get the material yourself rather than be passive in first year a lot of people don't know how to study forgot information when reading textbook intimidated by textbook with 1000+ pages	drag/drop require more thought	online activities help learning to pay attention to detail of question online activities help learn about importance of giving concise and accurate answer intime feedback about how to correct work is important
	Value of education	dangerous if learn something incorrectly first time no time to reflect on feedback	helpful to know what you are not understanding	online gives more options for learning/study do not like quality of feedback in first year	like not being punished for using extra information believe the purpose of university is to use what leant in other situations applying knowledge is motivational do not like lectures that are disconnected
Relationships	Expectations of teachers	Teacher / lecturer is more reliable than other students for information	believe the type of feedback is marker dependent like to ask questions of lecturer by email do not like to ask questions after a lecture do not understand everything in a lecture	like to ask when don't understand cannot connect with lecturers so easily in first year	in first year aware lecturers want interactive classes some lectuers use great techniques (questions/responses) to support students to answer questions questions during discussion do not feel like assessment

			do not expect to receive useful feedback in lectures lecturers have different expectations talking to a teacher means you get corrected in time		do not like if contact/ access to teacher / lecturer is difficult motivation of lecturer/tutor to teaching is critical skills of teacher important for learning know lecturers have different expectations for assignments / marking feedback to class has extra information about learning
	Reliability of peers	reluctant to question peers about accuracy only ask questions in discussions if know content well	in first year a lot of people don't know how to interact with each other teaching other students forces you to learn material	not sure how well peers understand work not sure about reliability of peer feedback like sharing ideas with peers to increase knowledge	know that copying is bad do not trust feedback from peers in a large class do not trust feedback from peers in a competitive environment
Pick and mix feedback /variability feedback use	Getting directions	need to know what is required to pass	use textbooks to help understand / process lecture exemplars help you focus helpful to know what you are not understanding	Helpful to what a successful piece of work looks like	discussion is helpful to refine understanding to a good level like iterative/continuous questioning with feedback to help understand like to have some idea of what a successful piece of work looks like in year 2 and 3 believe feedback helps to produce a good piece of work
	Staying on the right path	learning within a course is different to learning from one year to the next it is important having the bigger picture feedback given after an assignment is handed in is too late	feedback helpful when explain "why" hints show the steps that lead to the answer practice questions are good for directing studies hints help you figure out your specific weaknesses like specific feedback in essay writing like feedback from marking rubrics and criteria having your thoughts directed is helpful hints remove guess work	like feedback that helps tell you how to correct work	hints help you to answer questions properly l it is OK to get wrong as becomes a low-risk decision getting immediate feedback for wrong answers multiple hints (feedback) for a question extend learning like confirmation of when correct important to know what you need to do to achieve goal / complete activity feedback that focuses on process required to improve work is better than knowing what a successful piece of work looks like like to get feedback about completed work before attempting next piece of work like immediate access to explanations / information in hints like having permission to get things wrong and then have opportunity to get right
	Worthwhile journeys	Having goal(s) / know where you are heading is important	see courses as connected		develop self-sufficiency as progress at university believe what is helpful for learning is separate from what helps for assessment

	Building confidence	personal positive feedback is motivating / reinforcing / building of confidence gain confidence if feedback confirms correct understanding			the feedback from the online system helps build confidence to talk to teachers and peers.
Technology as feedback	Obligatory	Dislike drag/drop style questions dislike rote learning difficulty getting started to use online system do exercises hurriedly complete by clicking through exercises online questions do not relate to lectures did not know enough about questions did not like getting another question when asked for hint/feedback/help believe using hints/feedback will lose marks effort is required to understand	scared to use hints in case lose marks do not like using hints look at hints after answering a question do not use hints so can complete questions as quickly as possible previous experience (penalised) means less likely to use hints		online activities as forced / made learning compulsory online activities feels like a chore while doing it
	Infotainment	animations are helpful You tube not reliable like pictures dislike reading words / science overwhelming	animations are good to help explain content online activities provide a break from reading the textbook	Animations are good prefer online activities to reading text book visual/diagrams material help learning	videos/animations useful for learning and interesting
	Technology receptive/committed	Online multichoice questions are good drag/drop style questions are good animations help understanding confidence in system because provided by university online diagrams in hints help definitions in hints are helpful hints give clues	animations are concise and contain a lot of information still diagrams need to be presented in stages to be helpful online learning activities give multiple perspectives hints are helpful online systems help bring everyone to the same level online systems are helpful if you did not do bio before extra material in online system is helpful online user friendly format hints similar to NCEA questions - build knowledge through levels there are multiple strategies to learn using hints favourite hints are ones that asked you a question	animations relate to lecture material animations easier to work with use activities during test and exam as revision use for review drag/drop activities helpful hints give more detail for understanding online is a different way of learning/thinking	hints combined with video / animations are good online activities help familiarisation of topic get extra information from hints that do not get from lecture enjoy reward (marks) for doing online activities (felt encouraged) online systems give answers when you do not want to answer questions computer feedback is important to help understand why answer incorrect

Appendix E: Participant information sheets and consent forms

THE UNIVERSITY OF AUCKLAND
FACULTY OF EDUCATION
Te Kura Akoranga o Tāmaki Makaurau
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School of Teacher Education Practice
Epsom Campus

Telephone 64 9 6238899
Facsimile 64 9 6238853
www.education.auckland.ac.nz

The University of Auckland
Private Bag 92601, Symonds Street
Auckland 1150, New Zealand

PARTICIPANT INFORMATION SHEET
REQUEST TO ACCESS SCHOOL OF BIOLOGICAL SCIENCES
(Director of School)

TITLE: The Utility of Online Homework in Learning Acquisition in First Year Biological Science Courses.
RESEARCHERS: *Dr Mary Hill, Mandy Harper and Assoc. Prof Ben Dyson*

Dear

Dr Mary Hill and A.P. Ben Dyson are teachers and researchers in the Faculty of Education. As an Education Doctoral student in the Faculty of Education and Director of stage one teaching in the School of Biological Sciences in the Faculty of Science, I am the researcher on this project.

I am interested in assessing the effects of online homework in learning gains in first year biological science courses. Online homework using Pearson Education Mastering products delivers formative assessment as part of mandatory coursework in first year biology classes. All students are provided with the access code to the Mastering system as part of course resources. It is proposed that students who complete online homework activities in a timely manner will be more likely to learn effectively. The data we seek permission to analyse is generated as a natural outcome when students complete online activities for homework. These activities are designed to support learning concepts and content of lectures and provide appropriate preparation for other assessments. We would like to carry out this research with BIOSCI 101, 106 and 107 classes which use Mastering for homework in semester two 2011 and 2012 to 2014. This will provide historical data and the opportunity to investigate cohort differences.

If you agree, archived student data will be analysed after the completion of the course. For this reason we assure you this analysis has no impact on any assessments or final grades. However we anticipate analysis will be informative in modifying course assessment design for students enrolling in first year courses in the future.

The researchers will not be able to identify students taking part in the study, because another person will be distributing information and collecting consent forms. Student privacy will be maintained by coding the data. This coding will be done by a third party, who has signed a

confidentiality agreement, before any analysis is undertaken. As the researcher, I will ensure that students will not be able to be identified in any way in any publications resulting from this research.

Students will also be emailed through Cecil at various times during the course an invitation to complete a quick survey which seeks their views about the online homework activities. Each survey is anonymous.

The results of the data analysis and anonymous questionnaire will be used in conference presentations and research reports. We will provide you with a research report.

We hope you will give permission for this research to take place in your school. If you have any queries please contact us or the Head of the School of Teacher Education Practice at the Faculty of Education.

Dr Lexie Grudnoff
Head of School of Teacher Education Practice
Faculty of Education
The University of Auckland
Private Bag 92601
Auckland
l.grudnoff@auckland.ac.nz
Tel: 09 623 8899 ext 48890

Dr Mary Hill
School of Teacher Education Practice
Faculty of Education.
The University of Auckland
Private Bag 92601
Auckland
mf.hill@auckland.ac.nz
Tel: 09 623 8899 ext 48630

Associate Professor Ben Dyson
School of Critical Studies in Education
Faculty of Education
The University of Auckland
Private Bag 92601
Auckland
b.dyson@auckland.ac.nz
Tel: 09 623 8899 ext 48337

Mandy Harper
School of Biological Sciences
Faculty of Science
The University of Auckland
Private Bag 92019 Auckland
a.harper@auckland.ac.nz
Tel: 09 373 7599 ext 87794

Yours sincerely

Mandy Harper

For any queries regarding ethical concerns you may contact the Chair, The university of Auckland Human Participants Ethics Committee, The University of Auckland, Office of the Vice Chancellor, Private Bag 92019, Auckland 1142. Tel (09) 373 7599 ext 83711.

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS EHTICS COMMITTEE on 26/10/11 for (3) years.
Reference Number 2011/ 7641

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Incorporating the Auckland College of Education

School of Teacher Education Practice
Epsom Campus

Telephone 64 9 6238899
Facsimile 64 9 6238853
www.education.auckland.ac.nz

The University of Auckland
Private Bag 92601, Symonds Street
Auckland 1150, New Zealand

PARTICIPANT INFORMATION SHEET
(Students)

TITLE: The Utility of Online Homework in Learning Acquisition in First Year Biological Science Courses.
RESEARCHERS: *Dr Mary Hill (P.I), Mandy Harper and Assoc. Prof Ben Dyson*

Dear Students

Dr Mary Hill and Assoc. Ben Dyson are teachers and researchers in the Faculty of Education. Mandy Harper is an Education Doctoral student in the Faculty of Education and Director of stage one teaching in the School of Biological Sciences in the Faculty of Science.

We are interested in assessing the effects of online homework in learning gains in first year biological science courses. It is intended to use Pearson Education Mastering products which are online formative assessment tools. Online homework is part of your coursework and you are provided with the access code to the Mastering system as part of course resources. It is proposed that students who complete online homework activities in a timely manner will be more likely to learn effectively. The data we seek permission to analyse is generated as a natural outcome when you complete online activities for homework. These activities are designed to support learning concepts and content of lectures and help you prepare for other assessments which are part of your course design. Data from your homework is archived and we propose to analyse this data after the completion of the course. For this reason we assure you this analysis has no impact on any of your assessments or final grades. However we anticipate analysis will be informative in modifying course assessment design for students enrolling in first year courses in the future.

The researchers will not know if you take part in the study or not, because another person Caroline Aspden will be distributing information and collecting consent forms. Your privacy will be maintained by coding the data. This coding will be done by a third party before any analysis is undertaken. As the principal investigator, I will ensure that you will not be able to be identified in any way in any publications resulting from this research.

If you decide to withdraw from the research please email Caroline within a month of signing the consent form. Your data will not be included in the analysis. Caroline's email address is c.aspden@auckland.ac.nz.

We will also email the class at various times during the course to invite you to complete a quick survey which seeks you opinion about the online homework activities. Each survey is anonymous.

We hope you take part in this research. If you have any queries please contact us or the Head of the School of Teacher Education Practice at the Faculty of Education.

Dr Mary Hill
School of Teacher Education Practice
Faculty of Education
The University of Auckland
Private Bag 92601
Auckland
mf.hill@auckland.ac.nz
Tel: 09 623 8899 ext 48630

Associate Professor Ben Dyson
School of Critical Studies in Education
Faculty of Education
The University of Auckland
Private Bag 92601
Auckland
b.dyson@auckland.ac.nz
Tel: 09 623 8899 ext 48337

Mandy Harper
School of Biological Sciences
Faculty of Science
The University of Auckland
Private Bag 92019 Auckland
a.harper@auckland.ac.nz
Tel: 09 373 7599 ext 87794

Yours sincerely

Dr Mary Hill

For any queries regarding ethical concerns you may contact the Chair, The university of Auckland Human Participants Ethics Committee, The University of Auckland, Office of the Vice Chancellor, Private Bag 92019, Auckland 1142. Tel (09) 373 7599 ext 83711.

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS EHTICS COMMITTEE on 26/10/11 for (3) years. Reference Number 2011/7641

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Facsimile 64 9 6238853
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CONSENT FORM
(Director / Head of School)

TITLE: The Utility of Online Homework in Learning Acquisition in First Year Biological Science Courses.
RESEARCHERS: *Dr Mary Hill, Mandy Harper and Assoc. Prof Ben Dyson*

I have read the Participant's Information Sheet and have understood the nature of the research and been given the opportunity to ask any questions and have them answered to my satisfaction.

I understand:

- That the data analysis is unable to identify individual students as it will be coded by a person not involved in the research.
- All questionnaires are anonymous. There will be no identifying features about students in the research report.
- I will be provided with a research report.

I therefore give my informed consent for the research project *The Utility of Online Homework in Learning Acquisition in First Year Biological Science Courses* to be carried out in the School of Biological Sciences, The University of Auckland.

Name_____

Signed_____ Dated:_____

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS EHTICS COMMITTEE on 26/10/11 for (3) years.
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CONSENT FORM
(Student)
This form will be kept for a period of six years

TITLE: The Utility of Online Homework in Learning Acquisition in First Year Biological Science Courses.
RESEARCHERS: *Dr Mary Hill, Mandy Harper and Assoc. Prof Ben Dyson*

I have read the Participant's Information Sheet and have understood the reasons for this research and why I have been asked to take part.

I understand:

- That the data analysis is unable to identify me individually as it will be coded by a person not involved in the research. The researchers will be unable to identify me individually.
- All questionnaires are anonymous and I do not have complete online questionnaires.
- I understand that if I decide to withdraw from this research at any time until the end of December 2011, I can email Caroline Aspden who will remove my coded information.

I therefore give my permission for data relating to my homework other assessment activities to be analysed for the research project *The Utility of Online Homework in Learning Acquisition in First Year Biological Science Courses* to be carried out in the School of Biological Sciences, The University of Auckland.

Name_____

Signed_____ Dated:_____

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS EHTICS COMMITTEE on 26/10/11 for (3) years.
Reference Number 2011/ 7641

THE UNIVERSITY OF AUCKLAND
FACULTY OF EDUCATION
Te Kura Akoranga o Tāmaki Makaurau
Incorporating the Auckland College of Education

School of Teacher Education Practice
Epsom Campus

Telephone 64 9 6238899
Facsimile 64 9 6238853
www.education.auckland.ac.nz

The University of Auckland
Private Bag 92601, Symonds Street
Auckland 1150, New Zealand

CODING CONFIDENTIALITY AGREEMENT

TITLE: The Utility of Online Homework in Learning Acquisition in First Year Biological Science Courses.

RESEARCHERS: *Dr Mary Hill, Mandy Harper and Assoc. Prof Ben Dyson*

CODER:_____

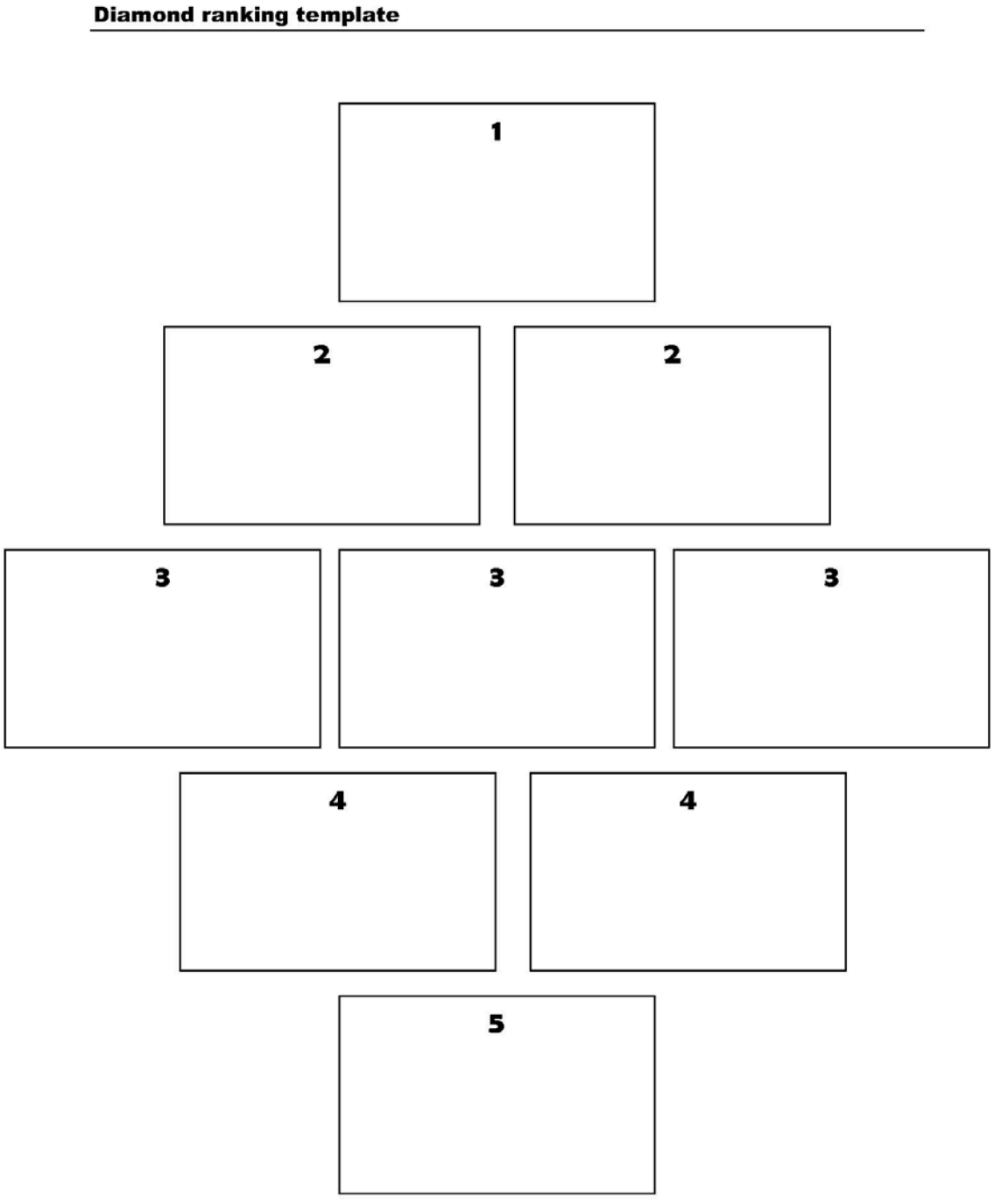
I agree to code the student data from the MasteringBiology grade book and Cecil grade book for the above project.
I understand the data is confidential and must not be disclosed to, or discussed with anyone else in a manner that will identify individual students.

Name_____

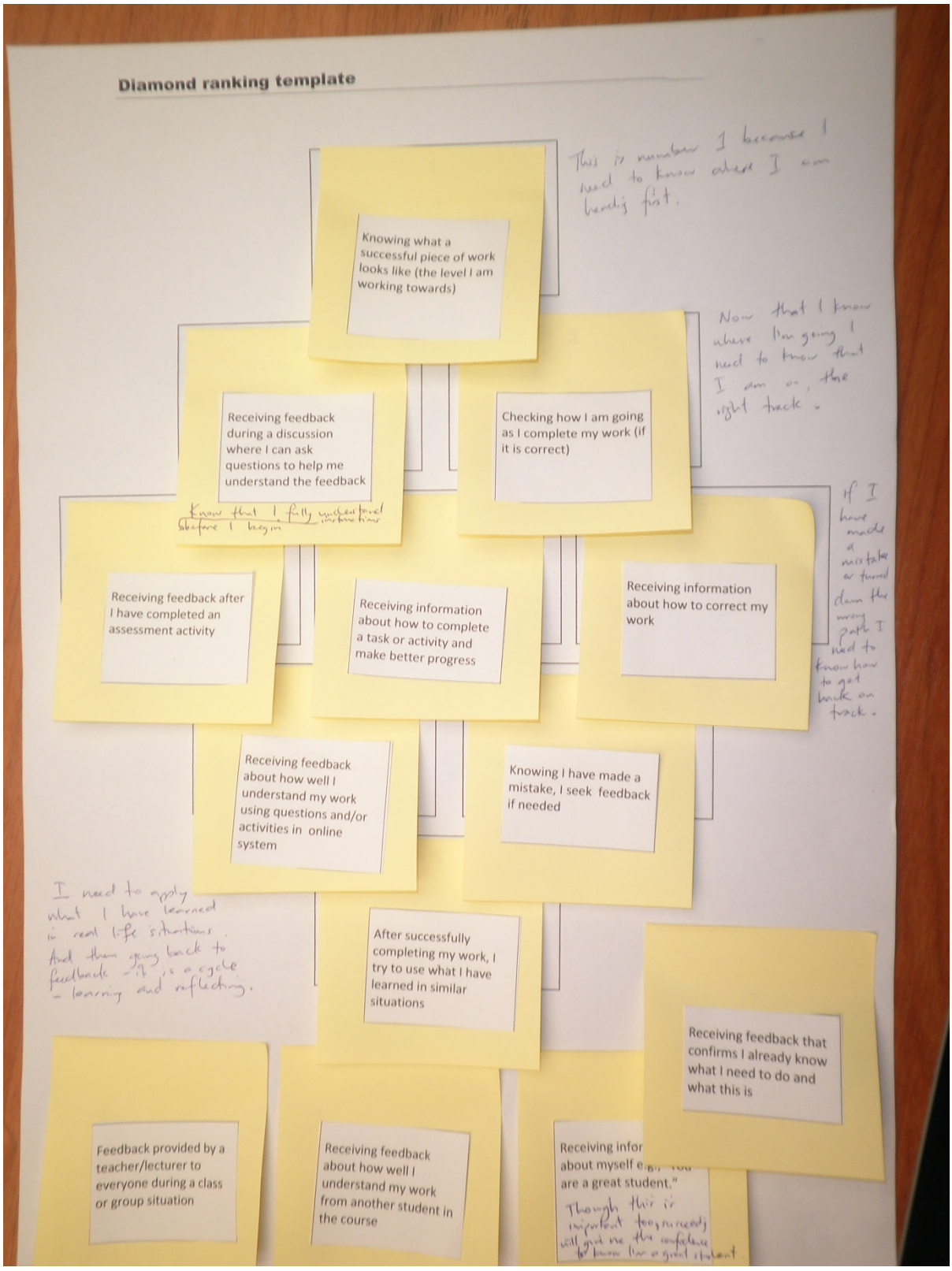
Signature_____

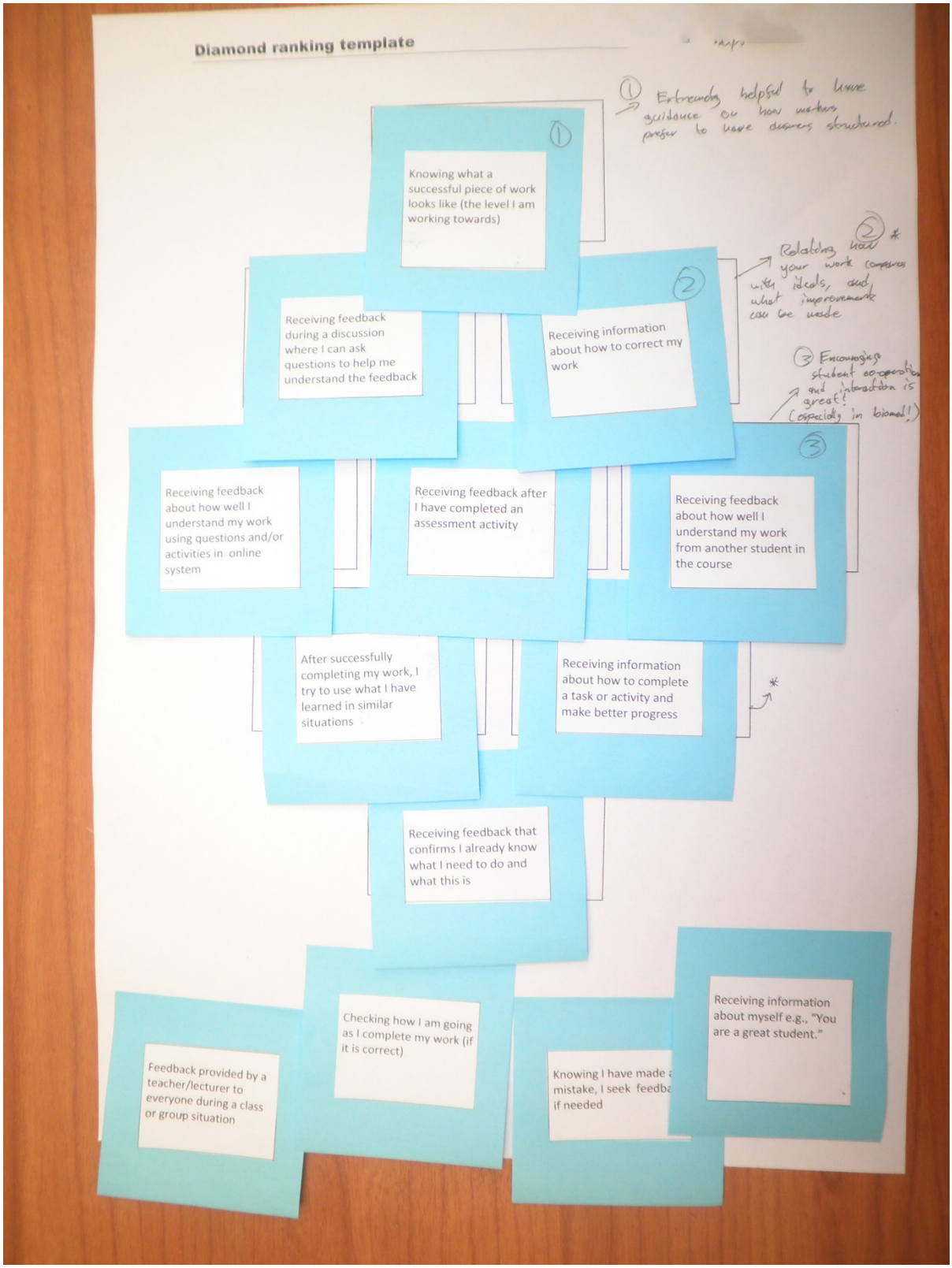
Date_____

Appendix F: Diamond template used in focus groups and examples of students after ranking exercise.



Examples Students diamond ranking:




Diamond ranking template
Knowing what a successful piece of work looks like (the level I am working towards)
Receiving feedback during a discussion where I can ask questions to help me understand the feedback
Receiving information about how to correct my work
Receiving feedback about how well I understand my work using questions and/or activities in online system
Receiving feedback after I have completed an assessment activity
Receiving feedback about how well I understand my work from another student in the course
After successfully completing my work, I try to use what I have learned in similar situations
Receiving information about how to complete a task or activity and make better progress
Receiving feedback that confirms I already know what I need to do and what this is
Feedback provided by a teacher/lecturer to everyone during a class or group situation
Checking how I am going as I complete my work (if it is correct)
Knowing I have made a mistake, I seek feedba if needed
Receiving information about myself e.g., "You are a great student."

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