The Potential and Pitfalls of Blended Learning

An Investigation of Student and Teacher Perceptions of Blended Learning in two Australian Secondary Science Classes

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by

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STATEMENT OF CONTRIBUTION OF OTHERS

To the best of my knowledge and belief, this thesis contains no material previously published by any other person, except where due acknowledgement has been made. The research presented in this thesis was undertaken by the author under the supervision of Dr. Clifford Jackson and A/Prof Hilary Whitehouse who provided ongoing contributions to my research design, proposal writing, data analysis and editorial assistance.

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ABSTRACT

In 2013, The FNQ Explicit Teaching Project was implemented in an effort to improve learning outcomes for all students in Far North Queensland. The policy was developed to address perceptions of poor teaching quality brought about, in part, by Queensland's performance in the inaugural 2008 NAPLAN tests (Hardy, 2016). At the same time, teachers at the school where I was working were looking for ways to increase student participation and engagement in science lessons. Lyons and Quinn (2010) argue engaging and inclusive science teaching is more valued by students, and Carter et al. (2012) found that students perform well in learning situations that promote competence, engender autonomy, and encourage relatedness. Integrating new and emerging technologies into the classroom has the potential to make learning more engaging through individualised and cooperative learning opportunities (Chandra & Briskey, 2012; Chandra & Watters, 2012; O. L. Liu, Lee, & Linn, 2010; Lyons & Quinn, 2010; Rosen & Nelson, 2008; Sun & Looi, 2013). One approach used to integrate new technologies into classrooms is blended learning. Blended learning or hybrid learning is the combination of online and traditional face-to-face learning in a synergistic manner (De George-Walker & Keeffe, 2010; Francis & Shannon, 2013). Studies investigating the use of blended learning in secondary math and science have found that students generally have a positive perception of learning using the approach, leading to higher academic achievement and improved student engagement (Chandra & Briskey, 2012; Chandra & Watters, 2012; Yapici & Akbayin, 2012). However, much of research on blended learning has been conducted in universities, and few studies have explored student and teacher perceptions of using blended learning in secondary schools. To better understand the potential and pitfalls of

blended learning, I chose to investigate the implementation of blended learning in two of my Year 10 Science classes.

Loughran (2002) wrote that "Teacher-researchers can be characterised as those practitioners who attempt to better understand their practice, and its impact on their students, by researching the relationship between teaching and learning in their world of work" (Loughran, 2002, p. 3). As a reflective practitioner my goal was to look deeply at my own teaching practice and its impact on my students as a means of self-reflection to guide improvements in my teaching practice. To do this I needed to examine both my own and my students' perceptions of blended learning in secondary science. I conducted the study in a public secondary school in Far North Queensland with two, Year 10 science classes using a convergent mixed methods strategy of inquiry. During the study I collected and analysed qualitative and quantitative data including pre- and post-test scores, student surveys using the Web-based Learning Environment Instrument (WEBLEI), student focus-group interviews, in-class observations from a third party (explicit teaching coach), and teacher-researcher observation and reflections.

My results contribute to our understanding of factors that influence student and teacher perceptions of blended learning, and elucidate the potential and pitfalls of using blended learning in secondary science. Results from the pre-test and post-test comparison demonstrated that blended learning had a positive effect on my students' achievement in secondary science, and the qualitative data indicates that my students felt that blended learning had a positive influence on their achievement. My research shows that students valued blended learning features which allowed them to learn at their own pace, prioritise specific topics, catch up at home on missed lessons, revise past lessons, access online text-books, access self-marking quizzes, and learn using engaging learning objects. Interestingly, my research revealed mixed perceptions of blended learning with the majority of students (62%) indicating that they learned more with blended learning, but only 55% indicating that they enjoyed learning in this modality. From a teacher-researcher perspective, I found that the *Explicit Teaching Model – FNQ* provided a sound framework for structuring and planning secondary science unit using blended learning. While it was initially very time consuming to design lessons and quizzes, in the long run I feel this would be alleviated by the ability to re-use content with only slight modification in subsequent iterations. My research fills a gap by providing insight into using explicit teaching as a framework for planning and implementing blended learning in secondary science and demonstrates the value of high level practitioner research.

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LIST OF ABBREVIATIONS

ACARA	Australian Curriculum, Assessment and Reporting Authority
ACER	Australian Council for Educational Research
AITSL	Australian Institute for Teaching and School Leadership
COLLES	Constructivist On-Line Learning Environment Survey
DELES	Distance Education Learning Environments Survey
ETLM-FNQ	Explicit Teaching Lesson Model - FNQ Region
FNQ	Far North Queensland
ICT	Information and Communication Technology
LMS	learning management system
NAPLAN	National Assessment Program – Literacy and Numeracy
OECD	Organisation for Economic Co-operation and Development
OLES	Online Learning Environment Survey
PCK	Pedagogical Content Knowledge
PISA	Programme for International Student Assessment
STEM	Science, technology, engineering and mathematics
TROFLEI	Technology-Rich Outcomes-Focused Learning Environment Inventory
TSPCK	Topic-Specific Pedagogical Content Knowledge
UNESCO	United Nations Educational, Scientific and Cultural Organization
WEBLEI	Web-Based Learning Environment Instrument

CHAPTER 1 INTRODUCTION

1.1 Origin of this thesis

This thesis was inspired by my experiences as a secondary science teacher, and explores the opportunities afforded by the integration of new technology in secondary science teaching and learning. Students are seen as increasingly disengaged with science in Australia, and with formal learning in general. Many schools are failing to nurture students' curiosity and creativity, resulting in students who struggle with the creative thinking required to be successful in science. We are thus seeing a decline in students enrolling in secondary science (Tytler, 2007). Fundamental and dramatic reforms are needed at all levels of education, to inspire and nurture a creativity and passion for learning. The current construct of the teacher standing at the front of the classroom has been refuted numerous times throughout the educational research literature. However, we continue to see this in classrooms around the world. Despite a wealth of evidence to the contrary, the teacher-directed construct remains prevalent, suggesting a dramatic researcher-practitioner gap in education. Just because we are teaching, does not necessarily mean that the students are learning. I believe that educators must put a greater emphasis on broad skills such as independent research, interpreting evidence and critical thinking rather than learning dates, facts and figures by rote. My research was therefore focused on investigating an emergent pedagogical approach, blended learning, and evaluating student and teacher perceptions of the approach.

1.2 Background to this study

Science and innovation are seen as critical components of society, facilitating productivity, growing economies and enhancing global competitiveness (Office of the Chief Scientist, 2014). In Australia, this awareness has led to calls for improvements in STEM (Science, Technology, Engineering and Mathematics) “teaching at all levels, supported by high quality and relevant teacher training and subject-specific professional development” (Office of the Chief Scientist, 2014, p. 20). However, several studies have identified declines in post-compulsory science enrolments in Australian secondary schools (Ainley, Kos, & Nicholas, 2008; Goodrum, Druhan, & Abbs, 2012; Kennedy, Lyons, & Quinn, 2014; Lyons & Quinn, 2010; Office of the Chief Scientist, 2012). This downward trend in secondary science enrolments, and a lack of qualified STEM teachers provides a challenging obstacle towards increasing STEM capabilities in Australia (Ainley et al., 2008; Goodrum et al., 2012; Lyons & Quinn, 2010; Tytler, Osborne, Williams, Tytler, & Clark, 2008). Several studies link the decline in post-compulsory science education in Australian secondary schools to a decline in student engagement with science in the junior secondary school (i.e. students aged 12-16) (Ainley et al., 2008; Goodrum et al., 2012; Kennedy et al., 2014; Lyons & Quinn, 2010, 2012; Office of the Chief Scientist, 2012).

Blended learning combines online digital media with traditional classroom pedagogies, and has been shown to improve student attitudes and achievement in secondary science (Chandra & Watters, 2012; Sun & Looi, 2013), create opportunities for collaborative learning (Rosen & Nelson, 2008), and increase student engagement (Lyons & Quinn, 2010). Chandra and Watters (2012) demonstrated that the success of blended learning is linked to facilitating individual coaching, scaffolding, modelling, and more effective questioning. However, research also shows that computer use is not always well integrated into classroom teaching and learning (Donnelly, McGarr, & O'Reilly, 2011; Goodrum et al., 2012; Hayes, 2007; Webb, 2013). In their report on *The Status and Quality of Year 11 and 12 Science in Australian Schools*, Goodrum et al. (2012) found the transmission model for teaching science still prevails, and 73% of science students still spend a significant amount of their time copying notes from the teacher. Also, students reported they had little choice in pursuing areas of interest, and that practical work tended to be 'recipe based' with students asked to follow a set of instructions rather than embarking on true inquiry. Present research on blended learning has demonstrated promising results in secondary science classrooms (Chandra & Fisher, 2009), however there is presently limited research on student and teacher perceptions of using blended learning in secondary science classrooms.

1.3 Purpose and Research Questions

The purpose of this study was to investigate student and teacher perceptions of blended learning in a Year 10 Science classroom.

Research Questions

1. What features of blended learning are important to secondary science students?
2. What are students' perceptions of using blended learning in secondary science?
3. How does blended learning influence student achievement in secondary science?
4. How can the *Explicit Teaching Lesson Model – FNQ Region* be used to inform blended learning?
5. What are the teacher's perceptions of using *Explicit Teaching Lesson Model – FNQ Region* to design and deliver a blended learning course in secondary science?

1.4 Rationale of the Study

> It seems that the curiosity and wonder one would hope is associated with studying science is missing for a large proportion of students. It is clear that further actions need to be undertaken to transform this continuing situation. (Danaia, Fitzgerald, & McKinnon, 2013, p. 1501)

Computer-based information and communication technology (ICT) has revolutionised all aspects of our lives, but may not yet be fully utilized in many aspects of education. From the emergence of the first personal computers in the 1960's to the increasingly proficient smart-phones and tablets in the 2000's, and more recent advances in wearable technology, ICT continues to have an increasingly important role in society. ICT is also changing education around the world by providing opportunities to improve equity in education, through universal and on-demand access to education (OECD, 2015). ICT also has the potential to make learning more engaging through individualised and cooperative learning opportunities (Chandra & Briskey, 2012; Chandra & Watters, 2012; O. L. Liu et al., 2010; Lyons & Quinn, 2010; Rosen & Nelson, 2008; Sun & Looi, 2013). However, while there are many examples of the benefits of ICT in education, technology is not always well integrated into classroom teaching and learning (Donnelly et al., 2011; Goodrum et al., 2012; Hayes, 2007; Webb, 2013). A recent report from the Organisation for Economic Co-operation and Development (OECD) argues that, "we have not yet become good enough at the kind of pedagogies that make the most of technology" (OECD, 2015, p. 3).

The increasing use of ICTs in society, and perceived benefits in educational contexts has led to continuing changes by education policymakers around the world in an attempt to formalise ICT policies as part of educational renewal and reform (Wallet, 2014). The *Dakar Framework for Action, Education for All: Meeting our Collective Commitments* was adopted by The World Forum in April 2000. In doing so, its participants reaffirmed the vision of the *World Declaration on Education for All* adopted ten years earlier *(UNESCO, 2000)*. The Dakar Framework established a number of initiatives towards achieving education for every citizen in every society; among these initiatives were one of the first international commitments to ICT integration in education:

> Governments will therefore need to establish clearer policies in regard to science and technology, and undertake critical assessments of ICT experiences and options. These should include their resource implication in relation to the provision of basic

> education, emphasizing choices that bridge the 'digital divide', increase access and quality, and reduce inequity. (UNESCO, 2000, p. 21)

The growing importance of ICT in education has been recognised in most countries through a growing global interest in STEM (science, technology, engineering and mathematics) education, and science and innovation are seen as critical components, in facilitating productivity, growing economies and enhancing global competitiveness (Office of the Chief Scientist, 2014). Blended learning is one successful approach to integrating technology into standard classrooms (Moskal, Dziuban, & Hartman, 2013). For the purposes of this study, blended learning is defined as a pedagogical approach that explicitly integrates online and face-to-face learning, and where students have meaningful interactions with their teacher with and without the mediation of electronic technology (Waha & Davis, 2014). Blended learning can provide a more personalised and student-centred learning experience while still allowing students to readily access teacher support (Boulton, 2008; Staker & Horn, 2012). However, the challenge of blended learning is to create well-designed and organised content that maintains students' motivation and strengthens their time management skills (Barbour, 2008). There is consensus that, when designed in conjunction with good teaching practices, blended learning can contribute to improved student achievements and engagement (Calderon, Ginsberg, & Ciabocchi, 2012; Chandra & Briskey, 2012; Chandra & Fisher, 2009; Chandra & Watters, 2012; López-Pérez, Pérez-López, & Rodríguez-Ariza, 2011; Pina, 2012; Yapici & Akbayin, 2012). Improving student engagement is a key factor in improving enrolments and achievement in secondary school science.

1.5 Limitations of this study

The limitations of this study are twofold, firstly, although not unusual in this type of research, the sample size was fairly small (N=52), and secondly there are complex issues involved in undertaking the study from an 'insider' perspective. These issues are not independent of one another, and the small sample size was ultimately a function of the need to undertake this study without the undue influence of multiple teacher perspectives. It has been well established that the teacher has a significant role in influencing student perceptions of learning (Dewey, 1910; Lyons & Quinn, 2010). To mediate the effect of the teacher it was determined that it would be most effective to focus on one teacher, who was teaching two Year 10 classes. As the researcher for the present study was also the classroom teacher, this gave rise to the complex issues of insider research. The advantages of insider researcher are detailed by Atkins and Wallace (2012) and include pragmatic (access to organisation and participants), potential opportunities for positive change, economic benefits, and a more in-depth understanding of the context. Challenges in conducting insider research must therefore consider issues of confidentiality, relationships, power and impartiality (Atkins & Wallace, 2012). In the present study, measures were put in place to address potential issues, and were a key component of the ethics approval granted for this study. To avoid issues of power, I, as the teacher-researcher, did not conduct invitations to students to participate in the study, or supervise the student written surveys. Invitations to participate in the study and supervision of written surveys were undertaken by one of the school's laboratory technicians. To address issues of confidentiality, all documents were coded. Relationships and impartiality were mediated through periodic observation from a neutral observer (school appointed teaching coach), and the teacher-researcher's primary supervisor attended focus group interviews. The researcher followed a detailed theoretical framework to conduct the study, and the researcher's supervisor reviewed data collected. This type of research, when conducted carefully, conscientiously and ethically, provides valuable insight into student and teacher perceptions of blended learning in secondary science.

1.6 Overview of the Methodology

This study was conducted with two Year 10 Science classes from the teacher-researcher's school in North Queensland. The researcher modified the Year 10 Earth and Space Science unit based on the Australian Curriculum (ACARA, 2013) using the *Explicit Teaching Lesson Model – FNQ Region* (ETLM-FNQ). The unit was covered in 10 weeks with three, 70-minute lessons per week. Each lesson followed the ETLM-FNQ where students received a teacher directed consolidation of the previous lesson, followed by a short explanation of the key topics for the lesson (*I Do*). Students then accessed online learning materials through the subject website which they worked through in small groups with teacher assistance (*We Do*), or individually (*You Do).* Online learning materials were presented in Blackboard Learn™, and included video clips, reading comprehension exercises, interactive learning objects, discussion board tasks, and a short quiz at the end of each lesson.

To investigate the research questions within the theoretical framework, this study used a convergent mixed methods strategy of inquiry. According to Creswell, there are three primary types of research designs, quantitative, qualitative, and mixed methods (Creswell, 2009). Hoepfl (1997) explains that while "quantitative researchers seek causal determination, prediction, and generalisation of findings, qualitative researchers seek instead illumination, understanding, and extrapolation to similar situations" (p. 48). Qualitative research is a research approach that seeks to describe and explain a persons' experiences, behaviours, interactions and social contexts without the use of statistical quantification (Fossey, Harvey, McDermott, & Davidson, 2002), and is particularly useful in social science research, as many research questions regarding human behaviour do not lend themselves to quantifiable measurements. Qualitative research may be used to understand individuals' and groups' subjective experiences, cultural and political factors, and interactions among participants (Fossey et al., 2002). In contrast, quantitative studies test objective theories through analysis of numerical data (Creswell, 2009). Quantitative methods are appropriate for deductive approaches to research where theories or hypotheses are being tested (Borrego, Douglas, & Amelink, 2009). Mixed methods research combines both qualitative and quantitative research methods (Creswell, 2009). The combination of qualitative and quantitative data collected simultaneously throughout this classroom study was therefore seen to yield a more complete and accurate interpretation of student perceptions of using blended learning in secondary science. Furthermore, the key questions in the present study sought to understand student perceptions of web-based learning as measured using the Web-based Learning Environment Instrument (WEBLEI), which by design relies on both qualitative and quantitative data (Chandra, 2004; Chang & Fisher, 2003; Skelton, 2007; Wong et al., 2006).

This qualitative and quantitative data collected are summarised in Table 1.1. Student perceptions of blended learning were investigated using a written survey and focus group interviews. The WEBLEI (Chandra, 2004) was used to gather data on students' perceptions of the learning environment. This instrument is uniquely suited to evaluating secondary students' perceptions of blended learning. Focus group interviews were then conducted to further investigate the aspects of the blended learning course students found most useful. Student achievement was assessed using a Pre/Post Test. Prior to instruction participants were given a Year 10 Earth & Space Science Pre-Test consisting of both multiple choice and short answer content-understanding questions. Upon completion of the unit, students were given the Year 10 Earth & Space Science Post-Test which contained the same multiple-choice and written-response components used in the Pre-Test. Teacher-researcher perceptions were evaluated using qualitative data which included written observations and reflections from the schools explicit teaching coach, teacher-researcher observations, teacher-researcher reflective journal, and written teacher-researcher reflections to the WEBLEI scales.

Table 1.1 Summary of Data Analysis

Research Question	Type of Data Collected	Instruments for Data Collection
Research Question 1: What features of blended learning are important to secondary science students? **Research Question 2:** What are student's perceptions of using blended learning in secondary science?	Quantitative & Qualitative	Web-based Learning Environment Instrument (WEBLEI) (Chandra, 2004) Focus group interviews
Research Question 3: How does blended learning influence student achievement in secondary science?	Quantitative	Pre-test/Post-test
Research Question 4: How can the *Explicit Teaching Lesson Model – FNQ Region* be used to inform blended learning.	Quantitative & Qualitative	Teacher-researcher observations and teacher-researcher journal Blackboard Learn ™ data on student access and usage Explicit teaching coach observations and meetings
Research Question 5: What are teacher's perceptions of using the *Explicit Teaching Lesson Model – FNQ Region* to design and deliver a blended learning course in secondary science?		

1.7 Significance of the Study

Current declines in enrolment in senior secondary science may be attributed to a lack of engagement in science in years 7-10. Recommendations for improving student engagement and ultimately improving student's perceptions of science as a career option are linked to providing engaging and valued experiences in secondary science. Traditional teaching methods provide a foundation for improving teaching practices, however, these approaches have gaps in achieving a holistic approach to teaching science and engaging students. Previous research has highlighted the benefits of using blended learning in teaching secondary science, however there is limited research on pedagogical strategies used in blended learning.

This study provides an original contribution to the current body of knowledge by presenting and investigating a cohesive pedagogical approach for planning and implementing blended learning in secondary science using the *Explicit Teaching Model – FNQ Region.* This study contributes to the understanding of factors affecting students' perceptions of blended learning in secondary science and reports on the effects of blended learning on student achievement. In addition, the study provides valuable insight into teacher-researcher perceptions of planning and implementing a blended learning course in secondary science.

1.8 Thesis Overview

Chapter 1 provides and introduction and overview of the thesis. In Chapter 2, previous work on blended learning reviewed, illustrating a gap in the literature with particular regards to student and teacher perceptions of using blended learning in secondary science. Chapter 3 provides a detailed account of the methodology. In Chapter 4, qualitative and quantitative data of student perceptions and achievement are presented and analysed. Chapter 5 describes the teacher's perceptions of designing and implementing blended learning. Finally, Chapter 6 discusses the conclusions and limitations of the study, demonstrating this studies' contributions to blended learning research and possible directions for future research.

CHAPTER 2 LITERATURE REVIEW

"If education is growth, it must progressively realize present possibilities, and thus make individuals better fitted to cope with later requirements."

(Dewey, 1916, p. 61)

2.1 Introduction

2.1.1 Science Education - Australia

Studies continue to recognize declines in post-compulsory science enrolments in Australian secondary schools (Ainley et al., 2008; Goodrum et al., 2012; Kennedy et al., 2014; Lyons & Quinn, 2010; Office of the Chief Scientist, 2012). The downward trend in secondary science enrolments has been linked to a decline in student engagement with science in the junior secondary school (i.e. students aged 12-16) (Ainley et al., 2008; Goodrum et al., 2012; Kennedy et al., 2014; Lyons & Quinn, 2010, 2012; Office of the Chief Scientist, 2012). Researchers have proposed a number of measures to address declining engagement and enrolment in secondary science (Ainley et al., 2008; Goodrum et al., 2012; Kennedy et al., 2014; Lyons & Quinn, 2010; Tytler et al., 2008). These recommendations can be summarized as: (1) improved curriculum content; (2) improved teacher quality and expertise; and (3) enhanced focus and flexibility of enacted science pedagogies. Australian Government reforms to develop a national science curriculum and implement coherent professional standards for teachers address the first two recommendations. The new Australian Curriculum for Science in 2012 addressed gaps in the curriculum, specifically the inclusion of the *Science as a Human Endeavour* strand, which connects science learning to everyday life (ACARA, 2013a). As science is one of the least taught subjects in elementary schools in Australia, it is suggested that explicit inclusion of science in the Australian national curriculum may lead to modifications in science teacher education programs and improved inclusion of science at the lower year levels (Treagust, Won, Petersen, & Wynne, 2015). A greater focus on science education in primary schools could have a positive influence on students' perception of science later in their education. In addition to the new Australian Curriculum for Science, the Australian Government addressed national teacher quality by establishing the Australian Institute for Teaching and School Leadership (AITSL) in 2010. In 2011, AITSL developed the Australian Professional Standards for Teachers comprised of seven standards which outline what teachers should know and be able to do (AITSL, 2011). However, a three-year study evaluating the usefulness, effectiveness and impact of the Australian Professional Standards for Teachers found that, while educators had positive attitudes and intentions towards the implementation of the standards, many teachers perceived implementation of the standards as hard work (AITSL, 2015). The evaluation presented in AITSL (2015) indicates that while educators had a positive attitude and intentions towards the implementation of the standards, many teachers perceived implementation of the standards as hard work (AITSL, 2015). In a review of science teacher education in Australia, Treagust et al. (2015) suggested that political reforms inhibiting teacher autonomy, and low entry requirements for teacher education programs has contributed to poor student performance and engagement in science. It has also been reported that a lack of qualified mathematics and science teachers is resulting in "out-of-field" teachers for these subjects (Productivity Commission, 2012). Despite improvements in the national curriculum, and increasing focus on teaching standards, PISA 2015 results show that Australia has continued to have a negative trend in science results over the past 3 years (OECD, 2016). Hattie (2013) argued that the major influence on student learning in formal schooling is the classroom teacher, and suggested that there needs to be greater focus on evidence-based teaching and learning, and improved pedagogies. In science education in particular, Tytler (2007) proposed that:

> What is needed is a re-imagining of science education that involves a re-thinking of the nature of science knowledge dealt with in schools, moving away from authoritarian knowledge structures to more flexible, and more challenging, conceptions of classroom activity and more varied ways of thinking about knowledge and learning (p.67).

Despite current efforts to improve science education in Australia, enrolments in secondary science continue to decline, and it is clear that further research in this area is needed.

2.1.2 Traditional and Emerging Pedagogies in Science

There are generally two prominent pedagogical approaches for secondary science, explicit instruction and inquiry-based teaching (Cobern et al., 2010; Seimears, Graves, Schroyer, & Staver, 2012). Explicit instruction is a "teacher-centred approach in which the teacher delivers academic content in a highly structured form, directing the activities of the learners and maintaining a focus on academic achievement" (Killen, 2007, p. 102). Direct

Instruction is a form of explicit instruction developed by Siegfried Engelmann and Wesley C. Becker in the 1980s to explicitly teach reading, arithmetic and language to early primary school students (Engelmann, Becker, Carnine, & Gersten, 1988). The Direct Instruction model has since grown in popularity, and is one of the most commonly used explicit teaching models. In contrast, inquiry-based teaching is a more student-centred approach where students engage in increasingly independent investigation of open-ended questions (V. Lee, 2012).

Inquiry-based learning is particularly relevant to science as an approach to teaching 'scientific inquiry' skills, one of three content organisers (strands) for the Australian Curriculum for Science (ACARA, 2014). Inquiry-based strategies can assist students in developing scientific inquiry questions, and can facilitate improvement in students' content knowledge, and approaches to solving scientific questions (Fitzgerald, McKinnon, Danaia, & Deehan, 2015; Kang, DeChenne, & Smith, 2012; H.-S. Lee, Linn, Varma, & Liu, 2010; Varma & Linn, 2012). Kang et al. (2012) used qualitative pre- and post-test data to evaluate the effect of a problem-based inquiry unit in a high school science inquiry course. The study from Kang et al. (2012) demonstrated that the inquiry curriculum had a positive effect on students' ability to develop inquiry questions and generate hypotheses, but did not provide direct comparison to alternative pedagogical approaches. In contrast, H.-S. Lee et al. (2010) conducted a quasi-experimental investigation of inquiry-based teaching in middle school and high school science. The investigation from H.-S. Lee et al. (2010) was based on data collected from 27 different teachers. During the first year of the study, teachers used typical instruction practices, such as lectures, and memorization of scientific facts. During the second year of the study, teachers implemented inquiry units, using inquiry-based teaching strategies, such as student-generated questions, real world examples, and individual inquiry. H.-S. Lee et al. (2010) compared the results from teacher surveys; project records and interviews, and reported "students were more likely to develop integrated understanding of science topics from the inquiry units than from typical instruction methods" (pg. 81). Fitzgerald et al. (2015) also investigated the impact of an inquiry-based instruction on student learning. In a large-scale, quasi-experimental study, Fitzgerald et al. (2015) explored the impact of an inquiry-based educational approach on high school astronomy students' content knowledge and views of their school science experience. While the authors reported a moderately significant improvement in students' content knowledge (pre-test/ post-test), the student engagement data, based on the *Secondary School Science Questionnaire* (SSSQ), suggests that students' enjoyment of science was not affected, or was negatively affected by the interventions. The findings may suggest that the project did not adequately address issues of student learning engagement in its design. Varma and Linn (2012) also used a pre- and post-test to investigate the effect of web-based inquiry teaching on grade 6 students' conceptual understanding of global warming. While data from the post-test showed improved content knowledge, it has been argued that any conscientious teaching will have a positive effect on achievement (Hattie, 2013), so it is unclear whether the results from Varma and Linn (2012) are exclusively due to inquiry-based teaching. In contrast, Blanchard et al. (2010) conducted a quantitative study comparing guided inquiry–based instruction to more traditional, verification laboratory instruction. Their results clearly demonstrate significant improvements in students' conceptional knowledge and long-term retention knowledge when using inquiry-based compared to more traditional verification methods (Blanchard et al., 2010). Mavhunga and Rollnick (2015) used a mixed-methods research approach to investigate the relationship between Pedagogical Content Knowledge (PCK) and student-centered teaching among pre-service chemistry teachers. They concluded that targeted development of Topic-Specific Pedagogical Content Knowledge (TSPCK), fostered student-centered beliefs about classroom practices of pre-service chemistry teachers (Mavhunga & Rollnick, 2015). Mavhunga and Rollnick (2015) argued that learner-centred classrooms, rather than teacher-centred ones, are the ideal learning situation. (Weimer, 2013, p. 10) writes that, "Teaching that promotes learning is not teaching that endlessly tells students what they should do and what they should know." While inquiry-based teaching is an important pedagogical approach for science education, it is equally important to consider the potential of alternative approaches such as explicit instruction.

Explicit instruction models are argued to provide opportunities for clear instruction, particularly when teaching science content knowledge (Klahr & Nigam, 2004; Leno & Dougherty, 2007). Researchers also argue that explicit teaching models can be used to improve student's scientific vocabulary learning, specifically in an elementary (primary) school setting (Leno & Dougherty, 2007; Upadhyay & DeFranco, 2008). Klahr and Nigam (2004) found that third and fourth grade students taught using explicit instruction developed a better understanding of scientific methods than students taught with an inquiry learning approach. However, Dean and Kuhn (2007) attempted to replicate the work by Klahr and Nigam (2004), and found that when students were monitored over a longer timeframe, explicit instruction was neither a necessary nor sufficient condition for retaining knowledge over time. In their book, *Explicit Direct Instruction (EDI): The Power of the Well-Crafted,* *Well-Taught Lesson,* Hollingsworth and Ybarra (2009) argue that "activating prior knowledge facilitates the retrieval of pertinent information from students' long-term memories that will make it easier for them to learn the new content" (p. 82). To achieve this, explicit instruction often incorporates the use of drill and practice techniques, such as consolidation, which is "a fast paced session prior to every learning episode in which previously explicitly taught essential concepts and skills are recited, recalled and applied to ensure that they are: moved from short to long term memory, and automatized" (FNQ Explicit Teaching Team, 2014, p. 2). Early work on consolidation advocated its use as an important teaching strategy for culturally deprived children (Ausubel, 1963). Ausubel (1963) argued that consolidation provides "mastery of ongoing lessons before new material is introduced, to make sure of continued readiness and success in sequentially organized learning" (p. 456).

Ricker and Cowan (2014) investigated working memory consolidation for university students through manipulations of the duration and presentation of memory items. Their results indicate that verbal consolidation improved knowledge retention, and that increasing the amount of time available for working memory consolidation had a positive influence on knowledge retention. In an experimental study with university students, Kök and Canbay (2011) demonstrated that consolidation had a positive influence on students' vocabulary level when compared with students who received no consolidation. Similarly, in a quasi-experimental study with German 5th grade science students, Gerstner and Bogner (2010) investigated the effect of consolidation on students cognitive achievement. Part of Gerstner and Bogner's (2010) study specifically addressed the use of consolidation strategies in conjunction with hands-on instruction. Their results indicate that the use of concept mapping consolidation technique supported short-term improvements in content knowledge when compared to student who did not have the same consolidation experience. However, they note that consolidation using concept mapping provided no long term advantage in student comprehension (Gerstner & Bogner, 2010).

In Far North Queensland, schools are encouraged to use the *recite, recall, apply* strategy for consolidation (FNQ Explicit Teaching Team, 2014). The recite, recall, apply strategy for consolidation is based on rote learning. In a study with undergraduate chemistry students, Grove and Lowery Bretz (2012) used qualitative, grounded theory approach to investigate the learning continuum between meaningful learning and rote memorization. Grove and Lowery Bretz (2012) suggested students were more successful when they chose study techniques that emphasised meaningful connections rather than defaulting to rote memorization. Although inquiry-based teaching and explicit instruction have been extensively debated in the literature, there is little evidence to suggest that either approach is more or less effective in terms of science education. In a review of literature, Kirschner, Sweller, and Clark (2006) attempted to make a case for the superiority of explicit instruction over inquiry-based teaching. While their review demonstrates the effectiveness of explicit instruction in developing students' content knowledge, it is clear that this approach is not optimal developing students' scientific inquiry skills.

Science education continues to oscillate between a focus on inquiry-based learning and explicit instruction, however, in practice, a balance between these two prominent pedagogical approaches is more conducive to a holistic science education. In the early 1990's, Gallagher found that science teachers had a significant emphasis on science content knowledge, with a particular focus on terminology, leaving little time for developing students' understanding of scientific principles, relationships and laboratory work (Gallagher, 1991). More than 20 years later, it appears that little has changed. In their report on *The Status and Quality of Year 11 and 12 Science in Australian Schools*, Goodrum et al. (2012) stated that the transmission model for teaching science is still prevalent. The report revealed that the majority (73%) of science students in Australia still spent a significant amount of time copying notes from the teacher, and practical work tended to be 'recipe based' with students required to follow specific instructions to collect data. Goodrum et al. (2012) also reported that students felt they had little choice in pursuing areas of interest. In a review of factors contributing to the effectiveness of secondary science programs, A. Cheung, Slavin, Kim, and Lake (2017) wrote:

> The types of programs that make a difference in student outcomes are those that help teachers teach more effective lessons: technology designed primarily to help students visualize science concepts, and instructional process models that provide teachers with extensive professional development to help them apply strategies such as cooperative learning, use of metacognitive skills, and science literacy integration. (pg. 78).

Publications over the past 10 years have described benefits for the use of both explicit (Kirschner et al., 2006) and inquiry-based (Cobern et al., 2010) instruction within a science curriculum, although neither approach appears suitable to address both science content knowledge and scientific inquiry skills. Two key studies provided experimental comparisons of inquiry and direct instruction in science (Cobern et al., 2010; Di Scala-Fouchereau & Fouchereau, 2012). Both studies found that there was no significant difference in the students' content knowledge between the two approaches, although Cobern et al. (2010) suggested that inquiry-based instruction could better promote student appreciation of scientific inquiry. Taylor et al. (2015) conducted an experimental study with Year 9 students using a constructivist, research-based curriculum. Their results suggested that while the inquiry-approach had a modest positive effect on student outcomes, teacher practice had a stronger effect on student achievement. These findings are consistent with a large-scale study from Hattie (2008). Based on meta-analyses of more than 50,000 research articles, Hattie (2008) concluded that teacher estimates of achievement had the highest effect size in relation to student achievement. Due to the inquiry nature of science combined with a large body of content knowledge, it seems logical that both inquiry-based teaching and explicit instruction will continue to be important aspects of science pedagogy. Further work developing strategies to integrate inquiry-learning and direct instruction would provide a valuable contribution to science education. Furthermore, increasing opportunities driven by technological advances are also likely to be important contributors to developing pedagogies in science education.

2.2 Blended Learning

Throughout the world, the ubiquitousness of Information and Communication Technology (ICT) has had a significant impact on the education landscape. In Australia, the *Melbourne Declaration on Educational Goals for Young Australians* described ICT as one of the major changes in the world placing new demands on Australian education (Ministerial Council on Education Employment Training and Youth Affairs, 2008). To address this challenge in Australia, ICT was included as a General Capability in the Australian Curriculum:

> Students develop capability in using ICT for tasks associated with information access and management, information creation and presentation, problem solving, decision-making, communication, creative expression, and empirical reasoning. This includes conducting research, creating multimedia information products, analysing data, designing solutions to problems, controlling processes and devices, and supporting computation while working independently and in collaboration with others.
>
> (ACARA, 2013b, p. 49)

When the right mix of policies, technologies and capacities are in place, UNESCO suggests that ICT can contribute to universal access to education, equity in education, the delivery of quality learning and teaching, teachers' professional development, and improved education management (UNESCO, 2015). Throughout the world, numerous policies have been implemented to facilitate ICT integration in education, however these policies have met with varying degrees of success. In a recent report for UNESCO, Wallet (2014) lists the key reasons why ICT policy implementations do not succeed. Wallet (2014) argues that ICT policies in education fail when they are developed without teacher collaboration and support, lack connections to pedagogical practices, or do not provide adequate professional development for teachers regarding implementation. The success of ICT integration in education is therefore, greatly dependent on the availability of different types of technology in schools, and teacher training and innovation (Wallet, 2014; White, 2008).

Early ICT policies in education focused on getting technology into classrooms, and for many countries, this is still an issue, however, according to a recent report from the OECD (Organisation for Economic co-Operation and Development) based on the PISA 2012 data, 72% of students surveyed across OECD countries reported using desktop, laptop or tablet computers at school (OECD, 2014). The report also noted an increase for individual computer activities, such as online chats, practice and drilling, and homework. In Australia, more than 70% of students surveyed reported using the internet for schoolwork at least once per week (OECD, 2015). Despite the increased availability of ICT in schools, computer use is not well integrated into learning and teaching (Donnelly et al., 2011; Goodrum et al., 2012; Hayes, 2007; Webb, 2013). There is evidence suggesting that the lack of technology integration in education is a function of resource availability, time and support, initial and ongoing teacher training, and teachers general lack of knowledge of technology (Donnelly et al., 2011; Guzey & Roehrig, 2012). In a recent report from Australian Council for Educational Research (ACER), obstacles for ICT teaching and learning in Australian secondary schools include a lack of ICT skills among teachers, insufficient time for teachers to prepare lessons, a lack of professional learning resources, and a lack of incentives for teachers to incorporate ICT use in their teaching (Thomson, 2015). Not all schools have the funding required to obtain adequate technology such as computers or mobile devices, or may not have sufficient internet access (Barbour, 2010), though this trend is improving with the falling cost of technology (L. Johnson, Adams, & Cummins, 2012). In recent years, access to technology in schools has improved, and the emerging focus is on improving teacher expertise and professional development in the use of technology (Barbour, 2010). The teacher is therefore seen as one of the most important factors of both educational success (Hattie, 2014; Kozma, 2011), and the successful integration of ICT in education (Behar & Mishra, 2015).

Blended learning or hybrid learning is the integration of online and traditional face-to-face learning (De George-Walker & Keeffe, 2010; Francis & Shannon, 2013). Blended learning "incorporates and integrates the strengths of face-to-face and online learning in a synergistic manner to create a ―unique learning experience congruent with the context and intended educational purpose" (Zhang & Zhu, 2017, p. 673). Staker and Horn (2012) defined blended learning as:

> A formal education program in which a student learns at least in part through online delivery of content and instruction with some element of student control over time, place, path, and/or pace and at least in part at a supervised brick-and-mortar location away from home. (p. 3)

Blended learning has been supported through the development of learning management systems (LMSs) such as Blackboard Learn™ and Moodle (Florian & Zimmerman, 2015; Psycharis, Chalatxoglidis, & Kalogiannakis, 2013). LMSs are software systems designed to facilitate the administration, documentation, tracking, reporting and delivery of online learning courses (Ellis & Calvo, 2007; Godwin-Jones, 2012; Psycharis et al., 2013). The development and use of LMSs improves resource availability and ease of use in setting up online courses (Godwin-Jones, 2012). LMSs also facilitate communication to support student collaboration (Brand, Kinash, Mathew, & Kordyban, 2011). LMSs incorporate many interactive, collaborative and synchronous functions, however, some researchers have suggested that the essential model is "a closed, self-contained system using cognitive-behavioural learning, with emphasis on information presentation and measurable performance assessment" (Godwin-Jones, 2012). It has also been argued that the integration of interactive components such as learning objects, video clips, discussion boards and self-marking quizzes can enhance the student-centred learning in online environments (Florian & Zimmerman, 2015; Liaw, 2008). LMSs provide a platform for planning and delivering online components of blended learning, providing opportunities for teachers to take advantage of increasingly advanced electronic technology.

Blended learning has gained popularity in universities around the world as it provides more flexibility, opportunities for independent work, and peer collaboration (Calderon et al., 2012; Smythe, 2012). In a mixed-methods study of more than 1400 university students, López-Pérez, Pérez-López, and Rodríguez-Ariza (2011) reported that the use of a blended learning approach reduced student dropout rates and resulted in improved academic achievement. Further findings from Calderon et al. (2012) found that university faculty and students valued the flexibility afforded by blended learning, however, academic staff were dissatisfied with the information about online learning and the quality of pedagogy in blended instruction. Successful implementation of blended learning is therefore reliant on appropriate resources availability, and alignment of institutional, faculty and student goals. While many of the studies on blended learning have been conducted in universities, some of the findings are still relevant to secondary schools.

2.2.1 Blended Learning in Secondary Schools

Studies of blended learning conducted in secondary schools have demonstrated promising results in terms of student achievement. Several studies, generally using pre- and post-test data, demonstrate improved student achievement in secondary maths and science classrooms (Chandra & Briskey, 2012; Chandra & Watters, 2012; Furberg, 2009; Lin, 2017; Yapici & Akbayin, 2012). Yapici and Akbayin (2012) conducted a case study on the effects of blended learning within four Year 9 Turkish biology classes. Two of the classes received traditional non-blended teaching, whilst the other two classes engaged in a blended learning course, where portions of the course were presented in an online format. Analyses of pre-test and post-test scores revealed a significant improvement in achievement for students taught using the blended learning model when compared to students taught using traditional methods (Yapici & Akbayin, 2012). In a mixed methods study, Chandra and Watters (2012) demonstrated similar results in a secondary school physics course. Chandra and Watters (2012) reported that students participating in a blended learning course felt it not only improved academic achievement but also has a positive impact on their attitudes towards studying science. Chandra and Briskey (2012) conducted an investigation comparing the use of blended learning and traditional pedagogies in a secondary school mathematics course. Based on qualitative and quantitative results, Chandra and Briskey (2012) indicated that in general students participating in a blended learning performed better and were more engaged with their learning. Research from a public secondary school in Colorado, which had been using blended learning with mathematics and science classes for four years, found that students at the study school scored significantly higher on PISA when compared with averages across the USA (Florian & Zimmerman, 2015).

Blended learning also contributes to improved student engagement with learning, and opportunities for more immediate student feedback. Active engagement in learning is critical factor in science education enhanced by the use of technology (Swarat, Ortony, & Revelle, 2012). Liu, Waight, Gregorius, Smith, and Park (2012) reported that interactive computer models (also known as learning objects) could provide effective and more engaging opportunities for assessing student learning. More recent studies have also demonstrated the potential of blended learning to support science-based laboratory comprehension (Rivera, 2016), providing more opportunities to engage students through virtual experiments. Blended and online learning has shown positive trends in enhancing peer feedback (Tsivitanidou, Zacharia, Hovardas, & Nicolaou, 2012). Feedback is an important factor in student learning as it enables students to identify what they have done well, and where they can improve (Tsivitanidou et al., 2012).

While blended learning can enhance student engagement and achievement in secondary math and science classes, not all students feel that it is an optimal learning environment (Chandra & Briskey, 2012; Emelyanova & Voronina, 2017; Furberg, 2009; So & Brush, 2008). In a qualitative study of student engagement in a web-based learning environment, Furberg (2009) found that students were prone to using *copy and paste* strategies to answer questions, which meant students avoided thinking too deeply about the content. Qualitative results from open-ended surveys and interviews reveal that students' technical expertise has an impact on their perceptions of blended learning, where students who have less technical expertise and confidence with computers and/or software have less favourable opinions of online learning (Chandra & Briskey, 2012). Similarly, in a study with Year 10 English language students, Emelyanova and Voronina (2017) found that some students preferred traditional instruction due to issues with self-discipline and technical competence. So and Brush (2008) found statistically positive correlations between student perceptions and collaborative learning in online learning environments. However, student perceptions may be influenced by achievement, with some researchers suggesting that high achieving students have a more positive perception of online learning (Lin, 2017; Luketic & Dolan, 2013), while low achievers are less able to cope (Owston, York, & Murtha, 2013). In a study with junior high school mathematics students, Lin (2017) found that male and high ability students were more motivated. Researchers agree that students perceptions of online learning environments are generally positive (Chandra & Fisher, 2009). Blended learning can have a positive influence on student engagement and achievement, though, it is important to develop online content which promotes critical thinking, considers student learning styles, and allows for flexible teacher intervention to address technical difficulties.

2.2.2 Developing Pedagogies for Blended Learning

Integration of ICT is an important goal for most schools and researchers have identified teacher training and confidence as important factors influencing ICT integration in classrooms (Behar & Mishra, 2015; Hechter, 2012; Kuo, Belland, Schroder, & Walker, 2014; Prestridge, 2012). In a study on ICT usage in four Catholic primary schools, Prestridge (2012) found that when teachers expressed a greater personal competency with ICT they were more confident to use ICT in the classroom. Behar and Mishra (2015) argue that, "the most productive way to use ICT to help deliver better and more equitable education at the primary and secondary levels is to concentrate resources on educating teachers" (p. 73). In recent years, ICT has become an important curriculum component of teacher education programs (Hechter, 2012), with many teacher education programs integrating blended learning in their education programs (Kuo et al., 2014; Yeh, Huang, & Yeh, 2011).

The growing interest in blended learning has led researchers to further explore the effect of different models of blended learning. Cheung and Hew (2011) investigated two models in a university setting. The first model was based on the GNOSIS framework to "integrate constructive and didactic instruction approaches" (W. S. Cheung & Hew, 2011, p. 1321). Their second model was based on Bloom's taxonomy (remembering, understanding, applying, analysing, evaluating, and creating). Their research generated useful insights into theoretical constructs supportive of blended learning, however these models were very labour intensive, reducing the potential for a high level of uptake in classrooms. Chen (2012) investigated two simplified models with primary school students, online plus peer interaction, and online plus student-teacher interaction. While noting improved student achievement overall, there was no significant difference between the two models of blended learning. Chou, Chuang, and Zheng (2013) researched varying ratios of face-to-face to online teaching, and found that a time ratio of 2:1 was optimal. Abdelaziz (2012) developed the D^4S^4 instructional strategy for blended and online learning, where the instructors and students' roles are described by the four D's– (designing, developing, delving and distributing), and the four S's (shared vision, sharable e-learning tasks, salvage knowledge, and scaffolding) Abdelaziz (2012) argues that the D^4S^4 instructional strategy has opportunities for adaptive learning, which was lacking from previous strategies of instruction for online and blended learning. In contrast, Dovros and Makrakis (2012) designed and tested a constructivist based instructional module using the four components - problem presentation, prior knowledge activation, dilemmatic negotiation, synthesis and evaluation. The Dovros and Makrakis (2012) instructional model was designed to teach middle school students about a specific context-based controversy on genetically modified foods. Devros and Makrakis's (2012) instructional model supported students to construct their own perspective about genetically modified foods, and this demonstrates the importance of integrating constructivist learning principles in instructional models for blended learning. Another innovative framework used to integrate blended learning and science education is the *Science Learning Activity Model (SLAM)* (Bidarra & Rusman, 2016). The model presented by Bidarra and Rusman (2016) includes 10 dualities to support science education through blended learning, such as individual and collaborative learning, and synchronous and asynchronous learning. However, while the *SLAM* model provides a reasonable theoretical framework for blended learning, the paper was purely theoretical with no evidence of classroom trials.

While new models for instruction may be useful, I would argue that teachers are more comfortable with what they know. Explicit teaching, loosely based on theoretical work from Bandura, Piaget, Vygotsky, and Wood, Bruner, and Ross (Fisher & Frey, 2008), is a teaching strategy often comprised of three key steps, *I Do, We Do,* and *You Do.* Explicit teaching is a traditional and familiar pedagogy found in many classrooms, and as such may be easier to implement than more complex models as many teachers are already familiar with the technique. Yeh (2009) conducted a quasi-experimental study with two groups of pre-service teachers. Based on assessments of critical thinking and teacher reflection, Yeh (2009) concluded the explicit teaching model supported improved critical-thinking skills, professional knowledge, and personal teaching efficacy for pre-service teachers in the experimental group. Wan and Nicholas (2010) proposed a "progressive pedagogy" based on a case study with high-ability 14-year old students participating in an online extended-learning project. Interestingly, the pedagogy proposed and tested by Wan and Nicholas (2010) is strikingly similar to the direct instruction model, *I Do, We Do, You Do,* where their model recommends "(a) structured whole group learning (b) structured, team learning (c) individual, open learning" (p. 240). Wan and Nicholas (2010) reported that their model provided an effective pedagogy for planning and implementing online learning and resulted in positive student engagement. In a comparative study, Kay (2013) found that students preferred web-based learning tools with direct instruction architecture significantly more than tools with a constructivist based architecture. While research on the use of explicit teaching in conjunction with blended learning is very limited, initial findings indicate this is a positive direction for inquiry. Contemporary flexible learning in classrooms requires a combination of sound pedagogical practices with well-designed virtual and physical learning environments (Stevens, 2016).

2.3 Designing and Evaluating Blended Learning Classrooms

Dewey (1910) identified three conditioning influences of school classrooms, the mental attitudes and habits of the persons with whom the child is in contact, the subjects studied, and current educational aims and ideals. Montessori (2010) placed similar emphasis, where much of her teachings are based firstly on the careful establishment of a beautiful learning environment promoting freedom in the students' choices to direct their own learning. Montessori (2014) wrote that:

> education is not what the teacher gives: education is a natural process spontaneously carried out by the human individual. It is acquired not by listening to words, but by experiences upon the environment. The task of the teacher then becomes not one of talking, but one of preparing a series of motives of cultural activity spread in a specially prepared environment (loc. 113).

Montessori placed great emphasis on the environment in which learning should take place. While Montessori was focused on a physical environment, in the same way it is now important to take equal care in the development of online learning environments.

Early work by Lewin (1939) argued that behaviour is a function of the person and their environment. However, evaluations of education have been largely focused on achievement outcomes (Fraser, 1998), and a growing body of research argues that these measures alone cannot give a complete view of students' educational processes. Fraser (1998) argued that student perceptions of, and reactions to, their learning environment must also be considered in developing a holistic evaluation. Recent advances in technology have added an additional layer of complexity, and Stevens (2016) argues that blended learning classrooms must consider the interaction between physical, emotional, technological, and historical spaces. Coming back to Dewey (2010), he wrote,

> The aim of education is the development of individuals to the utmost of their potentialities. An environment in which some are limited will always in reaction create conditions that prevent the full development even of those who fancy they enjoy complete freedom for unhindered growth. (p. 244)

Both Montessori and Dewey placed great emphasis on the learning environment, articulating the importance of the role of the learning environment in facilitating learning. This level of consideration is equally important whether the learning environment is physical or virtual.

Guidelines for designing online learning have emerged from the research on online and blended learning (Evagorou, Avraamidou, & Vrasidas, 2008; Liaw, Huang, & Chen, 2007; Napier, Dekhane, & Smith, 2011). Based on surveys from 30 instructors and 168 university students, Liaw et al. (2007) proposed four factors that can be considered when developing and facilitating online learning: highly autonomous learning, vivid multimedia instruction, enhancing teacher-learner communication, and improving learning effectiveness. Napier et al. (2011) suggested that when designing and implementing blended learning, teachers should focus on their strengths, utilize a variety of technology, create online classroom spaces, provide online support for students, and creatively manage out-of-class time. Evagorou, Avraamidou, and Vrasidas (2008) presented an innovative research project called *Technoskepsi*, which demonstrated the use of both on-line technologies and handheld computers to scaffold secondary science students while they worked in groups, and assist students in constructing scientific arguments. Their work demonstrates the importance of including scaffolded learning when designing blended learning (Evagorou et al., 2008). Designing a blended learning in a classroom is therefore dependent on the careful construction of the online learning environment in consideration with the physical learning environment as well as teacher expertise and competency.

2.3.1 Evaluating Teacher Perceptions

The role of the teacher as a guide in both face-to-face and online learning is a critical factor in developing, implementing and then evaluating quality blended learning experiences

(Wan & Nicholas, 2010). However, teachers' perceptions of planning and implementing blended learning in their classrooms has not been well documented (Ocak, 2011). In a phenomenographic study of vocational teachers perceptions of blended learning, Bliuc, Casey, Bachfischer, Goodyear, and Ellis (2012) found that teacher conceptions of blended learning varied widely, leading to differing approaches to designing and teaching for blended learning. While teachers agreed that blended learning supported their practice, challenges cited were students disengaging in the learning process, device and infrastructure concerns, and the time to integrate technology effectively. In one of the few studies with secondary school teachers, Sorbie (2015) conducted an qualitative case study investigating the success and challenges of blended learning with 12 high school teachers. The study reports that teachers believed "that blended learning promotes individualization, collaboration, organization, engagement, real-world relevance, and student-centered learning" (Sorbie, 2015, p. 4). However, Sorbie (2015) also reports that while teachers believed blended learning supported their practice, they identified a number of challenges including student disengagement, issues with technology functionality, and time intensive to integrate technology effectively.

Jokinen and Mikkonen (2013) identified nine themes to describe teachers' views about planning and implementing a blended-learning approach to an adult nursing programme, which were: collaborative planning; integration; student group; face-to-face teaching; online learning; learning activities; teaching and learning methods; learning in and about work; and confirming competences. In an investigation from two Turkish universities, Koſar (2016) found that while instructors that were using blended learning valued the learning autonomy and flexibility, the majority of instructors did not use blended learning in their courses. In a review of the literature, Bingimlas (2009) identified five barriers to implementation of blended learning which he described as lack of access, resistance to change, lack of time, lack of training and lack of technical support. Planning and implementing blended learning is a challenging and demanding task, which requires a high level of expertise with ICT. The relatively few studies investigating teacher perceptions suggest most teachers valued the benefits of using blended learning, however limitations such as time constraints and technological issues present a barrier to implementation.

Studies investigating teacher/instructor perceptions of blended learning have relied on both qualitative and quantitative data collected by external researchers (Bliuc et al., 2012; Kofar, 2016; Ocak, 2011; Sorbie, 2015), with only two studies identified that provide perspective from teacher-researchers (Cash, 2014; Stevens, 2016). Ocak (2011) used a combination of face-to-face interviews and email in order to identify the challenges and problems university lecturers had when teaching using blended learning. Bliuc et al. (2012) used open-ended questionnaires administered by email to investigate TAFE instructors' perceptions of blended learning and their approaches to teaching and design. Qualitative data on teacher perceptions were collected using a questionnaires, classroom observations, computer screenshots, and semi-structured interviews (Sorbie, 2015). Few studies have used mixed methods research to evaluate teacher perceptions of blended learning. In a descriptive study with 32 English language instructors from two different Turkish universities, Kofar (2016) used a quantitative questionnaire and semi-structured interviews to develop a more detailed understanding of teacher perceptions of blended learning.

Only two studies were identified which drew on autoethnographic studies of blended learning (Cash, 2014; Stevens, 2016). Cash (2014) conducted a descriptive case study to explore ways a teacher could use online technologies to enhance the learning of drama and foster engagement in a secondary school context. Cash (2014) investigated teacher-researcher perceptions through classroom observations, and a reflective practitioner blog. Cash (2014) also collected data on student perceptions using questionnaires and focus group interviews. In contrast, Stevens (2016) presents a narrative on his use of blended learning with middle school social studies students, reflecting on the importance of recognising and planning for different types of spaces within the classroom, both physical and virtual. In a comprehensive review of more than 100 peer-reviewed articles on blended learning, Zhang and Zhu (2017) found that the majority of papers concerned student learning factors, and these authors recommended that further research should focus on teacher perceptions of planning and implementing blended learning.

2.3.2 Evaluating Student Perceptions

Studies show that students generally have a positive perception of blended learning (Chandra & Fisher, 2009; Emelyanova & Voronina, 2017; Lin, 2017; So & Brush, 2008). In a mixed-methods study with secondary school physics students, Chandra and Watters (2012) found students reported blended learning had a positive impact on their attitudes towards studying science. Similarly, Chandra and Briskey (2012) investigated with students in secondary school mathematics, drawing on qualitative and quantitative data to find, in general, students participating in a blended learning were more engaged. Lin (2017) also gathered both qualitative and quantitative data surveying Year 7 students' perceptions and their results revealed that, in terms of improving attitude toward mathematics, blended learning was more effective than traditional methods. Kolikant (2012) conducted a qualitative study of secondary school students' perceptions of ICT integration using semi-structured, in-depth interviews. A teacher-centered, information-focused perspective emerged with many students identifying teachers as the "authoritative transmitters of required knowledge" (Kolikant, 2012). Not all students had a favourable perception of ICT integration in their classes, pointing to the importance of the teacher in effective ICT integration. While few studies have investigated student perceptions of blended learning in secondary schools, the studies identified have generally had positive results and relied on mixed methods research, collecting both qualitative and quantitative data.

A number of instruments have been developed to investigate online learning environments, such as the Constructivist On-Line Learning Environment Survey (COLLES) (Cook, Dickerson, Annetta, & Minogue, 2011), the Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI) (Earle & Fraser, 2016), the Distance Education Learning Environments Survey (DELES) (Walker & Fraser, 2005), the Online Learning Environment Survey (OLES) (Trinidad, Aldridge, & Fraser, 2005), and the Web-based Learning Environment Instrument (WEBLEI) (Chandra, 2004; Chang & Fisher, 1999). However, few instruments have been adapted for use in a secondary classroom. The Web-based Learning Environment Instrument is one tool that has been used successfully in evaluating student perceptions of online learning environments in secondary schools

(Chandra & Fisher, 2006; Chang & Fisher, 2003). In an interpretive study of elementary and middle school web-based learning environments, Tobin (1998) identified three key areas (emancipatory activities, co-participatory activities, and qualia) pertinent in assessing student perceptions on online learning environments. Building on the work of Tobin (1998), Chang and Fisher (2003) developed the Web-based Learning Environment Instrument (WEBLEI) to gather quantitative data about undergraduate and graduate students' perceptions of web-based learning environments. The WEBLEI contains four scales, these are Access, Interaction, Response and Results. The first three scales are based on the work of Tobin (1998), and aim to describe students' perceptions of emancipatory activities, co-participatory activities, and qualia (e.g. interest, curiosity, enjoyment, satisfaction) in an online learning environment. The fourth scale, results, focuses on the structure and delivery of the online material. Ten short response questions are included in the WEBLEI to give student the opportunity to more clearly articulate their perceptions. A modified version of the WEBLEI was presented by Chandra (2004) to evaluate secondary science students' perceptions of online learning. Wong et al. (2006) used the WEBLEI in a study investigating student and teacher perceptions of computer-supported project work, further validating the instrument. The WEBLEI is well established in the literature as a viable survey for evaluating student perceptions of blended learning, and is one of the few tools specifically adapted and validated for use with secondary school students.

2.4 Chapter Summary

There is consensus that, when designed in conjunction with good teaching practices, blended learning can contribute to improved student achievements and engagement (Calderon et al., 2012; Chandra & Briskey, 2012; Chandra & Fisher, 2009; Chandra & Watters, 2012; López-Pérez et al., 2011; Pina, 2012; Yapici & Akbayin, 2012). Understanding student and teacher perceptions of blended learning is an important aspect of evaluating blended learning teaching strategies, however, research in this area is very limited, particularly regarding secondary school classrooms. Blended learning is an emerging and valuable education program, which supports the integration of technology in classrooms, however, it is clear from this review that further research in this area is needed. This study will address these gaps in the literature through investigation of student and teacher perceptions of blended learning in secondary science classroom. The methodology of this project is discussed in the following chapter.

CHAPTER 3 METHODOLOGY

3.1 Introduction

This research project grew out of my desire to understand the potentials and pitfalls of using blended learning to teach secondary science. As a reflective practitioner, I was mostly interested in understanding the perceptions of my students, however, I soon came to realise that as a teacher-researcher my own perceptions would be an integral part of my research. The literature review, discussed in the previous chapter, identified the need for further research on the use of blended learning in secondary science, giving rise to my primary purpose, which is to investigate student and teacher perceptions of blended learning in two Year 10 secondary science classes. The present study addresses the following research questions:

1. What features of blended learning are important to secondary science students?
2. What are students' perceptions of using blended learning in secondary science?
3. How does blended learning influence student achievement in secondary science?
4. How can the *Explicit Teaching Lesson Model – FNQ Region* be used to inform blended learning?
5. What are the teacher's perceptions of using the *Explicit Teaching Lesson Model – FNQ Region* to design and deliver a blended learning course in secondary science?

Creswell (2009) describes the research design as the interaction between a philosophical worldview (paradigm), a strategy of inquiry, and the research methods. The research design for this study is illustrated in Figure 3.1.

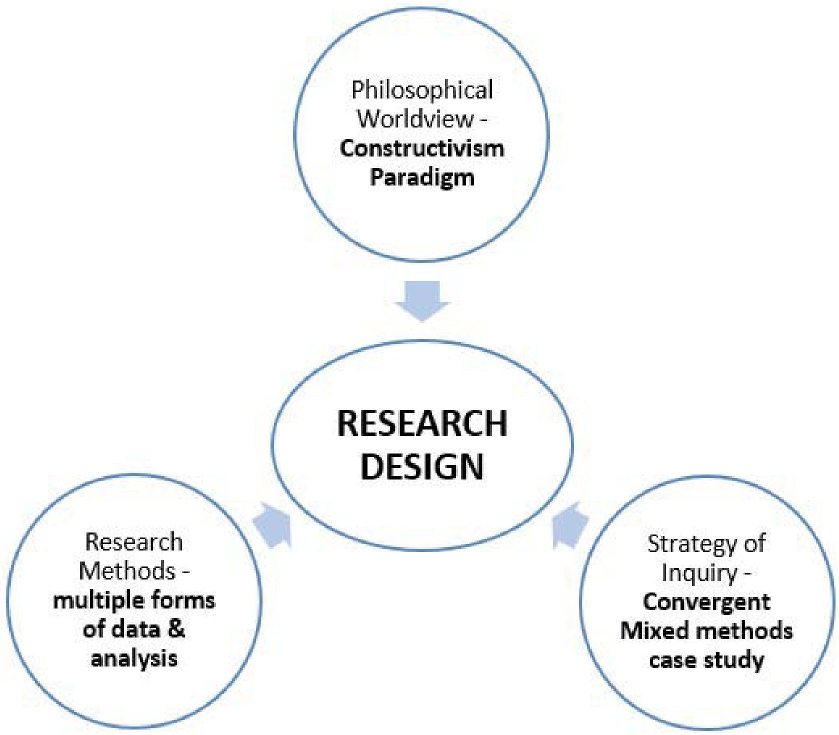


Figure 3.1 A Framework for Design *- The interconnection of Worldview, Strategies for Inquiry, and Research Methods. Adapted from Creswell (2009, p. 5)*

The research questions and purpose are best explored within a constructivist paradigm, the merits of which are discussed in section 3.2. Section 3.3 presents the strategy of inquiry as determined by the research questions and constructivist paradigm, and section

3.4 provides a detailed description of the research methods including data collection, data analysis, validation and ethics.

3.2 Philosophical Worldview

A researcher's philosophical ideas influence the research being conducted and these ideas must therefore be identified and explained in depth. Creswell (2009) uses the term 'worldview' to describe the theory of knowledge or set of beliefs, framing the research, and forming a research paradigm (Teddlie & Tashakkori, 2010). The paradigm sets out the intent, motivation and expectations of the research (Mackenzie & Knipe, 2006), including the axiological, epistemological, ontological and methodological assumptions (Creswell, 2012; Lincoln & Guba, 2013).

There are a number of theoretical paradigm choices discussed in the literature, and the wide variety of terminology deployed adds an additional layer of complexity (Mackenzie & Knipe, 2006). Four of the most common paradigms are: Post-positivist, Interpretivist/ Constructivist, Transformative/ Participatory, and Pragmatic (Creswell, 2009; Mackenzie & Knipe, 2006). *Post-positivistic* paradigms support research of cause and effect relationships, with researchers employing the use of the scientific method to collect and analyse quantitative data (Alise & Teddlie, 2010; Creswell, 2009). *Constructivist/ Interpretivist* paradigms are generally associated with qualitative data collection and analysis (Creswell, 2012; Goldkuhl, 2012), and hold the assumption that individuals construct meaning from the world in which they live and work (Creswell, 2009). *Transformative/ Participatory* paradigms commonly inquire into political questions, addressing issues of social justice and marginalised groups and can draw on qualitative and/ or quantitative data (Creswell, 2009, 2012; Mackenzie & Knipe, 2006). Research in a *pragmatic* paradigm seeks to clarify meanings and looks to consequences (Cherryholmes, 1992), and is often associated with mixed methods research using both qualitative and quantitative data (Creswell, 2009; Shannon-Baker, 2015).

My philosophical worldview grew out of my experiences throughout life, with foundations in my early years. My parents placed great importance on the education of their children, and their philosophies for raising children were largely based on the work of Piaget. As a young child, my parents emphasized experiential, discovery learning, with the aim of keeping our curiosity alive. As my siblings and I approached school age, we moved to Hawaii, where school options were limited. As a result, we were home schooled for several years. My father was a university professor and my mother is a licensed school teacher, whose teacher training program was strongly influenced by the principles put forth by John Dewey, Jean Piaget, and Maria Montessori. In secondary school, I chose to attend a public school, but found limited opportunities for self-directed study. Frustrated with conventional education, I eventually opted for a self-directed distance learning high school program available through the University of Nebraska. My father, with a doctorate in geophysics and my mother having now completed a master's degree in library science along with her master's degree in education, are both strong advocates of self-directed learning as were my teachers in my final years of high school. I believe my educational experiences nurtured my curiosity and passion for learning, which has continued throughout my life, and ultimately led to my constructivist worldview as a teacher-researcher.

Piaget, Dewey and Montessori were advocates of interactive, hands on learning, and emphasised the importance of the learning environment and independent learning. Though similarities exist between the theories of Piaget, Dewey and Montessori, there are also some notable differences, particularly in their contrasting approaches to research. Montessori, having first completed her medical training, conceptualised her educational theories through rigorous hands-on scientific observations relying heavily on quantitative data (Montessori, 2010; Ültanır, 2012). Montessori is famous "for having discovered the world within the child" (Thayer-Bacon, 2012, p. 7), developing a pedagogy focusing on autonomy for the learner, through the use of hands-on learning in carefully constructed multi-age learning environments (Montessori, 2010). In contrast, Dewey studied as a philosopher and psychologist, completing his Doctorate in social science (Dewey, 2015; Ültanır, 2012). Dewey's research in education was more philosophical in nature, largely relying on qualitative methods and focusing on the importance of authentic experiences in learning (Dewey, 2015). Piaget originally completed his doctorate in biology, but is best known for his work as a developmental psychologist, focusing on the questions: What is the nature of knowledge? How does it grow and develop? (Ültanır, 2012). Though their methodologies differ, Piaget, Montessori and Dewey are all credited for their contributions to constructivism. The justification for the use of constructivism in contrast to pragmatism is discussed below.

The pragmatism paradigm was developed from the work of Charles Sanders Peirce in the late 1800's, with later contributions from William James and John Dewey (Dewey, 2010; James, 1907). James described pragmatism as "a method of settling metaphysical disputes that otherwise might be interminable" (James, 1907, p. 35).

Ralph Barton Perry (1916), a student of William James, writes:

> Pragmatism like all contemporary philosophies is first of all a theory of knowledge. It is in the application of the vitalistic or bio-centric method to knowledge that all pragmatists are agreed. We may hope to discover here a body of common pragmatic doctrine from which the various pragmatisms diverge… It seeks to distinguish the cases of true knowledge from the cases of false knowledge. In short, it is both psychological and logical; and for the reason that both psychological and logical factors enter into that particular complex which we call knowing. (pp. 199-200)

From and within a pragmatism paradigm perception of knowledge is both constructed and based on direct experiences of the world we live in.

Though pragmatism continues to be shrouded in complex philosophical conjecture, in recent years, theorists have attempted to provide a distillation of the key principles of pragmatism towards defining a common pragmatic doctrine. Creswell (2009, p. 7) describes the four major elements of pragmatism as "consequences of actions, problem-centred, pluralistic, and real-world practice oriented". Johnson and Onwuegbuzie (2004) suggest that pragmatism rejects the traditional paradigm dualisms, and emphasises the importance of social and environmental factors. Within a pragmatism paradigm, theories are not fully true or false, but rather subject to current predictability and applicability (B. Johnson & Gray, 2010; B. Johnson & Onwuegbuzie, 2004).

Pragmatism continues to be a prominent paradigm in mixed methods research, though some theorists have called for further clarification of how pragmatic ideas are relevant and appropriate for mixed methods research (Biesta, 2010; B. Johnson & Gray, 2010; Shannon-Baker, 2015). Biesta (2010) contends that philosophical pragmatism cannot provide a philosophical framework for mixed methods research, but "rather a set of insights that can help us to have a more precise discussion about the strengths and weaknesses of mixed methods approaches" (p. 4). For Badley (2004) pragmatism is, "an allegiance to anything goes" allowing researchers diminished responsibility and promoting a "narrowness of vision". Johnson and Gray (2010) coin the term *dialectical pragmatism*, which they describe as a form of pragmatism tailored towards mixed methods research. Despite such differences in views, the increasing prevalence of pragmatism in social science research is strongly linked with mixed methods research (Biesta, 2010; Morgan, 2014; Tashakkori & Teddlie, 2010a, 2010b).

Mixed methods research draws on both qualitative and quantitative data to develop a deeper understanding of complex issues, which would not be possible using either approach alone (Creswell, 2009; Shannon-Baker, 2015). Pragmatism focuses attention on the research problem allowing researchers more freedom in choosing the methods, techniques and procedures most suited to the specific research problem (Creswell, 2012). Although pragmatism is regularly used in mixed methods research (Creswell, 2009), my philosophical worldview is more consistent with constructivism, framed by the philosophies of Piaget, Montessori and Dewey. Therefore, my research is guided by constructivism, seeking to uncover meaning from the data, rather than pragmatism, which aims to collect data, in order to find solutions.

3.2.1 Rationale for the Constructivist Paradigm

In their seminal book, *The Constructivist Credo*, Lincoln and Guba (2013) summarise the four philosophical pillars of constructivism through a discussion of the ontological, epistemological, methodological and axiological foundations. Relativism is the ontological presupposition of constructivism, the perspective that knowledge, truth, and morality exist in relation to culture, society, or historical context, and are not absolute (Lincoln & Guba, 2013). Epistemologically, constructivists adhere to a transactional subjectivism, adopting the assumptions that the researcher and the object of study are linked, as one cannot separate themselves from what they know (Merriam, 1998). These assumptions support an interpretive/explanatory method of hermeneutics, oriented toward interpreting the texts of life (Creswell, 2012; Lincoln & Guba, 2013). Therefore, the axiological presupposition of constructivism rejects objectivity as a possibility, and plausibility, transferability dependability and confirmability, take the place of internal validity, and external validity/generalisability, replicability/reliability, and objectivity (Lincoln & Guba, 2013). Constructivism explains specific rather than universal meanings and practices, concentrating on conditional forms of meaning construction (Neimeyer & Levitt, 2001). Constructivist methods reveal personal and collective perceptions in a specific time and place, through collaboration between the researcher and participants, supporting the role of the teacher as the researcher.

The theoretical paradigm of my study is constructivism, as I investigate the experiences of the students and teacher-researcher, and make meaning from those investigations, while simultaneously acknowledging that there are multiple participant meanings (Creswell, 2009). It was not my intentions to conduct a comparative study, looking at whether students learned “better” with blended learning, but rather to investigate perceptions. For the students, this meant investigating their experiences of learning using blended learning, and for the teacher-researcher recording my own perceptions of designing and delivering an Earth and Space science unit using blended learning. Previous research has shown that in an educational context, there is rarely a one-size-fits-all model (Cobern et al., 2010; Pugh, Linnenbrink-Garcia, Koskey, Stewart, & Manzey, 2009). Within even a small participant group, it is likely that participants will have widely differing experiences. As such, it is my expectation that the students participating in the study will have different experiences of blended learning, and this is best captured within a constructivist paradigm.

3.2.2 Constructivism and the Learning Environment (WEBLEI)

The constructivism paradigm is intricately woven with pedagogical approaches founded on the idea that people construct their own understanding and knowledge of the world, through experiencing phenomena and reflecting on those experiences. The work of leading philosophers and educationists, such as John Dewey, Maria Montessori, and Jean Piaget, drove the continued evolution of constructivist learning theories (Michael & Modell, 2003), providing for the emergence of constructivist based thinking on online learning environments (Fraser, 1998; Tobin, 1998).

As this project is situated at the intersection of science education and online/ web-based learning, the theoretics also rely on the principles behind the instrument used to collect data on student perceptions, the Web-based Learning Environment Instrument (WEBLEI). The Web-based Learning Environment Instrument (WEBLEI) (Chandra, 2004; Chang & Fisher, 1999) was chosen as it one of the few instruments evaluating student perceptions of online learning environments, that has been adapted for and tested within a secondary classroom. The Web-based Learning Environment Instrument is incorporates research done by Kurt Lewin in the mid-1930s on learning environments (Fraser, 1998). Through his research in human behavioural psychology, Lewin proposed a formula, $B=f(P,E)$ to describe human behaviour (B) as a function of the person (P) in their environment (E) (Fraser, 2002). In an educational context, the Lewinian formula shows the importance of having suitable learning environments. Fraser (1998) argued that accurate assessment of student learning must include factors for both academic achievement and learning environment. Tobin's early

(1998) work on *Connecting Communities Learning* (CCL), an interpretive study of graduate students' learning environments, proposed a framework and described the emergent categories salient to online learning environments. The work of Tobin (1998) and Fraser (1998) underpinned the development of a new instrument to assess web-based learning, called the Web-based Learning Environment Instrument (WEBLEI) (Chang & Fisher, 1999, 2003).

The WEBLEI was designed by Change & Fisher (1999, 2003) to measure university students' perceptions of web-based learning environments, and later modified by Chandra (2004) to measure secondary students' perceptions of web-based learning environments. As my research is set within a secondary school context, I used the WEBLEI (Appendix A), as modified by Chandra (2004), which is comprised of four scales: Access, Interaction, Response, and Results (Figure 3.1). The first three scales are based on the work of Tobin (1998), and aim to describe students' perceptions of emancipatory activities, co-participatory activities, and qualia (e.g. interest, curiosity, enjoyment, satisfaction) in an online learning environment. The fourth scale makes apparent a focus on the structure and delivery of the online material.

Table 3.1 Scales from the WEBLEI (Chang & Fisher, 1999, 2003)

Scale I: Emancipatory Activities	• *Convenience is achieved when students can access the learning activities at convenient times* • *Efficiency is described as not having to attend on campus classes and therefore allowed for efficient use of time* • *Autonomy is described as allowing students to decide when and how to access the curriculum*
Scale II: Co-Participatory Activities	• *Flexibility is described as allowing students to meet their goals.* • *Reflection is noted as asynchronous interactions which encouraged reflective interactions.* • *Quality is linked to the learning reflected in the level of activity undertaken by the students.* • *Interaction is described as enabling students to interact with each other asynchronously.* • *Feedback is described as the availability of feedback from students and the teacher.* • *Collaboration enabled students to collaborate in a variety of activities.*
Scale III: Qualia	• *Enjoyment is associated with academic success and mastery of technology.* • *Confidence is associated with successful learning and support for learning.* • *Accomplishments are described as allowing student to display their course accomplishments regularly and publicly.* • *Success has two dimensions - use of technology and conceptual aspects of the program.* • *Frustration is associated with the use of technology and the conceptual aspects of the program.* • *Tedium is associated with posting and responding to reviews on a regular basis.*
Scale IV: Information Structure and Design Activities	• *How the web based learning materials are structured and organised* • *Presentation of material in accordance with instructional design.* • *Relevance and scope of content* • *Validity of content* • *Accuracy and balance of content* • *Navigation* • *Aesthetic and affective aspect.*

Tobin (1998) identified three categories associated with emancipatory activities, these are efficiency, convenience, and autonomy. From a constructivist perspective, online learning best provides opportunities for students to make choices about how, when and how much they learn. Students should desirably be able to access learning at times that are convenient to them, be able to make choices about efficient use of time, and be afforded the autonomy to decide when and how to access learning materials online. Emancipatory activities are measured in the WEBLEI Scale I, and expressed in these following 8 statements:

- I can access lessons on the Internet at times convenient to me
- Lessons on the Internet are available at locations suitable for me.
- I can access lessons on the Internet on days when I am not in class or absent from school.
- Lessons on the Internet allow me to work at my own pace to achieve learning objectives.
- Lessons on the Internet enable me to decide how much I want to learn in a given period.
- Lessons on the Internet enable me to decide when I want to learn.
- The flexibility of lessons on the Internet allows me to meet my learning goals.
- The flexibility of the lessons on the Internet allows me to explore my own areas of interest

(Chandra, 2004; Chandra & Fisher, 2006)

The quality of interactions between students, the teacher and the online learning environment was described by Tobin (1998) as: flexibility, reflection, quality, interaction, feedback. From a constructivist perspective, science education and learning is enhanced when there are opportunities for students to collaborate and test the development of their knowledge through conversations with their teacher and peers (Lorsbach & Tobin, 1992). Interaction categories are measured in the WEBLEI Scale II, and expressed in these 8 statements:

- I communicate with my teacher in this subject electronically via email.
- In this learning environment, I have to be self-disciplined in order to learn.
- I have the options to ask my teacher what I do not understand by sending an email.
- I feel comfortable asking my teacher questions via email.
- The teacher responds to my emails.
- I can ask other students what I do not understand during computer lessons.
- Other students respond positively to questions in relation to Internet lessons.
- I was encouraged by the positive attitude of my friends towards the Internet lessons

(Chandra, 2004; Chandra & Fisher, 2006)

WEBLEI Scale III, Response, is derived from Churchlands's neural network theory (Chang & Fisher, 2003). Scale III is based on six categories: enjoyment, confidence, accomplishments, success, frustration and tedium, and is comprised of the following statements:

- This mode of learning enables me to interact with other students and my teacher.
- I felt a sense of satisfaction and achievement about this learning environment.
- I enjoy learning in this environment.
- I could learn more in this environment.
- I can easily get students to work with me on the Internet.
- It is easy to work with other students and discuss the content of the lessons.
- The web-based learning environment held my interest in this subject throughout this term.
- I felt a sense of boredom in this subject towards the end of this term.

(Chandra, 2004; Chandra & Fisher, 2006)

WEBLEI Scale IV, Results, assesses student perceptions of the way learning materials are structured and organised (Chang & Fisher, 2003). The structure and design of online learning activities are ideally developed through the use of sound pedagogical approaches (Gedik, Kiraz, & Ozden, 2013). These factors are expressed in WEBLEI Scale IV, and comprised of the following statements:

- I can work out exactly what each lesson on the Internet is about.
- The organisation of each lesson on the Internet is easy to follow.
- The structure of the lessons on the Internet keeps me focused on what is to be learned.
- The structure of the lessons on the Internet keeps me focused on what is to be learned.
- Internet lessons helped me better understand the work that was taught in class.
- Lessons on the Internet are well sequenced.
- The subject content is appropriate for delivery on the Internet.
- The presentation of the subject content is clear.
- The multiple-choice test at the end of lessons on the Internet improves my learning in this subject.

(Chandra, 2004; Chandra & Fisher, 2006)

3.2.3 Explicit Teaching and Constructivism

In 2014, many schools in Far North Queensland adopted a new initiative, the *Explicit Teaching Lesson Model – FNQ Region* (ETLM-FNQ) in an effort to improve learning across Far North Queensland (Department of Education and Training Far North Queensland, 2017). My constructivist thinking was challenged by the ETLM-FNQ, which was derived from the work of Hollingsworth and Ybarra's (2009) work on *Explicit Direct Instruction*. Hollingsworth and Ybarra's model for explicit instruction evolved from the increasing pressure on schools to improve achievement scores (Hollingsworth & Ybarra, 2009). In their book *Explicit Direct Instruction: The Power of the Well-crafted, Well-taught Lesson*, Hollingsworth and Ybarra (2009, p. 10) state that "students learn more and learn faster when the teacher stands up in the front of the room and explicitly teaches the whole class how to do it". Their controversial stance is seemingly at odds with constructivist, inquiry-based learning, providing a significant adaptive dissonance to my own teaching, which relied on inquiry-based learning techniques, such as the 5Es (Engage, Explore, Explain, Extend/Elaborate, Evaluate) instructional model (such as used in the Australian *Primary Connections* program (https://primaryconnections.org.au/about/teaching) and practical hands-on learning activities, and interactive online learning activities. In June 2014, the school I was working at joined the FNQ Explicit Teaching Project, which provided schools with an explicit teaching coach who observed lessons and guided teachers in the effective use of *Explicit Teaching Model – FNQ Region.* I agreed to participate in the observed lessons and worked with the explicit teaching coach to integrate the *Explicit Teaching Model – FNQ Region* with blended learning to teach secondary science. This experience provided valuable data on my use of explicit teaching, and weekly meetings with the explicit teaching coach gave me an opportunity to discuss and reflect on my practice.

Explicit teaching is based on theoretical work from Bandura, Piaget, Vygotsky, and Wood, Bruner, and Ross (Fisher & Frey, 2008). Rosenshine (1986, p. 60) describes explicit teaching as a "systematic method for presenting [learning] material in small steps, pausing to check for student understanding, and eliciting active and successful participation from all students". Rosenshine (1995) described three key instructional implications from his research: "(a) the need to help students develop background knowledge (b) the importance of student processing (engender autonomy), and (c) the importance of organisers" (p.262). In their model of *Explicit Direct Instruction (EDI)* Hollingsworth and Ybarra (2009) describe eight key design components. These are: learning objectives, activate prior knowledge, concept development, skill development, lesson importance, guided practice, lesson closure, independent practice. The *Explicit Teaching Lesson Model – FNQ Region* (ETLM-FNQ) incorporates these design components using four key stages: *opening the lesson, I Do, We Do, You Do, Closing the Lesson* (Department of Education and Training Far North Queensland, 2013)(Appendix B).

The theoretical rationale for the *I Do* phase of explicit teaching draws on Vygotsky's Zone of Proximal Development - the difference between what a child may learn on their own and what they can learn with guidance, including scaffolding (Wood, Bruner, & Ross, 1976). Scaffolding is described as a teaching strategy to stimulate a "child's interest in the task, establishing and maintaining an orientation towards task-relevant goals, highlighting critical features of the task that the child might overlook, demonstrating how to achieve goals, and helping to control frustration" (Wood & Wood, 1996, p. 5). Maynes et al. (2010) identified the *I Do* phase as motivation, modelling/ remodelling, and structured consolidation, giving teachers the opportunity to explicitly set out learning goals and explain key ideas and concepts.

In the *We Do* phase of explicit instruction, teachers give guided instruction to establish expectations and provide support for students to meet those expectations (Fisher & Frey, 2008). This phase emerges from Piaget's work on cognitive structures and schema, which emphasised listening to children, "valuing their stage of learning and thinking and ensuring learning activities are developmentally appropriate" (Groundwater-Smith, Le Cornu, & Ewing, 1998, p. 80). Well-connected and elaborate knowledge structures enable the integration of new information (Rosenshine, 1995). The *We Do* phase is intended to assist students in improving and consolidating their ability to access information they have learnt.

The *You Do* phase is founded on Social Learning Theory (Bandura, 1977) and emphasises the importance of internal reflection in the learning process. The *You Do* phase focuses on the active role of the learner in building understanding and provides opportunity for students to construct their knowledge both independently and in collaboration with peers.

3.3 Strategy of Inquiry

For this study, I use a convergent mixed methods strategy of inquiry. According to Creswell (2009), there are three primary types of research designs, quantitative, qualitative, and mixed methods. Hoepfl (1997, p. 48) writes that while "quantitative researchers seek causal determination, prediction, and generalisation of findings, qualitative researchers seek instead illumination, understanding, and extrapolation to similar situations". Qualitative research aims to describe and explain human experiences, behaviours, interactions and social contexts without the use of statistical quantification (Fossey et al., 2002). Qualitative research is particularly useful for answering research questions regarding human behaviour that do not lend themselves to quantifiable measurements. Qualitative research can be used to understand individuals' and groups' subjective experiences, cultural and political factors, and interactions among participants (Fossey et al., 2002). By contrast, quantitative studies usually test objective theories through analysis of numerical data (Creswell, 2009), and these methods are appropriate for deductive approaches to research and testing (Borrego et al., 2009). Mixed methods research combines both qualitative and quantitative research methods into one study, and is particularly applicable to classroom studies (Creswell, 2009). The approach achieves a result stronger than either qualitative or quantitative research provides individually (Creswell, 2009; Tashakkori & Teddlie, 2010a). The advantage is that the researcher can derive a more detailed understanding of a phenomenon, not achievable through using one approach alone (Creswell & Clark, 2006), making it a viable and desirable approach to educational research (Greene, 2005).

There are three approaches to mixed methods research: convergent design, explanatory sequential design and exploratory sequential design (Creswell, 2015). For this study I use a convergent design as detailed in (figure 3.2) as it was most suited to collecting and interpreting the data required by my research questions.

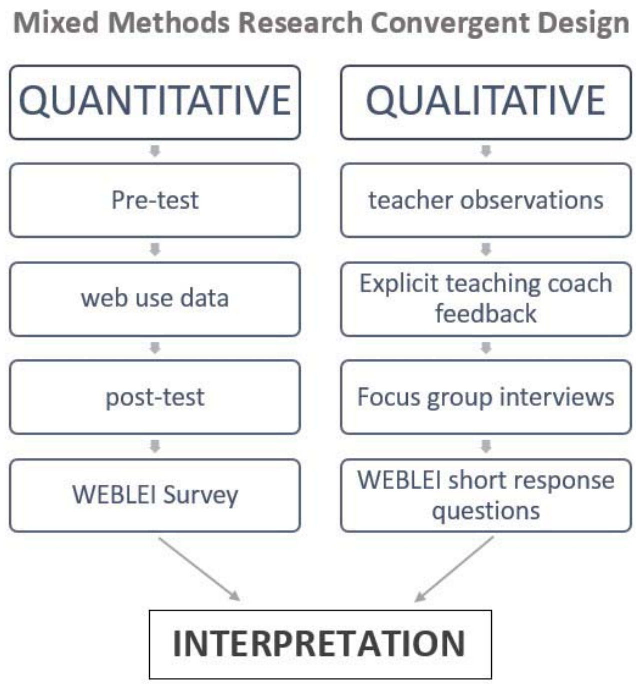


Figure 3.2 Diagram of the mixed-methods research convergent design used in this study.

My research was based on the constructivist paradigm (discussed in section 3.2), seeking to uncover meaning from both qualitative and quantitative data. I was not seeking to find solutions, as in the pragmatic paradigms, but rather to interpret the elements of my research within their own context. By combining qualitative and quantitative data collected simultaneously throughout the study I felt it would be possible to develop a more complete and accurate interpretation of student and teacher perceptions of using blended learning in secondary science. Furthermore, the key questions in the present study sought to understand student and teacher perceptions of web-based learning as measured using the WEBLEI, which by design relies on both qualitative and quantitative data (Chandra, 2004; Chang & Fisher, 2003; Skelton, 2007; Wong et al., 2006).

3.4 Research Methods

3.4.1 Questions

My primary goal in this study was to investigate my students' perception of blended learning. As a teacher-researcher I was also a participant in the study, so I was also investigating my own perceptions of designing and delivering the Year 10 Earth and Space science unit using blended learning and the *Explicit Teaching Lesson Model – FNQ Region*. To accomplish this, I sought to address the following key questions:

1. What features of blended learning are important to secondary science students?
2. What are students' perceptions of using blended learning in secondary science?
3. How does blended learning influence student achievement in secondary science?
4. How can the *Explicit Teaching Lesson Model – FNQ Region* be used to inform blended learning?
5. What are the teacher-researchers' perceptions of using the *Explicit Teaching Lesson Model – FNQ Region* to design and deliver a blended learning course in secondary science?

3.4.2 Study Context

The study was conducted in a suburban state high school (Grades 8-12), pseudo-named FNQ High School. FNQ High School is located in a culturally diverse regional city in Far North Queensland with a population of approximately 157,000 residents. During the study, 891 students were enrolled at FNQ High School, 48% females and 52% males, with 10% of the student population identifying as Aboriginal and/or Torres Strait Islander and 10% of students indicating they had a language background other than English. During the study period the school reported an average attendance rate of 89%. FNQ High School began a one-to-one laptop program in the school year preceding my study, where all students were issued with a laptop for use at school and at home. Thus, when I began my study, students had some familiarity with using computers regularly in their classes. However, as the program was new, the use of computers varied widely between classes and subjects throughout the school.

Students from two of my Year 10 science classes from FNQ State High School participated in this study. Year 10 science is a compulsory subject, and students are initially assigned to science classes based on their Year 9 science results. The intention is that some classes are mostly comprised of high-achieving students, and some are mostly comprised of weaker students. In practice, due to scheduling conflicts and late enrolment, the classes become of mixed ability, excluding the possibility of a true comparative study between classes. As a teacher-researcher I wanted to get the largest sample size possible, without varying curriculum content and teacher. Therefore, I negotiated with the school's administration to be assigned two Year 10 science classes. Fifty-two students across the two classes participated in the study, 35% female and 65% male, aged 15 and 16 years. I conducted the study during one, ten-week school term during which both classes studied a unit on Earth and Space Science based on the Australian Curriculum (ACARA, 2013a). Students at FNQ State School were allocated three 70-minute science lessons per week, with online content and activities available through Blackboard Learn™, the learning management system available to all Department of Education and Training schools.

3.4.3 Course Structure and Instruction

To assist state schools in implementing the Australian Curriculum, the Department of Education and Training, Queensland developed the Curriculum into the Classroom (C2C) resource, with unit plans aligned with the Australian Curriculum (The State of Queensland (Department of Education and Training), 2014). As the teacher-researcher, I modified the Year 10 C2C Earth and Space Science unit to include web-based content, school-designed assessment tasks, and lessons using the *Explicit Teaching Lesson Model – FNQ Region*. The modified unit (Appendix C) was covered in 10 weeks with three, 70-minute lessons per week. Each lesson followed the *Explicit Teaching Lesson Model – FNQ Region,* where students received teacher directed consolidation of the previous lesson, followed by a short explanation of the key concepts for the lesson (*I Do*). Students then accessed online learning materials through Blackboard Learn™, working in small groups with teacher assistance (*We Do*), or individually (*You Do).* Online learning materials included video clips, reading comprehension exercises, interactive learning objects, discussion board tasks, and short self-marking quizzes.

3.4.4 Data Collection and Analysis

To answer research question 3, **How does blended learning influence student achievement in secondary science? s**tudent achievement data was collected using a paper-based, 50-minute, Pre/Post Test. The test was administered by a delegate in the school's science department (not the teacher-researcher). Data were de-identified to ensure anonymity. Prior to the commencement of the unit, student participants were given the Year 10 Earth and Space Science pre-test consisting of both multiple choice and short answer content-understanding questions. Upon completion of the unit, students were given the Year 10 Earth and Space Science post-test, which had the same multiple-choice and written-response components used in the pre-test. The Year 10 Earth and Space Science test (Appendix D) was developed by me, as the teacher-researcher, in collaboration with other teachers in the science department at FNQ State School. The pre- and post-tests were graded using a pre-determined point-scale to provide comparative numerical data. Data were analysed using IBM SPSS Statistics Version 23. A paired-samples t-test was used to compare the pre-test and post-test results for both classes. Effect size was determined using Cohen's d value.

Student perceptions of blended learning were investigated using a 30-minute paper-based survey (WEBLEI) and two 60-minute focus group interviews (one 60-minute interview with 5 students from each of the two classes). Data collected using the WEBLEI inform research questions 1 and 2: **What features of blended learning are important to secondary science students?** and **What are students' perceptions of using blended**

learning in secondary science? The WEBLEI was used to gather qualitative and quantitative data on students' perceptions of the blended learning environment. I chose this instrument as it is uniquely suited to evaluating students' perceptions of an online learning environment. The WEBLEI is comprised of 32 Likert scale questions and 10 short response questions, and was administered by the Science Head of Department (not the teacher-researcher). Data were de-identified to ensure anonymity. Qualitative data were also collected using two 60-minute focus group interviews. The focus group interviews were conducted using open-ended questions (Appendix E) designed to provide a richer understanding of student perceptions of blended learning.

Quantitative data of student perceptions of blended learning were collected using the WEBLEI Likert scale questions, which were coded and entered as 1 (*Strongly Disagree),* 2 (*Disagree),* 3 (*Neither Agree nor Disagree),* 4 (*Agree),* and 5 (*Strongly Agree)*. Statistical measurements including mean, median, standard deviation, Alpha Reliability and Discriminant Validity were determined using SPSS Version 23.

Qualitative data of student perceptions of blended learning were collected using the WEBLEI short-response questions and focus group interviews. As the teacher-researcher I randomly selected 5 students from each of my two classes who had guardian/parental permission to participate in the interviews. I conducted interviews with the supervision of my JCU primary advisor. To maintain student confidentiality, I transcribed the audio of the interviews personally. I collated the student perceptions qualitative data using Excel 2016.

According to Creswell (2009) qualitative data can be coded on the basis of emerging information, predetermined codes, or a combination of predetermined and emerging codes. For this study, qualitative data were coded using predetermined codes, which were defined by the four scales of the WEBLEI (Access, Interaction, Response and Results). Statements that related to the students' ability to access the online content were coded as "Access". Statements that related to students' interaction with teacher-researcher or other students through email or face-to-face learning were coded as "Interaction". Statements that related to their enjoyment, confidence, accomplishments, success, frustration or tedium with blended learning were coded as "Response". Finally, statements that related to students' perceptions of the structure and organisation of the unit were coded as "Results". I then went through each of categories using sub-codes to differentiate between positive and negative statements. For example, statements where students expressed enjoyment of the blended learning unit were coded as "Response-positive". Statements that expressed a dislike of using blended learning were coded as "Response-negative". Statements related to explicit teaching, such as comments regarding consolidation were coded as "explicit teaching". This approach allowed for the convergence of quantitative (WEBLEI Likert-scale questions) and qualitative (WEBLEI short response questions and focus group interviews) data to provide a convergent analysis of the data as per the convergent mixed methods strategy of inquiry.

Research questions 4 and 5: **How can the *Explicit Teaching Lesson Model – FNQ Region* be used to inform blended learning?** and **What are the teacher's perceptions of using the *Explicit Teaching Lesson Model – FNQ Region* to design and deliver a blended learning course in secondary science?** are informed through teacher-researcher reflective journal and feedback on lessons observed by the schools explicit teaching coach. As the teacher-researcher, I recorded my own perceptions using a reflective journal where I recorded daily observations and planning. At the conclusion of the project, I recorded my reflection on each of the questions from the WEBLEI. During the study, the school's explicit teaching coach provided detailed feedback on lessons observed. The feedback forms (Appendix F) completed by the schools explicit teaching coach in conjunction with our weekly meetings also provided another source of data. Additional data became available through the Blackboard Learn™, which included records of the students' online activity such as quiz scores, discussion board participation, and the frequency and time of day students accessed online content. These data were used in conjunction with my personal observations to describe my perceptions of developing and implementing a secondary Earth and Space Science unit using blended learning and the *Explicit Teaching Lesson Model – FNQ Region*.

3.4.5 Ethics

The James Cook University Code for Responsible Conduct of Research describes "the principles and practices for encouraging the responsible conduct of research, for the University and its researchers; and provides a framework for resolving allegations of breaches of this Code and research misconduct, addressing the responsibilities of both the University and its researchers" (James Cook University, 2017). Adherence to ethical standards ensures that the welfare of the research participants are not harmed or unduly influenced as a result of the research being conducted (Lankshear & Knobel, 2004).

Formalising ethical practice in the form of an organisation coded is useful to higher degree research as it provides clear guidelines to assist the research in developing their confidence and protecting researchers from allegations of misconduct. Ethics not only involves the rights of participants, but also ensures data are collected and analysed in an ethical way. A research project that has not been conducted ethically cannot be trusted. The present study was granted ethics approval from James Cook University's Human Research Ethics Committee (#H5684, Appendix G), and The State of Queensland Department of Education and Training (Appendix H).

The study was conducted with secondary students, and required specific permission from the school Principal, science Head of Department, and from each student and their parents or guardians. In addition, I had to also consider how my own position as their teacher could influence this classroom inquiry. I therefore required assistance from a third party to administer the surveys, and monitor interviews in order to avoid compromising the ethical integrity of my research. My primary research advisor oversaw data collection and analysis to ensure the accuracy and integrity of statistical methods.

3.5 Methodology Summary

This chapter describes the methodology used to undertake this study of blended learning in two Year 10 secondary science classes. Five research questions guided the study employing a constructivist paradigm, and aimed at understanding the experiences of 52 students and one teacher-researcher.

CHAPTER 4 STUDENT PERCEPTIONS OF BLENDED LEARNING

4.1 Introduction

Chapter 3 described the methodology and the relationship between the research questions, the theoretical foundations, the strategy of inquiry, the research approach and research methods. In this chapter, I begin with an analysis of student demographics and achievement (Section 4.2). In Section 4.3 I present analyses of the reliability and validity of the WEBLEI. In Section 4.4 I provide a summary of the mean and scale results of the WEBLEI. In Section 4.5 I describe the results of analyses by gender, and in Section 4.6 I provide a detailed mixed methods analysis of the WEBLEI quantitative results in conjunction with the qualitative data from the WEBLEI survey and focus group interviews.

4.2 Student Demographics

4.2.1 Demographic profile

I conducted the study with two of my Year 10 science classes. In total, 52 students participated in the study, 35% female and 65% male, aged 15 and 16 years (Table 4.1).

Table 4.1 Participant demographics by gender

		Frequency	Percent
Valid	MALE	18	34.6
	FEMALE	34	65.4
	Total	52	100.0

4.2.2 NAPLAN Results

In the year prior to the study, some students had participated in the Year 9 National Assessment Program – Literacy and Numeracy (NAPLAN). I chose to include the NAPLAN data to give an overall picture of the student's general academic abilities in language and numeracy. NAPLAN is an annual assessment for all Australian students in years 3, 5, 7 and 9. The test includes assessment items for reading, writing, spelling, language conventions (grammar and punctuation) and numeracy, and are conducted every year in the second week of May (ACARA, 2016a). NAPLAN results are reported using a scale score and a Band category for each of the 5 domains (reading, writing, spelling, language conventions and numeracy). The NAPLAN scale score is calculated based on the number of correct responses and accounts for the difficulty of each question. The Scale scores are then translated into bands (1-10) to facilitate comparability across years. Score equivalence tables are provided for each year that can be used to convert a student's raw score to its equivalent on the 10 band NAPLAN scale. For example, in 2013 students in Year 9 who had a raw score of 24 out of 49 questions on the Reading test received a scale score of 547.23 which corresponds to NAPLAN Band 9 (ACARA, 2016b). As I conducted my research in 2014, the NAPLAN data is from 2013 when the students were in Year 9.

Descriptive statistics of the students' 2013 NAPLAN as well as a summary of Queensland and national NAPLAN results for comparison are presented in Table 4.2. The students' mean scale score for the NAPLAN assessment in Reading was 579.3 (SD 64.4), this is slightly higher than the mean scale score for Queensland, 572.4 (SD 62.0), and is consistent with the national mean scale score of 580.2 (SD 63.4). The students' mean scale score for persuasive writing was 569.2 (SD 94.68), this is slightly higher than both the mean scale score for Queensland, 548.6 (SD 84.0), and the national mean scale score 554.1 (SD 87.1). The students' mean scale score for spelling was 591.2 (SD 61.4), this is slightly higher than both the mean scale score for Queensland 578.0 (SD 62.9) and the national mean scale score 582.7 (66.7). The students' mean scale score for grammar and punctuation was 580.6 (SD 81.4), this is slightly higher than the mean scale score for Queensland, 568.5 (77.2), and the national mean scale score 573.1 (SD 77.6). The students' mean scale score for numeracy was 564.2 (SD 60.0), this is slightly lower than the mean scale score for Queensland, 573.2 (SD 74.5), and the national mean scale score, 583.6 (82.2). Overall the participants mean scale scores for the 2013 Year 9 NAPLAN were slightly higher than the mean scale scores for Queensland, and the national mean scale scores for Australia.

Table 4.2 Descriptive statistics for NAPLAN results 2013

	2013 NAPLAN Mean Scale Scores (SD)		
	Study Group (N=44)	Queensland*	Australia*
READING	579.30 (64.38), N=44	572.4 (62.0), N=53301	580.2 (63.4), N=258658
WRITING	569.18 (94.68), N=44	548.6 (84.0), N=54355	554.1 (87.1), N=259538
SPELLING	591.20 (61.38), N=44	578.0 (62.9), N=54560	582.7 (66.7), N=260298
GRAMMAR	580.61 (81.35), N=44	568.5 (77.2), N=54560	573.1 (77.6), N=260298
NUMERACY	564.20 (60.01), N=44	573.2 (74.5), N=53823	583.6 (82.2), N=256732

*NAPLAN Mean scale scores for Queensland and Australia are compiled from: *NAPLAN achievement in reading, persuasive writing, language conventions and numeracy: National report for 2013* (ACARA, 2013c).

4.2.3 Achievement Results

To evaluate achievement, I used a 33-point multiple-choice and short answer test (Appendix D). I obtained the test items from the question bank that accompanied the course textbook (Ruhnau, Stannard, & Williamson, 2012), and selected questions that were representative of the Science Standards for the Australian Curriculum (ACARA, 2013a). The students were administered the test on two separate occasions; once prior to instruction (pre-test), and once following instruction (post-test) (Figure 4.1). I expected that Earth and Space science content knowledge would increase following instruction.

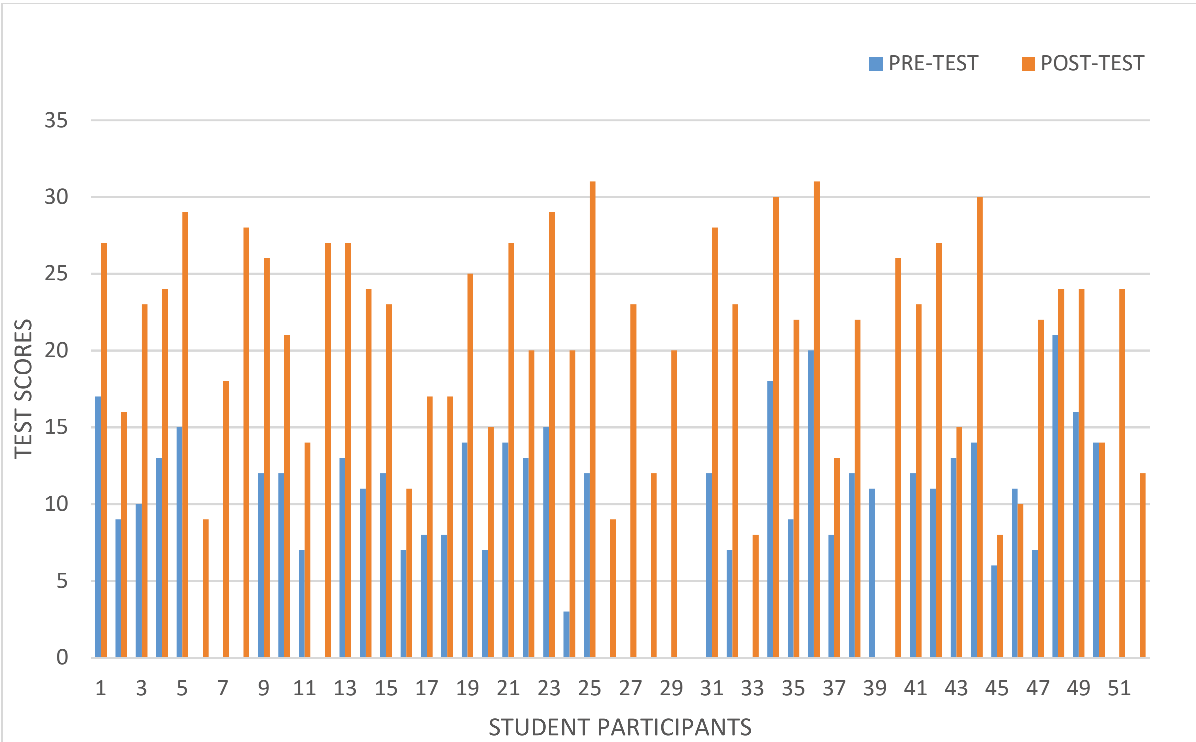


Figure 4.1 Graph of student pre-test and post-test results. (NB. Not all students completed both the pre-test AND post-test.)

Descriptive statistics for the pre-test, post-test and mean improvement for Earth and Space science content knowledge are shown in table 4.3. The pre-test mean score was 11.66 (35.4 % correct) with a standard deviation of 3.93. The post-test mean score was 21.89 (66.1 % correct) with a standard deviation of 6.22. The improvement score was calculated using the post-test score minus the pre-test score. The mean improvement for all participants was 10.54 with a standard deviation of 4.94. While this data cannot be used to show that blended learning is comparatively better than traditional methods, it does demonstrate that student content knowledge improved during the course, suggesting that blended learning did not have a negative impact on student content knowledge.

Table 4.3 Descriptive statistics of the 33-item Earth and Space Science Content Knowledge Pre-test and Post-test

	Pre-test (N = 38)	Post-test (N = 38)	Improvement (N = 38)
Mean (SD)	11.66 (3.93)	21.89 (6.22)	10.24 (4.94)

I used a paired samples t-test to compare student knowledge of Earth and Space science before and after the blended learning course. There was a significant difference in the student scores before (M=11.66, SD=3.93) and after (M=21.89, SD=6.22); t (38) =12.775, p = 0.000). Cohen's effect size value (*d*= 2.07) suggests a high practical significance in these results.

4.3 Reliability and Validity of the WEBLEI

I conducted reliability analysis to verify the internal structure of the WEBLEI. The WEBLEI consisted of four scales, Access, Interaction, Response, and Results. Independent analyses were conducted for each of the four scales, and are presented in Table 4.4. The internal consistency of each scale was determined using Cronbach's alpha reliability coefficient, and discriminant validity was calculated using Spearman's rho correlation coefficient. Cronbach's alphas for the four sub-scales Access, Interaction, Response and Results were .89, .68, .80 and .91, respectively (Table 4.4). These results are consistent with previous studies using the WEBLEI (Chandra, 2004; Chang & Fisher, 2003; Skelton, 2007), and further demonstrate the reliability of the instrument. The discriminant validity displays the mean correlations which ranged from 0.28 to 0.49, suggesting that the scales used in the WEBLEI measured distinct but related areas of the blended learning environment.

Table 4.4 Cronbach's Alpha Reliability and Discriminant Validity of the WEBLEI

Scales	Items	Valid Cases	Alpha Reliability	Discriminant Validity
Scale I: Access	8	29	0.89	0.31
Scale II: Interaction	8	29	0.68	0.28
Scale III: Response	8	29	0.80	0.38
Scale IV: Results	8	29	0.91	0.49

NB. Only 29 of the 52 participants completed the WEBLEI survey. Some participants returned blank surveys.

4.4 Mean and Scale Results

Descriptive statistics for student responses to the WEBLEI are presented in Table 4.5, include the mean, standard deviation and mode for each scale of the WEBLEI. The mean results for Scale I (3.86) and Scale IV (3.64) show that on average the student responses were neutral “neither agree nor disagree” or favourable “agree”. The mean score for Scale II (3.55), and Scale III (3.36) were slightly lower indicating more neutral or negative responses.

Table 4.5 WEBLEI Descriptive statistics

Scales	Items	Valid Cases	Mean (SD)	Mode
Scale I: Access	8	29	3.86 (0.74)	4.00
Scale II: Interaction	8	29	3.54 (0.54)	4.00
Scale III: Response	8	29	3.36 (0.65)	4.00
Scale IV: Results	8	29	3.63 (0.73)	4.00

The mode for all scales was 4 (Agree) (Figure 4.1), showing that overall students had a positive perception of the blended learning environment. These data show 86.21% of students selecting “agree” or “strongly agree” for Scale I questions, 62.07% for scale II, 55.17% for scale III, and 65.52% for Scale IV.

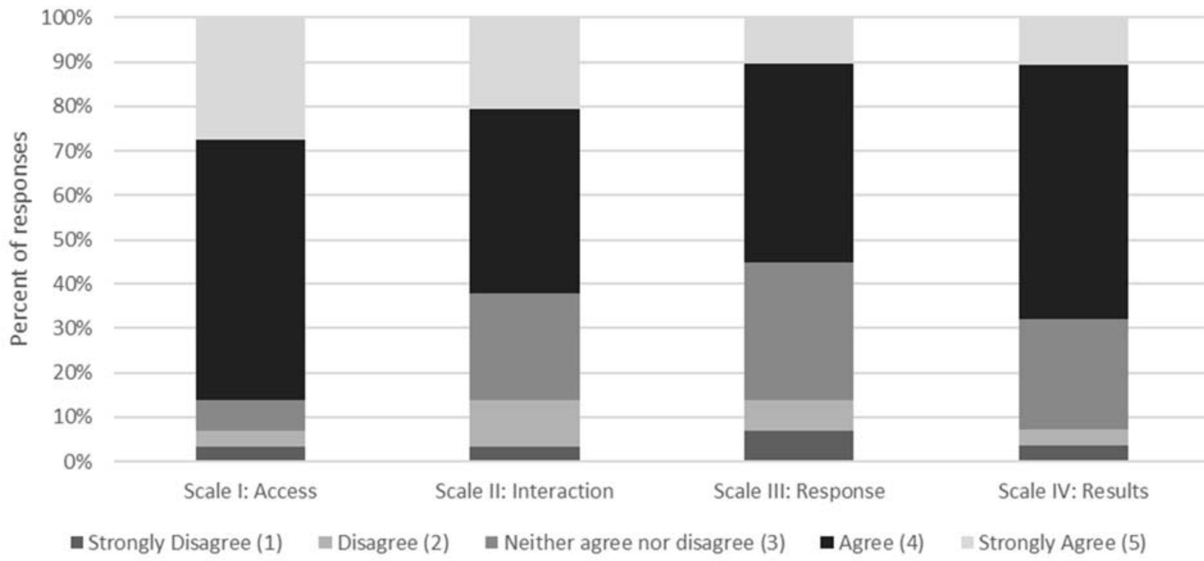


Figure 4.2 *Summary of the mode for student responses for the four scales of the WEBLEI.*

4.5 Gender Differences in the WEBLEI Responses

I examined students' responses to the WEBLEI to determine if there were differences between genders. I analysed gender differences using a Mann-Whitney U Test. The Mann-Whitney U test was used due to the uneven sample size, where only 29 of the participants completed the WEBLEI survey, 7 males (24 %) and 22 females (76 %). The Median and Interquartile range for the four scales of the WEBLEI are included in Table 4.6. The Mann-Whitney Test of the WEBLEI Scale I responses revealed no significant difference between males (Mdn=4, n=7) and females (Mdn=4, n=22), U=54, z=-1.319, p=0.247, r=-0.24. The Mann-Whitney Test of the WEBLEI Scale II responses revealed no significant difference between males (Mdn= 4, n=7) and females (Mdn=4, n=22), U=68, z=-0.471, p=0.669, r=-0.09. The Mann-Whitney Test of the WEBLEI Scale III responses revealed no significant difference between males (Mdn= 4, n=7) and females (Mdn=4, n=22), U= 70.5, z=-0.345, p=0.758, r= -0.06. The Mann-Whitney Test of the WEBLEI Scale IV responses revealed no significant difference between males (Mdn= 4, n=7) and females (Mdn=4, n=22), U=62, z=-0.863, p=0.449, r= -0.16. In summary, the results of the Mann-Whitney tests revealed no significant differences between male and female responses for any of the four WEBLEI scales.

Table 4.6 Median and Interquartile Range for Male and Female Students' Scores on the Four WEBLEI Scales

WEBLEI Scales	Males		Females	
	Median	**Interquartile Range**	**Median**	**Interquartile Range**
Scale I: Access	4	1	4	0
Scale II: Interaction	4	2	4	1
Scale III: Response	4	1	4	1
Scale IV: Results	4	0	4	1

Males n = 7, Female n=22

4.6 Mixed Methods Analyses

4.6.1 Questions from WEBLEI Scale I Access

The descriptive statistics for students' responses to WEBLEI Scale I are displayed in Table 4.7. One of the key aspects of blended learning is the ability to provide convenient and efficient access to learning. Although the responses from students varied from 1 to 5, of the four scales, students had the most positive responses to Scale I Access, particularly question 3 "I can access lessons on the internet on days when I am not in class or absent from school", with a mode response of 5 "strongly agree".

> Heather (pseudonym): It teaches a more independent way of learning and it's good for kids that have been away, they can catch up on the work from the day.

> Brenda (pseudonym): You can learn at your own pace, prioritise specific things to learn, catch up at home on missed lessons, revise other passed lessons, and access online text-books.

This scale also provides insight into students' perceptions of self-directed learning, particularly questions 4, 5, 7 and 8. Question 4 "Lessons on the internet allow me to work at my own pace to achieve learning objectives" had a mode response of 4 indicating that most students agreed with this statement. This is further supported by qualitative data:

Daniel (pseudonym): Online learning lets students go at their own pace.

Beth (pseudonym): Online learning teaches students to be independent and not depend solely on the teacher

Fifty-two per cent (52%) of students agreed blended learning allowed them more opportunity to explore their own areas of interest. Question 8, “The flexibility of the lessons on the internet allows me to explore my own areas of interest”, had the lowest mean response (M=3.41, SD =1.12), but it is interesting to note that responses varied from 1 to 5, this could indicate that students did not feel they had time to explore their own interests, however, it is more likely that students were not motivated to pursue their own areas of interest. This is further supported by qualitative data from focus group interviews, and may also depend on the student’s level of interest in the subject itself. The student perceptions were not dependent on educational achievement (in terms of grades).

Carl (pseudonym): I reckon if it’s an interesting subject that’s enough to motivate you, but if it’s just a terrible subject you’re just finishing with no motivation sometimes.

Terry (pseudonym): I feel like I learned more then what I would have if I had just done it with the teacher in the class, because I was able to branch off of the things that interested me and that I wanted to learn.

These results suggest that student who did want to pursue their interests more deeply were able to do so more easily in a blended learning environment.

Table 4.7 Descriptive statistics for student responses to items in WEBLEI Scale I: Access

Question	Statement	Valid Cases	Mean (SD)	Mode
1	I can access lesson on the internet at times convenient to me.	29	4.24 (0.69)	4
2	Lessons on the internet are available at locations suitable for me.	29	4.21 (0.82)	4
3	I can access lessons on the internet on days when I am not in class or absent from school.	29	4.07 (1.07)	5
4	Lessons on the internet allow me to work at my own pace to achieve learning objectives.	29	3.86 (1.06)	4
5	Lessons on the internet enable me to decide how much I want to learn in a given period.	29	3.62 (1.12)	4
6	Lessons on the internet enable me to decide when I want to learn.	29	3.66 (1.01)	4
7	The flexibility of lessons on the internet allows me to meet my learning goals.	29	3.83 (0.93)	4
8	The flexibility of the lessons on the internet allows me to explore my own areas of interest.	29	3.41 (1.12)	4

4.6.2 Questions from WEBLEI Scale II Interaction

WEBLEI Scale II measures students' perceptions of the co-participatory domain, mean and mode scores for the 8 questions for this scale are presented in Table 4.8. The mean response for Scale II was 3.55 (SD 0.54), a result strongly affected by a few questions that received low scores, question 9, 13, and 15. Question 9, "I communicate with my teaching in this subject electronically via email" received the lowest score, with a mode of 2 "disagree". Similarly, Question 13 "the teacher responds to emails" also received a low mode of 3, 'neither agree nor disagree'. In contrast, the mode of student's responses to Question 11, "I have the option to ask my teacher what I do not understand by sending an email", was 'agree'. The mode response to Question 12, "I feel comfortable asking my teacher questions via email", was 'agree'. This suggests that while students agreed that they could send me emails during the unit, most students did not choose to communicate with me in this way. Such findings strongly indicate the value of the face-to-face time when students can communicate with their teacher and their peers directly, rather than rely on electronic means of communication. Students also valued the ability to work with their peers, illustrated in Question 14 "I can ask other students what I do not understand during computer lessons ", which had a mode of 4, 'agree'. Scale II also evaluates students' perception of the self-discipline required in blended learning. For Question 4, "In this learning environment, I have to be self-disciplined in order to learn", the mode response was 4, 'agree'. Self-discipline is an important part of blended learning, and students in the focus group interviews discussed this key characteristic. However, this personal characteristic was not necessarily related to a student's level of achievement as related to passing grades A, B or C.

Daniel (pseudonym): In this learning environment, I have to be self-disciplined in order to learn.

Theresa (pseudonym): Sometimes it was hard to motivate yourself, but other than that I thought that everything was fine, except for the students who brought it on themselves, and the fact that they aren't passing is their own fault with the eLearn. If you want a good grade it's so much easier to get it because with a teacher you're only given limited information. But if you've got your laptop then you can just search the things you want to search and everything that you need to know. You're not limited, there is so much more out there especially through eLearn, you can get the basics of what you do need.

Robert (pseudonym): In class you'd have the people in one section that would do the work and they would get through all of it or nearly all of it depending on the content, but then you'd have people in a different area that did like one task to make it look like they were doing something, and then you'd have other people that just sat there pretending that they were doing something.

Table 4.8 Descriptive statistics for student responses to items in WEBLEI Scale II: Interaction

Question	Statement	Valid Cases	Mean (SD)	Mode
9	I communicate with my teacher in this subject electronically via email.	29	2.66 (1.08)	2
10	In this learning environment, I have to be self-disciplined in order to learn.	29	3.93 (1.07)	4
11	I have the options to ask my teacher what I do not understand by sending an email.	29	3.48 (1.18)	4
12	I feel comfortable asking my teacher questions via email.	29	3.38 (1.18)	4
13	The teacher responds to my emails.	28*	3.68 (0.90)	3
14	I can ask other students what I do not understand during computer lessons.	29	4.28 (0.75)	4
15	Other students respond positively to questions in relation to internet lessons.	28	3.64 (0.78)	3
16	I was encouraged by the positive attitude of my friends towards the internet lessons.	29	3.31 (0.81)	4

** One of the 29 respondents left item 13 blank*

4.6.3 Questions from WEBLEI Scale III Response

The third scale, Response, measured students' perceptions of qualia such as enjoyment and confidence. The majority of students, 62% indicated they learned more with blended learning (Question 20) and 55% indicated they enjoyed learning in this modality (Question 19) (Table 4.9). While these numbers seem low it is important to note that only 14% of students indicated that they did not enjoy learning using blended learning, and only 21% indicated that they did not learn more. These numbers are driven by a large group of students who selected neither agree nor disagree for these two questions, 31% for question 19, and 17% for question 20. The mean result for the WEBLEI Response scale was 3.36 (SD= 0.65, Table 4.6) - the lowest mean of the four scales. Year 10 students had varied opinions of the blended learning approach in terms of their expressed satisfaction, interest and enjoyment. Questions 17, 21, and 22 investigated student perceptions of their ability to work with other students in the class, and Questions 18, 19, 20, 23 and 24 investigated student enjoyment and interest. A slight majority of students generally enjoyed learning using a blended learning approach as 55% of respondents agreed or strongly agreed, 31% neither agreed nor disagreed, and 14% disagreed or strongly disagreed.

Table 4.9 Descriptive statistics for student responses to items in WEBLEI Scale III: Response

Question	Statement	Valid Cases	Mean (SD)	Mode
17	This mode of learning enables me to interact with other students and my teacher.	29	3.28 (0.84)	3
18	I felt a sense of satisfaction and achievement about this learning environment.	29	3.28 (1.07)	3[a]
19	I enjoy learning in this environment.	29	3.55 (1.02)	4

20	I could learn more in this environment.	29	3.55 (0.99)	4
21	I can easily get students to work with me on the internet.	29	3.38 (1.05)	4
22	It is easy to work with other students and discuss the content of the lessons.	29	3.62 (0.82)	4
23	The web-based learning environment held my interest in this subject throughout this term.	29	3.17 (1.04	3
24	I felt a sense of boredom in this subject towards the end of this term.	29	3.07	3

[a] Multiple modes exist. The smallest value is shown

Overall, students had mixed perceptions of blended learning, some students clearly preferred this type of learning, while others indicated a strong preference for more teacher directed learning. Measured student achievement was not linked to these differences in perceptions. I consider that unfamiliarity with blended learning may have had an impact on these students' perceptions, because, as noted, blended learning was only recently introduced to the school at the time. And I was one of the first teachers to incorporate a blended learning approach into the school's science program. The comments below illustrate the mixed responses from students.

Students who were very positive about using blended learning said:

> Karen (pseudonym): I believe it is a good idea with plenty of potential. Easier access and ability to search for alternate resources.

Ben (pseudonym): I do think that eLearn has improved my results in this subject as I learned at my own pace and got to choose what elements of the topic to prioritize when revising.

Daniel (pseudonym): I think it improved my learning where I think the in-class teaching may have been slower to keep everyone at an even pace, but because of eLearning I learnt more things that I would have in class because I used the resources I had to get a better mark on the test.

Students who preferred a more teacher directed approach said:

Tim (pseudonym): eLearn didn't really improve my results in science because it is hard to focus when you are just using the internet. I learn better when a teacher is telling me what to do.

Terry (pseudonym): It's better having a teacher up at the front teaching you and going over the stuff instead of having each lesson [online] to do.

Wendy (pseudonym): I feel like a whole lesson with the teacher is interactive. You get to ask questions and you get to have class discussions about it. I feel like that's

> interactive enough, we don't need a computer and then specific interactive activities, I feel like I would prefer just the teacher.

There was also some indication that students' unfamiliarity with online learning was an important factor in their perceptions of blended learning.

> Robert (pseudonym): Some people find (online) learning easier, but others find internet learning a lot more complicated and it can get confusing, so those people fall behind.

> Karen (pseudonym): I do think maturity is a pretty big factor because this is the first time we've really had this much independence with something online … and I think in order for online learning to work you would need to introduce it probably in year 6 or 7, in primary schools, so you got used to it throughout, because it will be something in university and probably senior schooling as well that we will need to get used to and being independent is pretty important.

4.6.4 Questions from WEBLEI Scale IV Results

The final scale, Scale IV Results, evaluated students' perceptions of the course structure, how the course was organised, including the interactive capability of the course and availability of opportunities diverse learning styles. The mean for the Results scale was 3.64 (*SD* = 0.73), indicating students were satisfied with the structure and delivery of the online learning component. The mode for student responses in this scale was 4 (agree) for all questions. Descriptive statistics for the 8 statements in this scale included in Table 4.10.

Table 4.10 Descriptive statistics for student responses to items in WEBLEI Scale IV: Results

Question	Statement	Valid Cases	Mean (SD)	Mode
25	I can work out exactly what each lesson on the internet is about.	28	3.75 (1.00)	4
26	The organisation of each lesson on the internet is easy to follow.	29	3.97 (0.98)	4
27	The structure of the lessons on the internet keeps me focused on what is to be learned.	29	3.59 (1.05)	4
28	Internet lessons helped me better understand the work that was taught in class.	29	3.31 (1.11)	4
29	Lessons on the internet are well sequenced.	29	3.62 (0.86)	4
30	The subject content is appropriate for delivery on the internet.	28	3.54 (0.74)	4
31	The presentation of the subject content is clear.	29	3.72 (0.84)	4
32	The multiple choice test at the end of lessons on the internet improves my learning in this subject.	28	3.64 (0.99)	4

The majority of students (83%) said the organisation of each online lesson was easy to follow and 69% perceived online lessons help them better understand the content taught in class. Overall students had a positive perception of the unit structure, organisation, and availability. These findings are further supported from qualitative data, detailed below.

Students who agreed that the organisation of lessons was easy to follow said:

> Heather (pseudonym): I agree everything was set up really well so you could find the information you needed pretty quickly.

> Amanda (pseudonym). Yeah, I thought it was alright to me, it was easier to find things and it wasn't too hard.

Students were particularly positive about the online, multiple-choice review quizzes at the end of lessons, as indicated in focus group interviews.

> Tim (pseudonym): The lesson quizzes helped me get better at the subject because it made me rethink what I had already learnt.

> Megan (pseudonym): The quizzes were good to test our knowledge and to help us improve.

Bob (pseudonym): The lesson quizzes were very useful in terms of helping me understand the lesson

David (pseudonym): The online quizzes they were useful, but because they were so key-sensitive it was confusing, like when you got marked wrong on something that was obviously right so it quite confusing so I think with improvement to the eLearning system it could be very useful

Students identified some of the key aspects of blended learning which were most and least helpful.

Chris (pseudonym): I reckon when we're using the eLearning how I didn't really like the questions where you had to go find the answers like around the Internet, but if it was reading about stuff and then answer questions and then like just a bunch of pages and that kind of thing, I reckon that's pretty good; and I think looking at the diagrams and stuff was good

Wendy (pseudonym): I think pictures are also good because sometimes were looking at just a really huge page of just heaps of text, and breaking it up would be less intimidating because then you're not like there's two whole pages to read, you're like there's pictures!

> Robert (pseudonym) I kind of found the focus questions helpful if you forgot all of the questions like you spent a little bit of time writing out the questions then the answer, but if you didn't write down the questions you forgot what the question was about, and that was a lot of the activities it was like just copy this down and you copy it down and you look back through your book and your like why do I have this written here and what's relevant to ta certain topic

And some students said that the organisation and accessibility of the online learning environment made it more useful as a study tool, rather than for doing work in class.

> Megan (pseudonym): I think to make it better instead of doing all of our lesson work on eLearn, I think we should just balance it out, so more revision and homework and studying with the eLearn because you can access it easier and because of the way its formatted. It's all very organized so you know exactly what you're looking for where as in studying that would be good for at home not in class, but in class we should be focused on just learning instead of trying to like do all these other things and its really distracting.

4.7 Summary of Quantitative Results of Student Perceptions

As part of my research, I wanted to understand my students' perceptions of using blended learning in secondary Earth and Space science. The results I have presented in this chapter show that students were generally positive about the blended learning approach, particularly as to the design and development of the curriculum unit. The positive responses to the design and organisation of the course support the use of the *Explicit Teaching Lesson Model – FNQ Region.* In addition, the use of the ETLM-FNQ can help support students who preferred a high level of teacher guidance. My research suggests that blending learning can be used to support student engagement and success in secondary science. In addition, these data demonstrate that students had a positive perception of the course structure using the *Explicit Teaching Lesson Model – FNQ Region* and illustrates the potential of the model in planning and implementing blended learning in secondary science.

CHAPTER 5 - TEACHER PERCEPTIONS OF BLENDED LEARNING IN SECONDARY SCIENCE

5.1 Introduction

The previous chapter discussed students' perceptions of blended learning through analysis of their WEBLEI responses, and focus group interviews. This chapter describes my personal perceptions of designing and implementing a blended learning course, as the teacher-researcher. When I began this study, my educational purpose was to find a better way to engage my students in learning science. With bachelors and master's degrees in Wildlife Biology and Marine and Tropical Biology respectively, I have a passion for science, that drives my enthusiasm for teaching science. However, as a result of my observations over my first 3 years of teaching, I felt that students, despite my best efforts, were disengaged with science education, and needed further and more extensive opportunities for autonomous, self-directed learning. Blended learning was gaining interest, but little research had been conducted in Australian secondary schools. I set out to design, implement, analyse and evaluate an approach to use blended learning to teach secondary science. In the following section I explore the qualitative data from the teacher perspective and situate my role as a pedagogist and as a doctoral researcher.

5.2 Planning a blended learning course

I completed my Graduate Diploma of Education in 2010, and began teaching at a government secondary school in Tropical Far North Queensland. Having a strong interest in the use of computer technology in teaching, I made every effort to incorporate Information Communication Technology (ICT) into my lessons. The school held a license to use the Blackboard Learn™, a popular learning management system (LMS), which, at the time, was poorly implemented and under-used by most of the teaching staff. I joined with the school e-Learning committee, the task of which was to increase ICT integration into classrooms, and provide professional development for teachers. Teachers initially used Blackboard Learn™ primarily as a document repository, a location to share documents with students. In 2011, during my second year of teaching, I had the opportunity to work with a local university to develop an online learning environment using the Blackboard Learn™ to assist pre-service teachers in developing their science content knowledge. Through this work, I began to see the potential in using LMS systems in secondary science education. In 2011 and 2012 I developed an online learning unit for the Certificate II in Animals Studies for secondary school students, and what I learned creating this unit became a pre-cursor for the research presented in this thesis.

In developing the Certificate II in Animals Studies, the first challenge I faced was determining the best organisation for online content, and this developed as I taught the unit over the school year. I was constantly discussing with students, what content they felt was most helpful, and what they thought was challenging. Encouraged by the positive response from my students, I used this experience to embark on my next project which would be to develop an online learning unit for students in Year 10 science.

As blended learning was just beginning to gain momentum, there were not many examples of what a ‘good’ blended learning unit should look like in a regional, state school context. Blended learning, at its best, should facilitate the integration of online and face-to-face teaching using a variety of learning resources and communications options (Francis & Shannon, 2013). My research and practice was also influenced by new mandates requiring teachers to implement the *Explicit Teaching Lesson Model – FNQ Region* (ETLM-FNQ) (Appendix B). Students had three 70-minute science lessons each week. The first part of the lesson was face-to-face explicit teaching, during which time I summarised content from the previous lesson/s (activation of prior skills and knowledge), and presented the day’s learning goals. Following explicit instruction, students could then use the rest of the lesson to work through online content. Table 5.1 shows the relationship between the ETLM-FNQ, and how the model informed the structure of lessons over the ten-weeks.

Table 5.1 Relationship between blended learning and the ETLM-FNQ

FNQ Region Explicit Teaching Model	Blended Learning
Opening the Lesson (lesson intent, success criteria, activate prior knowledge, and establish lesson importance)	Introduction and consolidation from previous lesson using MS PowerPoint Slides (whole class, teacher-directed)
I Do (content delivery, concept and skill development)	Introduce lesson topics using MS PowerPoint Slides, videos and teacher explanations (whole class, teacher-directed)
We Do (working together, guided practice, check for understanding)	Class discussion questions about the topic (whole class, teacher-directed)
You Do (independent practice)	Online learning tasks (individual, student-centred)
	Self-directed learning and weekly quizzes (individual, student-centered)
Closing the Lesson (lesson review)	Revision and class discussion (whole class, teacher-directed)

At the study school, the Year 10 science program covers 4 study areas representing broad disciplines, Earth and Space Science, Physics, Chemistry, and Biology. Over the year, 10 weeks were allocated to each area. The study areas were further divided into two 5-week units for the Earth and Space Science program, this consisted of “Unit 7: Global Systems”, and “Unit 8: Space Science” (Figure 5.1). The units are then divided into individual lessons. Students were asked to complete three lessons each week. Each lesson included clear learning goals in accordance with the ETLM-FNQ, and most lessons included three tasks.

Students were given time during face-to-face lessons where they could ask the teacher for assistance, and were advised to finish any uncompleted tasks for homework. An example of one of the lesson overviews in included in Figure 5.2.

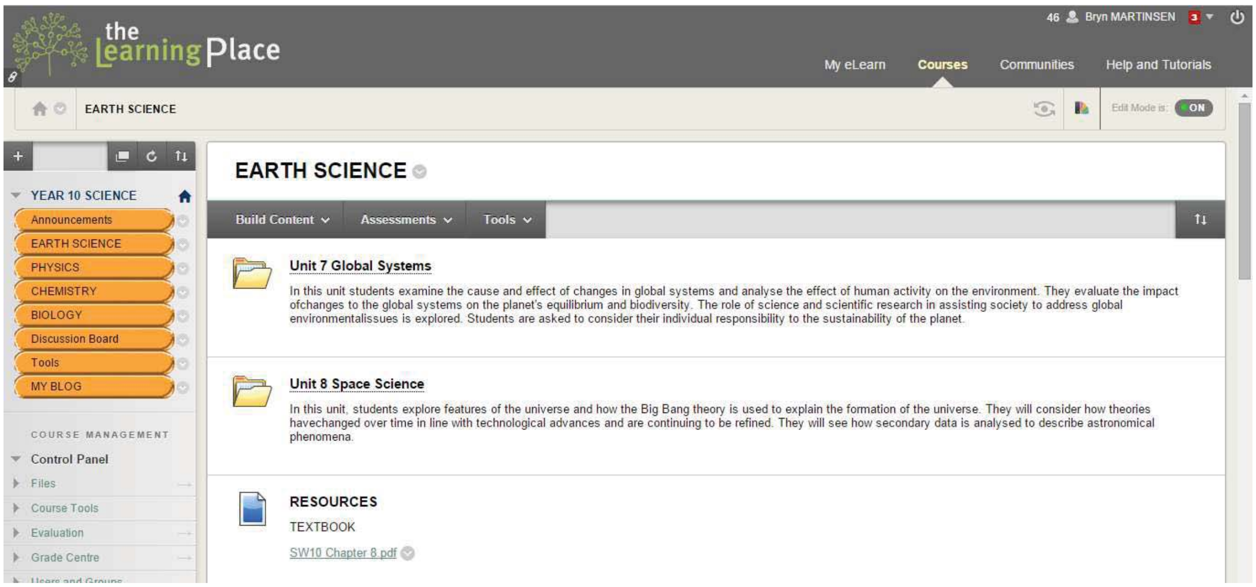


Figure 5.1 Earth and Space Science units page from the Year 10 Science Blended Learning Course

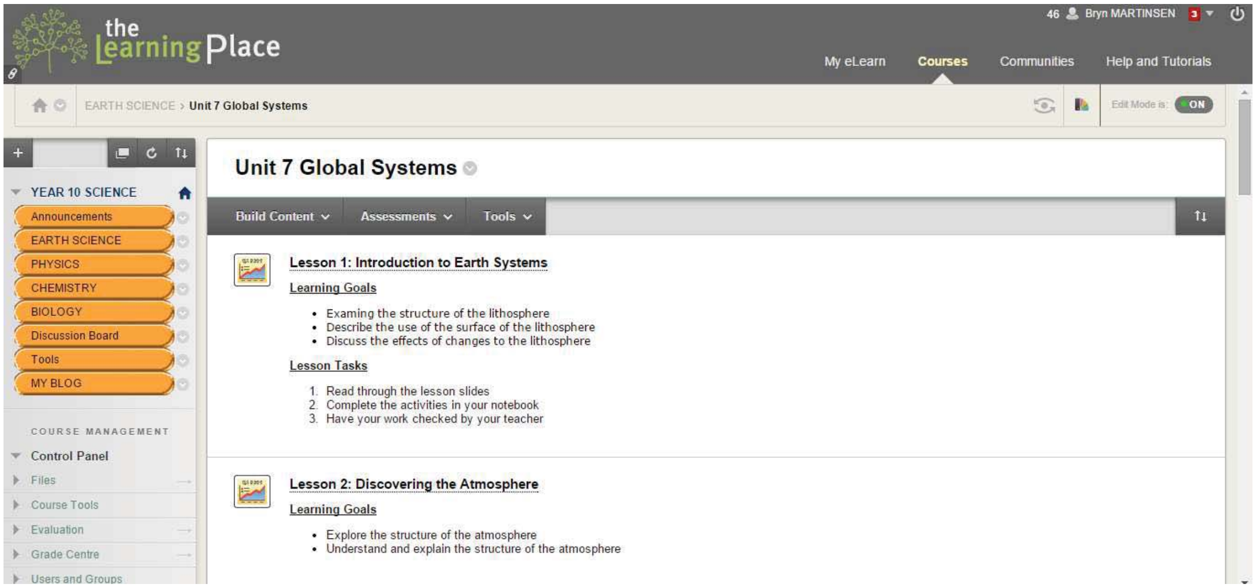


Figure 5.2 Unit structure from the Year 10 Science Blended Learning Course

5.3 Teaching a blended learning course using Explicit Teaching

Throughout the duration of the study, the school's explicit teaching coach observed five lessons. Explicit teaching coaches were assigned to state schools in Far North Queensland as part of the Intensive Explicit Teaching project (Department of Education and Training Far North Queensland, 2014). The role of the explicit teaching coach was to:

- Establish protocols and processes for professional interactions between the coach and teacher or coach and leadership team
- Support teachers by working through the professional learning workshop tools
- Promote explicit teaching and consolidation as best practice

- Support teachers by observing, providing feedback, collaboratively planning and demonstrating
- Ensure that the focus of all sessions and feedback are directly related to the elements of Explicit Teaching and Consolidation
- Provide weekly written and verbal feedback using the structure/ template provided in the toolkit (Appendix F)
- Provide additional readings as provided in the coach's toolkit
- Negotiate, schedule and commit to dates and times of in-class and feedback sessions.
- Complete documentation e.g. feedback sheets & logs

(Department of Education and Training Far North Queensland, 2014, p. 2)

Observations from the explicit teaching coach were recorded using the Explicit Teaching Observation Form (Appendix F), and these were discussed during our weekly meetings. According to Ingvarson, Meiers, and Beavis (2005) "coaching during the difficult phase of implementing significant change in the classroom is a feature of effective programs" (p. 18). Similar to findings from Sharplin, Stahl, and Kehrwald (2016) on the use of coaching, I found the advice from the explicit teaching coach practical and useful. The weekly meetings enabled me to continually reflect on what aspects of explicit teaching were working well and on which aspects I needed to improve. The following section summarise data from the explicit teaching observation and my teacher-researcher reflections.

Observations from the explicit teaching coach focused on the key components of an explicit direct instruction lesson, which should/must include: *Opening the Lesson, Teacher Modelled – I Do, Guided Practice – We Do, Independent Practice – You Do,* and the *Conclusion*. In the five lessons observed by the explicit teaching coach, *Opening the Lesson* phase was observed in 100% of the lessons, the *Teacher Modelled – I Do* phase was observed in 60% of the lessons, the *Guided Practice - We Do* phase was observed in 20% of the lessons, the *Independent Practice - You Do* phase was observed in 80% of the lessons, and the *Conclusion* phase was observed in 80% of the lessons (Figure 5.3).

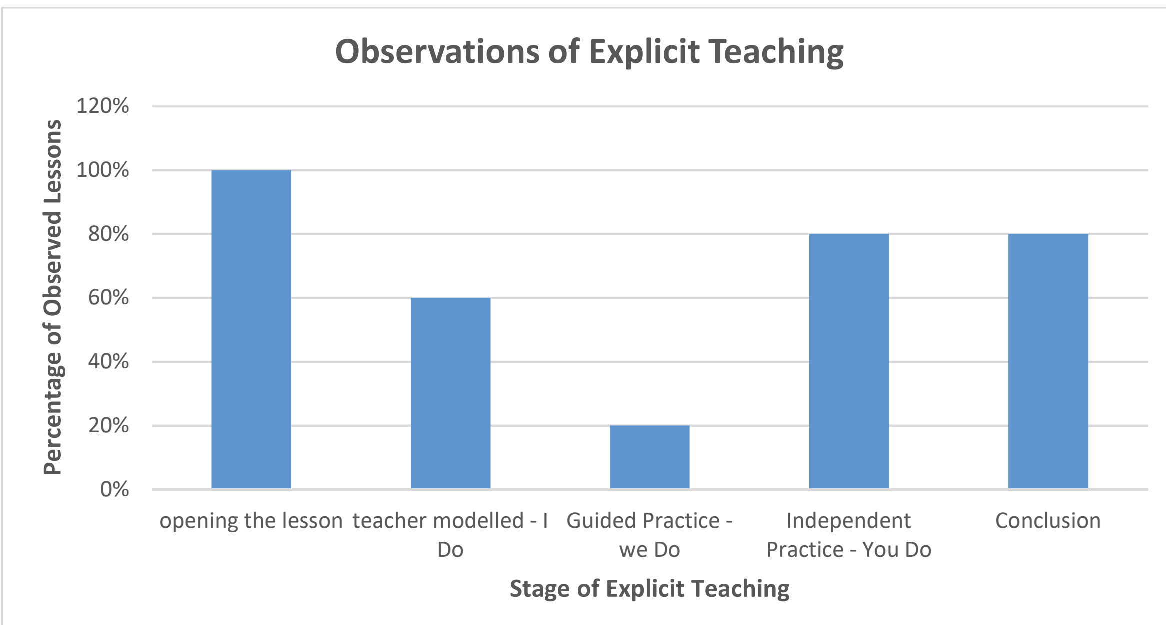


Figure 5.3 Percent of lessons in which the different phases of ETLM-FNQ were observed.

5.3.1 Opening of Lesson

The ETLM-FNQ recommends the following five practices be addressed at the start of a lesson:

- Gain attention of students
- Establish learning intentions
- Define clear and measurable success criteria
- "Why are we learning this?"
- Activate prior skills and knowledge.

The *Opening of Lesson* phase was done using MS PowerPoint, and included an introduction slide containing the lesson title, learning intentions, and success criteria (Figure 5.4). The *Opening of the Lesson* phase of the ETLM was observed in 100% of lessons attended by the explicit teaching coach.

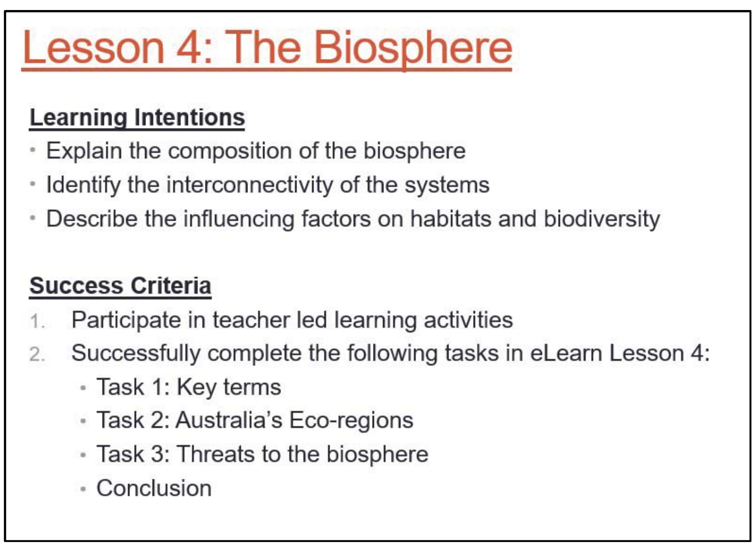


Figure 5.4 Sample of a slide for opening lesson slide

Justification for "why are we learning this" was made by explicitly explaining links to everyday life, such as some of the reasons why students had a lesson on space technology (Figure 5.5).

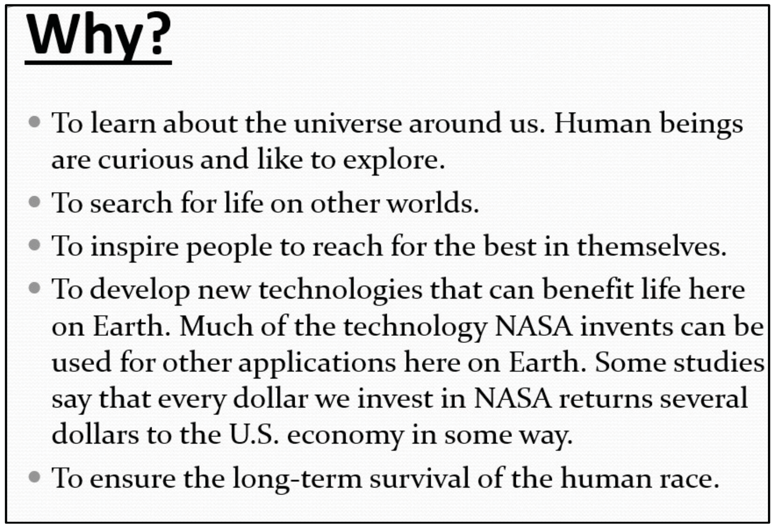
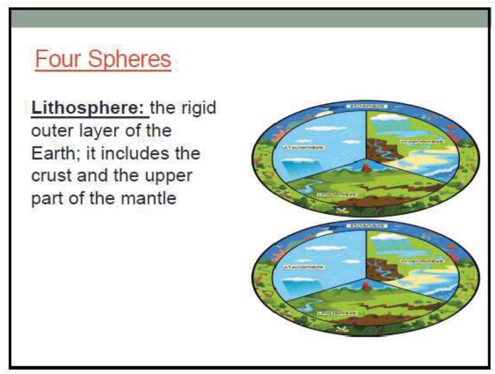
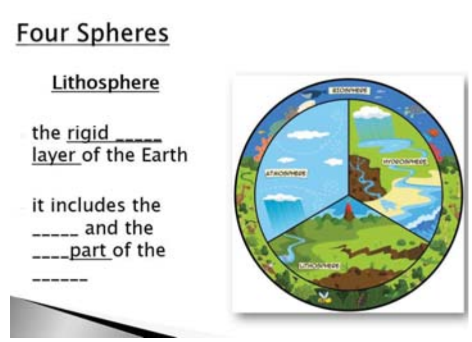
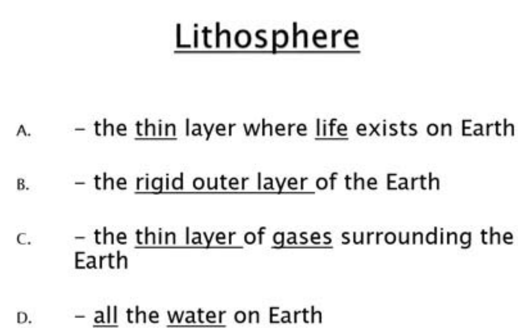


Figure 5.5 Lesson slide showing an example of "Why are we learning this"

The school had clear expectations for strategies to activate prior skills and knowledge, which was termed "consolidation". All teachers employed at this high school were encouraged to use the consolidation technique *Recite, Recall*, and *Apply (FNQ Explicit Teaching Team, 2014)*. Consolidation is a memory practice to move concepts from short-term to long-term memory. Feedback on the inclusion and use of consolidation was an important part of the observations from the explicit teaching coach, and demonstrates the focus that the study school had on this teaching/learning strategy. I found consolidation time consuming and repetitive, and I did not see the value of the high level of focus placed on this technique. Nevertheless, I was an employee and in alignment with school policy, I incorporated consolidation into each of the lessons using PowerPoint slides, an example of which is shown in Table 5.2.

Table 5.2 Consolidation elements from the Explicit Teaching Lesson Model – FNQ Region.

<table>
<tr><th>Consolidation Element</th><th>Purpose and Strategy</th><th>Example PowerPoint Slide</th></tr>
<tr><td>Recite</td><td>Review concepts that have been covered in previous lessons, read facts aloud as a whole class</td><td>
</td></tr>
<tr><td>Recall</td><td>Students remember previous concepts</td><td>
</td></tr>
<tr><td>Apply</td><td>Students demonstrate that they can apply the concepts they have previously learning</td><td>
</td></tr>
</table>

Comments and suggestions from the explicit teaching coach on observed consolidation sessions are presented in Table 5.3 and show my progression from a lesson observed in week 5 and a lesson observed 4 weeks later in week 9.

Table 5.3 Progression of teacher integration of consolidation sessions during the study period.

	Observation notes from the Explicit Teaching Coach	
	Consolidation- What went well	**Consolidation – Next steps/refinements**
Week 5	Consolidation packs make collection easier Good use of student whiteboards and "✓" and "X" cards Elements evident: recall, recite, apply Brisker pace	Ensure student say 'term' not just the definition Embed whiteboard routines ('chin it', 'check it', 'clean it', choral if necessary) especially at the start of the unit Select 'Apply' questions, can vary from lesson to lesson Continue to embed routines.
Week 9	Routine around delivery firmly established Much brisker paced (good) student engagement Immediate effective feedback, brisk pace maintained	Continue to embed routines/ expectations Ensure all students "showing" (boards) regardless of answer Incorporate class corralling where appropriate, this proved effective when used Work on strategies for students to clean their boards

Consolidation is focused on moving concepts from short-term to long-term memory (Hollingsworth & Ybarra, 2009), but this is almost exclusively factual knowledge, such as memorising definitions. Research has shown use of consolidation has been beneficial in helping improve students' vocabulary (Kök & Canbay, 2011). However, Grove and Lowery Bretz (2012) found that students were more successful when they chose study techniques which emphasised meaningful connections rather than defaulting to rote memorization and repetition. From the teacher-researcher perspective I did not feel that the consolidation sessions were a productive use of my or the students' time, as it could take up more than 20 minutes of a lesson, often covering the same scientific concepts repeated lesson after lesson. The increasingly long sessions are due to the build-up of knowledge, where new concepts are added from each subsequent lesson. At the study school, justification for the long consolidation sessions was attributed to Hollingsworth and Ybarra (2009), however, in their book, *Explicit Direct Instruction (EDI): The Power of the Well-Crafted, Well-Taught Lesson,* Hollingsworth and Ybarra (2009) recommend that session activating prior knowledge should not take more than five minutes, with the rest of the class time to be spent on teaching and learning new skills and content. Therefore, the implementation in my classroom was not in line with the original suggestions for a well-crafted lesson. My teacher-researcher observations of student participation in the consolidation phase during each lesson were that some students participated, and others pretended to participate. While consolidation may be a useful strategy with younger (primary school) students, many of my Year 10 secondary school students found this technique tiresome and appeared bored. Conversations with other teachers at the school revealed similar thoughts, to mine although there are no data regarding other teachers' perceptions. As the teacher-research my perceptions were that this strict, scripted approach to "activation of prior skills and knowledge" using consolidation did not promote active student learning. While I found many aspects of explicit teaching useful, I found that in this respect, the idealised pedagogical suggestions did not emerge as efficient or necessarily meaningful in practice.

5.3.2 Teacher Modelled – I Do

The explicit teaching coach recorded evidence of *Teacher Modelled – I Do* phase in in 60% of the observed lessons. According to the ETLM-FNQ the *Teacher Modelled – I Do* phase of lessons ideally should include:

- A logical sequence, progressing from simplest to more complex
- Modelled/demonstrated/explained step-by-step
- Effective demonstration of think aloud
- Examples and non-examples (when appropriate) are provided
- Common errors or misconceptions are addressed
- Brisk pace or appropriate pace established

The *Teacher Modelled – I Do* phase was usually presented using PowerPoint slides and included teacher notes and explanations, defining key terms, and videos with comprehension questions. An example of a slide showing *Teacher Modelled – I Do* from one of the observed lessons is included below (Figure 5.6). This was part of a lesson where students were investigating the relationship between increasing global temperatures and sea level. In the example slides (Figure 5.6), I explained key terms, followed by a demonstration of a practical experiment modelling glacial melting.

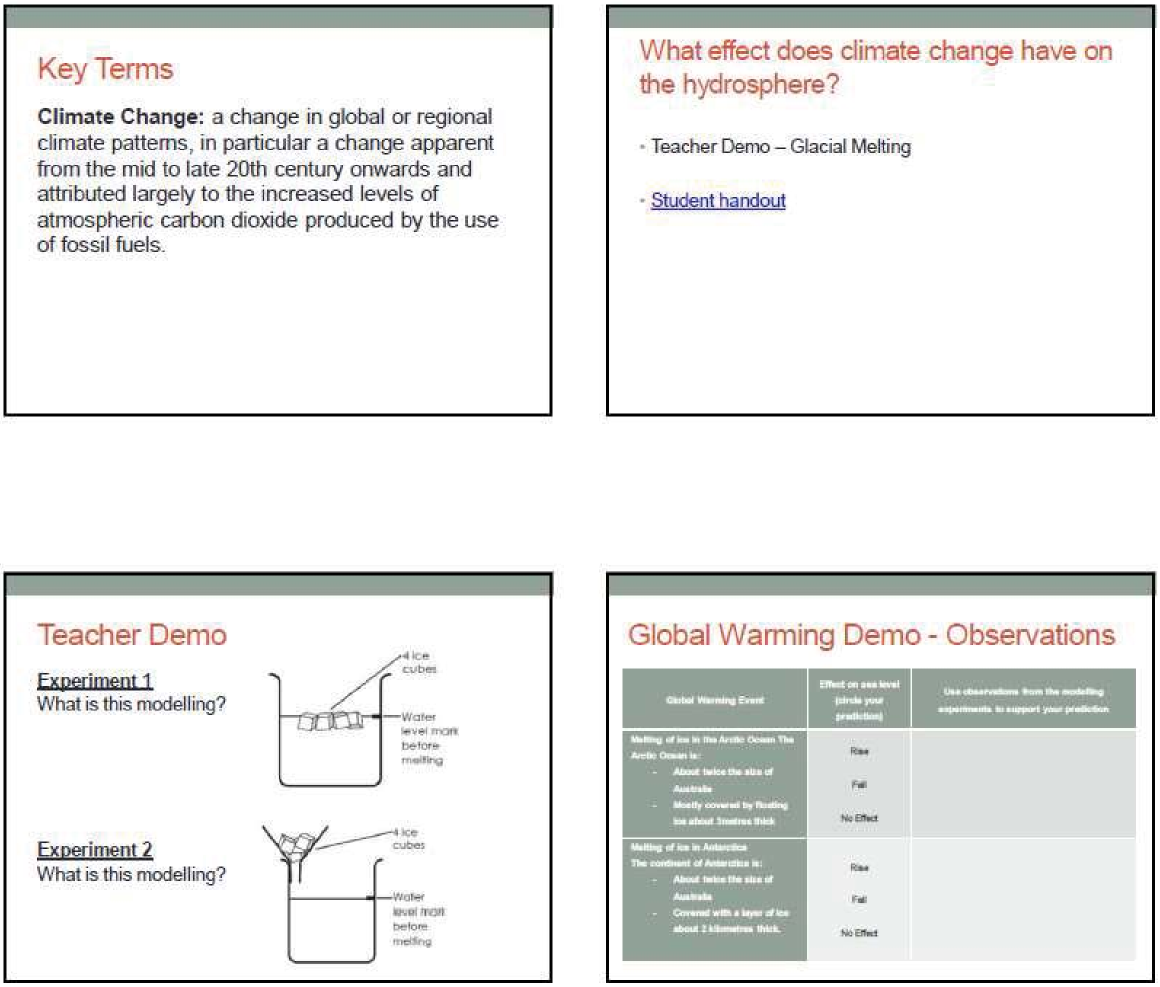


Figure 5.6 Slides showing an example of the Teacher Modelled – I Do phase of the ETLM-FNQ.

The *I Do* phase of explicit teaching relies on scaffolding, where students are given the explicit support they need when they are learning something new, with the aim of improving the likelihood a student will be able to use that knowledge independently. There are many applications of scaffolding in science, for example it may be used to teach students new laboratory techniques, learning definitions, finding information or calculating mathematical problems. The *I Do* phase of explicit teaching gives teachers the opportunity set out learning goals and explain key ideas and concepts, through Maynes et al. (2010) identified the *I Do* phase as motivation, modelling/ remodelling, and structured consolidation. From a pedagogical perspective, the inclusion of scaffolding is important in science education, particularly in terms of safety in the science laboratory as there are often times where it is important to demonstrate clear steps regarding a particular activity. While I think the *I Do* phase of the ETLM-FNQ is pedagogically sound, I do not think that it is necessary in all lessons. Some lessons are more powerful when students are given more open, inquiry-type activities, and I would argue for a balance between explicit and inquiry techniques, particularly in science education.

5.3.3 Guided Practice – We Do

The explicit teaching coach observed the *Guided Practice – We Do phase* in only one lesson. In the *We Do* phase of explicit instruction, teachers give guided instruction to establish expectations and provide support for students to meet those expectations (Fisher & Frey, 2008). The *We Do* phase is intended to assist students in improving their ability to access information they have learnt. In the *Guided Practice – We Do* phase of the ETLM-FNQ:

- Guided practice follows the SAME steps & level of complexity as demonstrated in the I DO
- Students complete – all together, step by step
- Monitoring of students throughout – requiring varied response types (establishing readiness of students for independent work)
- Confirmation that all students are completing multiple examples with the teacher
- Immediate affirmative and corrective feedback provided
- Re-teaches concept when necessary
- Brisk pace or appropriate pace maintained

In reviewing PowerPoint slides, many of the lessons did include the *Guided Practice – We Do* phase of the ETLM-FNQ. However, this was not always evident during the observed lessons. Figure 5.7 provides an example of *Guided Practice - We Do* tasks during a lesson not observed by the explicit teaching coach. In this example, students watched a short video together, followed by a whole class discussion of the focus questions. Figure 5.8 provided another example of *Guided Practice - We Do* tasks where the teacher worked with students to complete practice questions and answers.

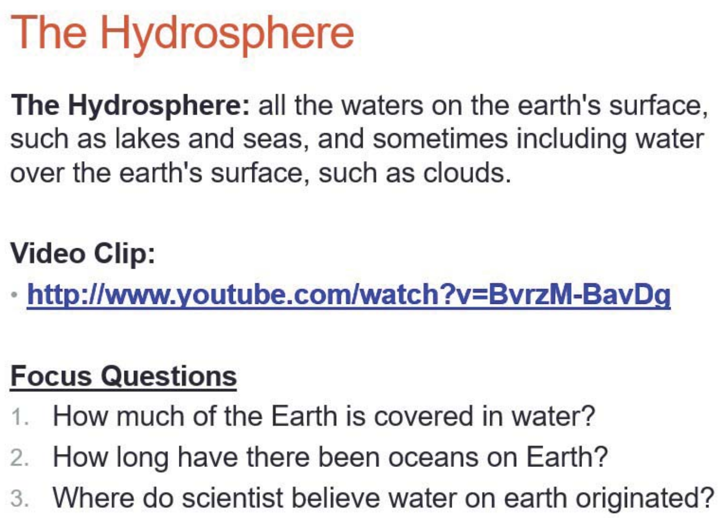


Figure 5.7 *An example of a slide demonstrating an activity from the Guided Practice – We Do phase of the ETLM-FNQ.*

Figure 5.8 *Example of a slide demonstrating an activity from the Guided Practice – We Do phase of the ETLM-FNQ.*

The *We Do* phase of explicit instruction provides opportunity for teachers to give guided instruction and to provide support for students to meet those expectations (Fisher & Frey, 2008). Students then work in a supported environment to improve their ability to access and use information they have learnt. My perception is that this is a very useful phase, and one I had not previously put enough emphasis on. Further, I think this phase is strongly supported by blended learning. One of the notable strengths of blended learning is the incorporation of ICT such as animated learning objects, which rely on the use of computer-assisted, guided instruction, such as the *Atmosphere Design Lab* (Figure 5.9).

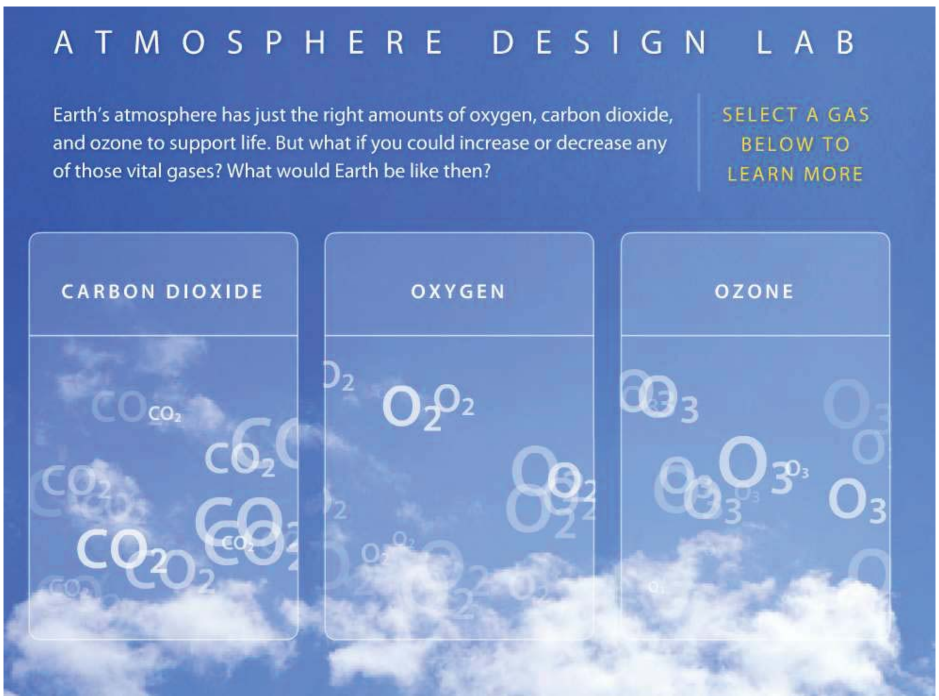


Figure 5.9 The Atmosphere Design Lab *is an example of computer-assisted learning developed by the Smithsonian Environmental Research Center which allows students to explore and investigate the importance of different gases in Earth's Atmosphere (Smithsonian Environmental Research Center, 2014).*

Computed assisted learning animations, by design, provide a structured *We Do*-type learning experience, allowing students to practice skills in a supported way. Though the explicit teaching coach did not observe the inclusion of the *We Do* phase in many of the observed lessons, I would argue that it was nevertheless present in most lessons through the inclusion of computer assisted learning programs.

5.3.4 Independent Practice – You Do

The *Independent Practice - You Do* phase was observed in 80% of the lessons. The following points are included in the *Independent Practice – You Do* of the ETLM-FNQ:

- Independent task set – matching the task practiced
- Expectations are set for minimum completion
- Task adjusted for targeted students

The *Independent Practice – You Do* phase is best supported by online learning or in-class laboratory experiments, which were included in all of the lessons. The explicit teaching coach recorded observations of the *Independent Practice – You Do* phase in 80% of observed lessons. One of the observed lessons provided the introduction to a practical activity with students completing the laboratory experiment (*You Do*) during the following lesson. Figure 5.10 provides an example of one type of online activity, in this case a short video with focus questions, which was used to support the *Independent Practice – You Do*.

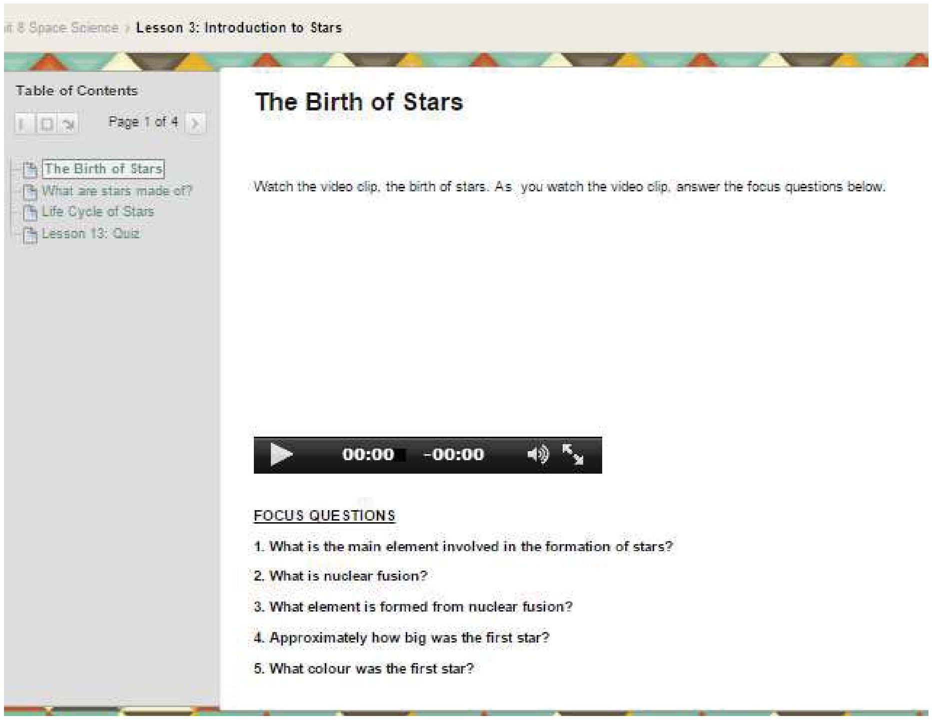


Figure 5.10 Online activities from the Independent Practice – You Do phase

The *You Do* phase is founded on Social Learning Theory (Bandura, 1977) and emphasises the importance of internal reflection in the learning process. The *You Do* phase focuses on the active role of the learner in creating their own understanding and can provide an opportunity for students to construct their knowledge both independently and in collaboration with peers. During weekly discussions with the explicit teaching coach, we agreed that blended learning was particularly useful in supporting this phase of the ETLM-FNQ. This phase was particularly focused on developing students' scientific inquiry skills through self-directed, autonomous learning opportunities, an area which I had found lacking when using more in traditional teaching techniques.

5.3.5 Lesson Conclusion

The explicit teaching coach observed the *Conclusion* phase of the ETLM-FNQ in 80% of observed lessons. In accordance with the ETLM-FNQ, the *Conclusion* phase should include four key steps:

- Revisit – learning intentions
- Review – main points
- Reflect – students explain or demonstrate that they have met success criteria
- Project – follow on learning

It was my aim to include a short 5-minute conclusion at the end of each lesson, however, in practice I found this difficult as it was easy to lose track of time. I was often distracted by individual discussion with students and small groups of students, doing my job as a helpful teacher. Lesson conclusion is supposed to provide a concise summary of the lesson, and provide an opportunity for students to ask any remaining questions. Though not always adequately evident in my lessons, I am conscious of the value of concluding lessons in a succinct way.

5.4 Teacher Reflection of the WEBLEI Scales

The WEBLEI scales informed the planning and implementation of the Earth and Space Science Unit as these provide a checklist of areas to consider while designing a program incorporating online learning. My intention was always to align curriculum development with learning intention as articulated by the scales of the WEBLEI. Upon completion of the blended learning unit, I recorded my reflections of how effectively this unit supported each of the four scales of the WEBLEI, and these are discussed below

5.4.1 Scale I Access

Scale I from the WEBLEI assesses students' perceptions of their ability to access the online components of the blended learning for which the school provided all students with a school issued computer for use at school and at home. This arrangement worked well, however, difficulties arose when computers were damaged and could often take some time to repair. There were always 2 or 3 students who did not have access to their own computer meaning, some students were asked to share computers. While this did provide opportunities for collaboration, it did limit access to online content for some students at different times.

Regarding the online structure, I felt this worked very well as each lesson had a similarly structured introduction, and layout. The online structure as described in section 5.2, had visibly defined lessons, supported by clear, concise learning goals for each lesson. After the initial introduction, most students were able to navigate through the lessons with ease. Students were given the freedom to do as much or as little work during class time as they wished, however, there were requirements that unfinished tasks were to be completed for homework. While this flexibility worked well for some students, others found it difficult to stay on task. The structure of lessons did not always allow for enough time for each student to pursue their own areas of interest. In future, I feel that including more open-ended tasks and more time for students to engage in self-directed learning would be valuable.

5.4.2 Scale II Interaction

WEBLEI Scale II measures students' perceptions of the co-participatory domain, their perception of interactions with the online learning environment, peers and the teacher. I observed that students preferred face-to-face interactions when asking questions, rather than sending emails. For example, I received very few emails from students regarding questions, but many students had individual questions during class times. This illustrates one of the key benefits of blended learning, as opposed to fully online courses. Students also enjoyed working in small groups, where they were free to collaborate on tasks and initiate discussions between each other. I made myself available to answer questions either in small groups or individually. In addition, the structure allowed for improved peer interaction, which according to Tsivitanidou et al. (2012) is an important benefit of blended or online learning. The enhanced flexibility of the learning environment was also of benefit to students who were struggling as they could get more specific one-on-one assistance from me and from each other. The blended learning structure provided opportunities for students to develop collaborative skills assisting their peers and allowing them to develop deeper understanding through these peer-teaching opportunities.

5.4.3 Scale III Response

Scale III, Response, measures students' perceptions of qualia such as enjoyment and confidence. High achieving students seemed to enjoy the flexibility, however students who found the science content more difficult seemed also to find blended learning difficult. There were a proportion of students that seemed very interested in the content, while others were less interested. However, in general, the blended learning approach did seem to hold students interest. There are students who appreciate the freedom to be self-directed, and others who clearly struggle to stay on task. For example, one student in particular finished most tasks very quickly and spent more time exploring more in-depth areas of the curriculum, such as climate change, where as another student who was less self-directed rarely finished the tasks for a lesson. This may affect how much and how deeply students learned using blended learning when compared with stricter teacher-directed activities. As a teacher I feel it is my job to provide positive learning opportunities, and encouragement, but ultimately it is a student's choice whether they make (or can make) the most of these opportunities.

5.4.4 Scale IV Results

The final scale, Scale IV Results, evaluates students' perceptions of how the learning unit was organised, and the interactive capability and availability of opportunities to cater to diverse learning styles. The ETLM-FNQ was particularly useful here, supporting the presentation of clear goals for each lesson. In addition, the inclusion of weekly quizzes provided opportunities for students to assess their own learning. After the initial introduction, most students seemed to be able to easily navigate through the lessons. The lesson structure included three tasks per lesson, however, there are always some students who are easily distracted, and some lessons may have included too much content. I found it difficult to know how much or how little to include in a lesson. Some students finished early, while others only finished the first task. The combination of face-to-face direct instruction at the beginning of each lesson, coupled with individual online time provided clarification for students, but the long consolidation sessions lessened the amount of time students had to finish online lessons. As indicated in previous studies, I also came to the conclusion that science in general, and Earth and Space science in particular, were good topics for this type of learning, despite the normal classroom challenges. This is consistent with previous studies which have demonstrated the positive influence of blended learning on the students' achievement in science (Yapici & Akbayin, 2012), attitudes towards learning science using the internet (Chandra & Fisher, 2009), and scientific reasoning (She & Liao, 2010). To develop a comprehensive understanding of science, students need to develop both content knowledge and inquiry skills. While content knowledge can be developed through explicit teaching (Leno & Dougherty, 2007), inquiry skills are better developed through more flexible, inquiry based teaching (Kang et al., 2012). Blended learning in conjunction with the ETLM-FNQ provides opportunities for students to develop content knowledge and inquiry skills by integrating explicit and inquiry based teaching instruction. Blended learning in classrooms can provide more flexible, autonomous, self-directed learning experiences, which I think is critically important in improving student engagement in science education.

5.5 Summary of Teacher Perceptions of Teaching a blended learning course using explicit teaching

As the teacher-researcher, I found the observations and discussion with the explicit teaching coach to be helpful and valuable. From a researcher perspective, these independent observations provided a rich source of data, and from a teacher perspective the observations provided an opportunity for reflection and for improving my own teaching strategies to align with the ETLM-FNQ. However, the consolidation expectations from the ETLM-FNQ I found were difficult to integrate with blended learning, primarily due to time constraints. Figure 5.11 provides a comparison of my perception of time actually spent in each of the phases of the ETLM-FNQ model, versus what I analysed would be a better use of the time.

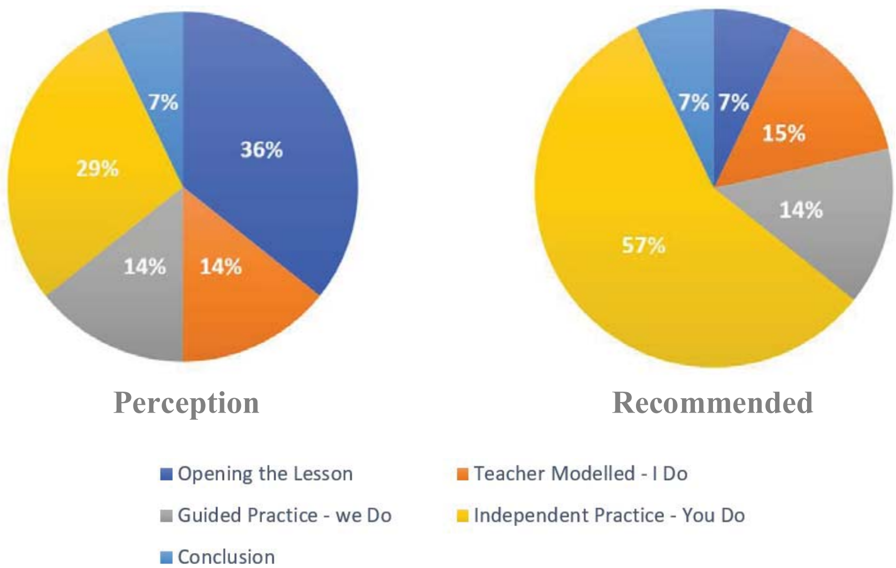


Figure 5.11 Comparison of perceived and recommended time spent in each of the ETLM phases

These calculations are based on a 70-minute lesson. As noted, a large amount of time was spent *Opening the Lesson*, mainly due to the inclusion of long consolidation sessions. Based on recommendations from Hollingsworth and Ybarra (2009), the model shows a much shorter amount of time spend in the *Opening the Lesson* phase*,* providing more time for independent student learning during the *Independent Practice – You Do* phase.

CHAPTER 6 - DISCUSSION AND CONCLUSIONS

6.1 Introduction

One of the most inspirational talks I have seen was presented by Ken Robinson in 2006, entitled "Do schools kill creativity?" (Robinson, 2006). In this talk, Robinson suggests that we are all born with extraordinary natural talents, but through the current systems of education we lose touch with our natural ability for creativity. His talk inspired me to look more deeply at my own teaching practice, and as a reflective practitioner, I agreed with his assertions, I still do. So, I set out to explore what I could do in my own classroom to nurture and inspire the creativity of my students. My doctoral research grew out of this desire to improve my teaching practice, because I could see, as has been so clearly articulated in the literature (Lyons & Quinn, 2010), that students were becoming disengaged with science education. I believed that technology could form part of the solution, and found that blended learning could be used to integrate technology into classrooms.

The purpose of this final chapter is to discuss and summarise the findings from the research. The primary purpose of this study was to investigate student perceptions of blended learning in Year 10 secondary science using the *Explicit Teaching Lesson Model – FNQ Region*. To accomplish this, the study sought to address these research questions:

1. What features of blended learning are important to secondary science students?
2. What are students' perceptions of using blended learning in secondary science?

3. How does blended learning influence student achievement in secondary science?
4. How can the *Explicit Teaching Lesson Model – FNQ Region* framework be used to inform blended learning?
5. What are the teacher's perceptions of using the *Explicit Teaching Lesson Model – FNQ Region* to design and deliver a blended learning course in secondary science?

"Teacher-researchers can be characterised as those practitioners who attempt to better understand their practice, and its impact on their students, by researching the relationship between teaching and learning in their world of work" (Loughran, 2002, p. 3). As a teacher-researcher, conducted within my "world of work", this project has enabled me to reflect more deeply on my own practice, and develop more responsive approaches that better meet the individual needs, concerns and interest of my students. This is one of the critical advantages of self-study, along with the ability to bridge the gap between researcher knowledge and classroom practice. Self-study is embedded in the need to create ways of better understanding what constitutes teachers and/or teacher educators' professional knowledge (Loughran, 2007). In Australia, science teachers' contributions to research in particular are highly regarded, potentially due to the fact that many Australian university based science educators have come to their positions after substantial school science teaching experience (Gunstone, 2000). However, Ryan et al. (2016) argue that " 'experts', including professors from colleges and universities, often spend a great deal of time talking *about* teachers and their work; however, they often exclude the *voice* of teachers themselves and their *lived* experiences in classrooms" (pg. 102). Classroom scholarship can provide valuable insight into the *lived* experiences of the teacher, and in my case the high level of research required as part of my doctoral thesis demonstrates my commitment to deep and focused research on my own practice, contributing more to the broader field of educational research.

6.2 Main Findings of the Study

My research shows that Year 10 students in 2 science classrooms valued features of blended learning that permitted them to learn at their own pace, prioritise specific topics, catch up at home on missed lessons, revise lessons, access online text-books, access self-marking quizzes, and learn using engaging learning objects. Findings from my study are similar to previous studies of blended learning where students report the value the integration of interactive components such as learning objects, video clips, discussion boards and self-marking quizzes (Florian & Zimmerman, 2015; Liaw, 2008). My study found that students enjoyed the use of interactive learning objects (page 90-91), although students were not always sure how the learning goals connected to the different learning objects. These results are consistent with previous research which also demonstrated the advantages of using interactive learning objects in secondary science (Kay & Knaack, 2007). This has implications for planning blended learning, indicative that the inclusion of interactive learning objects is important, but it is equally important that students are clear about the purpose and goals of learning objects. Students also valued the use of weekly quizzes that allowed them the opportunity to self-assess their learning and gain immediate feedback. Feedback is always an important factor in student learning as it enables students to identify what they have done well, and where they can improve (Tsivitanidou et al., 2012). Active engagement in learning is a critical factor in science education which can be enhanced by the use of ICT (Swarat et al., 2012), so it is important to design learning within classroom environments that include the features shown to be most important to students.

While only a small majority of students at the time (55%) indicated that they enjoyed learning using blended learning (page 87) this is largely driven by the high proportion of students (31%) who indicated no preference, and only 14% of students indicated that they did not like learning using blended learning. While some studies have found student preferences for blended learning may be influenced by achievement levels (Lin, 2017; Luketic & Dolan, 2013; Owston et al., 2013), I did not find this to be the case in my two classrooms. Focus group interview data show some of the lower achieving students (in terms of grades) had a very positive perception of blended learning, while some high achieving students indicated a preference for more traditional modes of teaching. Results from pre-test and post-test comparisons suggest that blended learning can contribute to or influence student achievement in secondary science, and data from the WEBLEI shows that a solid majority of students (62%) felt that blended learning had a positive influence on their achievement. At the time of this study, student perceptions were influenced by unfamiliarity with blended learning. Self-discipline was also raised during focus group interviews. My findings are consistent with previous studies that nominated self-discipline (Emelyanova & Voronina, 2017) and technical problems (Chandra & Briskey, 2012), as matters having a negative impact on students perceptions of blended learning. Blended learning can provide a positive learning experience for secondary science students, however, in future planning, students would most likely benefit from greater exposure to blended learning in conjunction with improved technical support.

This classroom study reveals that the *Explicit Teaching Model – Far North Queensland* (ETLM-FNQ) can be used to plan and structure blended learning for secondary science. The ETLM-FNQ consisted of five phases *Opening the Lesson, Teacher Modelled - I Do, Guided Practice - We Do, Independent Practice - You Do* and *Closing the Lesson*. The model provides opportunities for clear instruction from the teacher, supported by online learning tasks. Student perceptions of the unit indicate a strong preference for the model used in planning and implementing blended learning. The majority of students (83%) indicated that the organisation of each online lesson was easy to follow and 69% responded online lessons helped them better understand the content taught face-to-face in class (page 91). While research on the use of explicit teaching in conjunction with blended learning is still very limited, initial findings suggest this can have a positive influence on learning effectiveness, design, and engagement (Kay, 2013; Wan & Nicholas, 2010; Yeh, 2009). The data from this study shows the use of the ETLM-FNQ in planning and implementing blended learning in secondary science does not impede learning, and may support learning by providing clear learning goals, explicit instruction and more individualised opportunities for guided and independent practice. Differentiation in large classes of mixed ability and mixed motivation is often very difficult, and as a classroom teacher I often found myself "teaching to the middle". The use of the ETLM-FNQ in conjunction with blended learning provided a significant improvement in my ability to differentiate learning for my students. I was more available for one-on-one assistance, but I could at the same time utilise online learning technology to provide more advanced extension activities for students as well. As technology improves, the capabilities of online learning will also improve, and further research investigating blended learning and the ETLM-FNQ, particularly focusing on the role of ICT in supporting *Guided Practice - We Do* would further extend my findings.

From my teacher-researcher perspective, the ETLM-FNQ was a functional framework for structuring and planning online content. While it was initially very time consuming to design lessons and quizzes, in the long run this investment of time would be offset by being able to re-use stable content with only slight modification in subsequent iterations. Bingimalas' (2009) five barriers to implementation of blended learning are lack of access, resistance to change, lack of time, lack of training and lack of technical support. Planning and implementing blended learning in secondary science did and does require a high level of ICT skills. Thus it is important that schools invest in professional development to support teacher acquisition of improved ICT skills. The ETLM-FNQ is useful in planning and teaching content knowledge, and does enable students to develop science inquiry skills in the *We Do* and *You Do* phases of the model. In conjunction with blended learning, the *You Do* phase of the ETLM-FNQ provides many opportunities for students to explore and extend their self-learning, thereby leading to the pedagogically desirable aims of differentiated learning and autonomous learning. Students are more able to extend themselves and/or seek more individualized teacher assistance. Similar to findings from Sorbie (2015), I found that blended learning supported my teaching practice, promoting individualization, collaboration, organization, engagement, real-world relevance, and student-centered learning. However, it is clear from my classroom study that blended learning should begin much earlier than Year

10, as it is difficult for students to shift to this type of learning after many years of solely teacher directed instruction. I now think that opportunities for independent learning could begin as early as in Grade 1. Educational institutions in Australia would benefit greatly from putting greater emphasis on independent learning, nurturing student's creativity, rather than the growing trend, which is more preoccupied with high-stakes testing. The disproportionate focus on high-stakes testing is having a negative impact on curriculum and pedagogy in Australia (Polesel, Rice, & Dulfer, 2013). This suggests an even greater need for a focus on developing and encouraging the development of blended learning classrooms, providing more autonomous, and self-directed learning opportunities for our students.

6.3 Implications of this study: Potential and pitfalls of blended learning

In conclusion, blended learning provides improved opportunities for autonomous learning, where students improve computer skills and online learning skills. In addition, blended learning gives students positive opportunities for instantaneous feedback through online quizzes, and peer feedback through student-student collaboration and discussion boards. Blended learning can provide more opportunities for one-on-one instruction and small group instruction and students have control of the pace of their learning. Blended learning does appear to provide opportunities for deeper learning for the high achieving/talented, and self-motivated students (who are not always one and the same), and the range of students of many different interests and abilities who are not always looked after well in mixed ability classrooms. Well-designed blended learning can mean an improved student experience of learning in science. However, blended learning is not without its problems, especially concerning implementation. Initial establishment is resource intensive for the teacher and the school does need to provide resource support. There are students who will be easily distracted and those who struggle to stay on task when working online. Others struggle to adjust to self-directed rather than teacher-directed learning. The use of consistent classroom management strategies, such as giving clear instructions and positive reinforcement coupled with the principles of explicit teaching from the *ETLM-FNQ* can work synchronously as I have shown. As students become more familiar with blended and independent learning, and both teachers and students become more competent and confident, then science education can be engaging and motivating. Through my research, I found that blended learning, while time intensive to implement, provided positive teaching and learning opportunities for both the teacher and the participating students.

This doctoral research was a mixed methods inquiry and analysis of student and teacher perceptions of using blended learning in a Year 10 Earth & Space Science unit. The study is specific in time and space, occurring in one school in Queensland, in 2014, and the results cannot be generalised to a wider population. Any teacher-researcher will be limited by the contexts of their own classroom studies. My study was on an implementation of a blended learning approach in two science classrooms in a regional secondary school in Queensland. Nevertheless, some of the findings reported here can be used to inform the planning and implementation of blended learning in other classrooms.

The Year 10 students who participated in this study generally agreed that blended learning had a positive impact on their science learning, and suggested that self-directed learning, such as that required by blended learning, should begin much earlier, as it is difficult for students to shift to this type of learning after years of teacher directed instruction. This research fills a novel gap by providing insight into using explicit teaching as a framework for planning and implementing blended learning in science. This study has demonstrated the importance of providing autonomous learning opportunities for students in secondary science, and illustrated the value of high level practitioner research. Further research on the use of blended learning in secondary science, specifically focusing on teacher perceptions of planning and implementing blended learning in secondary schools would build on the findings of this classroom study.

REFERENCES

Abdelaziz, H. A. (2012). D4 S4: A four dimensions instructional strategy for web-based and blended learning. *The Turkish Online Journal of Educational Technology, 13*(4), 220-235.

ACARA. (2013a). *Australian Curriculum v5.1: Science*. Australian Curriculum Assessment and Reporting Authority Retrieved from http://www.australiancurriculum.edu.au/Science/Curriculum/F-10.

ACARA. (2013b). *Australian Curriculum: General Capabilities in the Australian Curriculum*. Australian Curriculum Assessment and Reporting Authority Retrieved from http://www.australiancurriculum.edu.au/GeneralCapabilities/Pdf/Overview.

ACARA. (2013c). *NAPLAN achievement in reading, persuasive writing, language conventions and numeracy: National report for 2013*. Sydney, Australia: Australian Curriculum, Assessment and Reporting Authority Retrieved from www.nap.edu.au.

ACARA. (2014). Australian Curriculum - Science V7.3. Retrieved from http://www.australiancurriculum.edu.au/science/curriculum/f-10?layout=1

ACARA. (2016a). *NAP National Assessment Program*. Australian Curriculum Assessment and Reporting Authority Retrieved from http://www.nap.edu.au/about.

ACARA. (2016b). NAP Score equivalence tables. Retrieved from http://nap.edu.au/results-and-reports/how-to-interpret/score-equivalence-tables

Ainley, J., Kos, J., & Nicholas, M. (2008). *Participation in science, mathematics and technology in Australian education* (Research Monograph No. 63). Retrieved from Melbourne: http://research.acer.edu.au/acer_monographs/4

AITSL. (2011). *Australian professional standards for teachers*. Retrieved from Victoria, Australia: https://www.aitsl.edu.au/docs/default-source/apst-resources/australian_professional_standard_for_teachers_final.pdf

AITSL. (2015). *Evaluation of the implementation of the Australian Professional Standards for Teachers: Interim Report 2, 2014 Key Findings*. Retrieved from Melbourne: http://www.aitsl.edu.au/

Alise, M. A., & Teddlie, C. (2010). A continuation of the paradigm wars? Prevalence rates of methodological approached across the social/behavioral sciences. *Journal of Mixed Methods Research, 4*(2), 103-126. doi:10.1177/1558689809360805

Atkins, L., & Wallace, S. (2012). Insider Research. In *Qualitative Research in Education* (pp. 47-64). London: SAGE Publications Ltd.

Ausubel, D. P. (1963). A teaching strategy for culturally deprived pupils: Cognitive and motivational considerations. *The School Review, 71*(4), 454-463.

Bandura, A. (1977). *Social learning theory*. Englewood Cliffs, N.J.: Prentice Hall.

Barbour, M. (2008). Secondary students' perceptions of web-based learning. *Quarterly Review of Distance Education, 9*(4), 357-371.

Barbour, M. (2010). Researching K-12 online learning: What do we know and what should we examine? *Distance Learning, 7*(2), 6-12.

Behar, A., & Mishra, P. (2015). *ICTs in schools: Why focusing policy and resources on educators, not children, will improve educational outcomes*. Retrieved from Geneva: http://www3.weforum.org/docs/WEF_Global_IT_Report_2015.pdf

Bidarra, J., & Rusman, E. (2016). Towards a pedagogical model for science education: bridging educational contexts through a blended learning approach. *Open Learning: The Journal of Open, Distance and e-Learning, 32*(1), 6-20. doi:10.1080/02680513.2016.1265442

Biesta, G. (2010). Pragmatism and the philosophical foundations of mixed methods research. In A. Tashakkori & C. Teddlie (Eds.), *SAGE Handbook of mixed methods in social & behavioral research* (pp. 95-118). Thousand Oaks: SAGE Publications, Inc.

Bingimlas, K. A. (2009). Barriers to the successful integration of ICT in teaching and learning environments: A review of the literature. *Eurasia Journal of Mathematics, Science & Technology Education, 5*(3), 235-245.

Blanchard, M. R., Southerland, S. A., Osborne, J. W., Sampson, V. D., Annetta, L. A., & Granger, E. M. (2010). Is inquiry possible in light of accountability?: A quantitative comparison of the relative effectiveness of guided inquiry and verification laboratory instruction. *Science Education, 94*(4), 577-616. doi:10.1002/sce.20390

Bliuc, A.-M., Casey, G., Bachfischer, A., Goodyear, P., & Ellis, R. A. (2012). Blended learning in vocational education: Teachers' conceptions of blended learning and their approaches to teaching and design. *Australian Educational Researcher, 39*(2), 237-257.

Borrego, M., Douglas, E. P., & Amelink, C. T. (2009). Quantitative, qualitative, and mixed research methods in engineering education. *Journal of Engineering Education, 98*(1), 53-66.

Boulton, H. (2008). Managing e-learning: What are the real implications for schools? *Electronic Journal of e-Learning, 6*(1), 11-18.

Brand, J., Kinash, S., Mathew, T., & Kordyban, R. (2011). *iWant does not equal iWill: correlates of mobile learning with iPads, e-textbooks, BlackBoard Mobile Learn and a blended learning experience.* Paper presented at the ascilite 2011, Hobart, Australia.

Calderon, O., Ginsberg, A. P., & Ciabocchi, L. (2012). Multidimensional assessment of pilot blended learning programs: Maximizing program effectiveness based on student and faculty feedback. *Journal of Asynchronous Learning Networks, 16*(3), 23-37.

Carter, C. P., Reschly, A. L., Lovelace, M. D., Appleton, J. J., & Thompson, D. (2012). Measuring student engagement among elementary students: Pilot of the Student Engagement Instrument--Elementary Version. *School Psychology Quarterly, 27*(2), 61-73. doi:10.1037/a0029229

Cash, J. (2014). *The use of online technologies to enhance student learning and foster engagement in drama education.* (Master of Education), The University of Melbourne, Melbourne.

Chandra, V. (2004). *The impact of a blended web-based learning environment on the perceptions, attitudes, and performance of boys and girls in junior science and senior physics.* (Doctor of Science Education), Curtin University of Technology, Retrieved from http://espace.library.curtin.edu.au/R?func=dbin-jump-full&local_base=gen01-era02&object_id=15943

Chandra, V., & Briskey, J. (2012). ICT driven pedagogies and its impact on learning outcomes in high school mathematics. *International Journal of Pedagogies and Learning, 7*(1), 73-83.

Chandra, V., & Fisher, D. (2006). Assessing the effectiveness of a blended web-based learning environment in an Australian high school. In D. Fisher & M. S. Khine (Eds.), *Contemporary approaches to research on learning environments worldviews* (pp. 461-478). Singapore: World Scientific Publishing.

Chandra, V., & Fisher, D. L. (2009). Students' perceptions of a blended web-based learning environment. *Learning Environments Research, 12*(1), 31-44.

Chandra, V., & Watters, J. (2012). Re-thinking physics teaching with web-based learning. *Computers & Education, 58*(1), 631-640.

Chang, V., & Fisher, D. (1999). *Students' perceptions of the efficacy of web-based learning environment: the emergence of a new learning instrument*. Paper presented at the HERDSA Annual International Conference, Melbourne.

Chang, V., & Fisher, D. (2003). The validation and application of a new learning environment instrument for online learning in higher education. In M. S. Khine & D. Fisher (Eds.), *Technology-rich learning environments: A future perspective* (pp. 1-18). Singapore: World Scientific Publishing Co. Pte. Ltd.

Chen, W.-F. (2012). An investigation of varied types of blended learning environments on student achievement: An experimental study. *International Journal of Instructional Media, 39*(3), 205-212.

Cherryholmes, C. H. (1992). Notes on Pragmatism and Scientific Realism. *American Educational Research Association, 21*(6), 13-17.

Cheung, A., Slavin, R. E., Kim, E., & Lake, C. (2017). Effective secondary science programs: A best-evidence synthesis. *Journal of Research in Science Teaching, 54*(1), 58-81. doi:10.1002/tea.21338

Cheung, W. S., & Hew, K. F. (2011). Design and evaluation of two blended learning approaches: Lessons learned. *Australasian Journal of Educational Technology, 27*(8), 1319-1337.

Chou, C.-T., Chuang, C.-p., & Zheng, B.-y. (2013). The study of blended learning on a vocational high school in Taiwan. *Journal of Modern Education and Computer Science, 5*(3), 1-7.

Cobern, W. W., Schuster, D., Adams, B., Applegate, B., Skjold, B., Undreiu, A., . . . Gobert, J. D. (2010). Experimental comparison of inquiry and direct instruction in science. *Research in Science & Technological Education, 28*(1), 81-96. doi:10.1080/02635140903513599

Cook, M., Dickerson, D. L., Annetta, L. A., & Minogue, J. (2011). In-service teachers' perceptions of online learning environments. *Quarterly Review of Distance Education, 12*(2), 73.

Creswell, J. W. (2009). *Research design: qualitative, quantitative and mixed methods approaches*. In. Retrieved from www.amazon.com

Creswell, J. W. (2012). *Qualitative inquiry & research design: Choosing among five approaches*. In. Retrieved from www.amazon.com

Creswell, J. W. (2015). *A concise introduction to mixed methods research*. In. Retrieved from www.amazon.com

Creswell, J. W., & Clark, V. L. P. (2006). *Designing and conducting mixed methods research*. Thousand Oaks, California: SAGE Publications.

Danaia, L., Fitzgerald, M., & McKinnon, D. (2013). Students' perceptions of high school science: What has changed over the last decade? *Research in Science Education, 43*, 1501-1515. doi:10.1007/s11165-012-9318-x

De George-Walker, L., & Keeffe, M. (2010). Self-determined blended learning: a case study of blended learning design. *Higher Education Research & Development, 29*(1), 1-13.

Dean, D. J., & Kuhn, D. (2007). Direct instruction vs. discovery: The long view. *Science Education, 91*(3), 384-397. doi:10.1002/sce.20194

Department of Education and Training Far North Queensland. (2013). *Explicit Teaching Lesson Model - FNQ Region*. Retrieved from http://www.farnorthqld.eq.edu.au/improving-teaching/wp-content/uploads/FNQ_ET_LessonModel_TOBECOMPLETED1.pdf.

Department of Education and Training Far North Queensland. (2014). *FNQ explicit teaching project intensive face to face teacher information*. Retrieved from http://www.farnorthqld.eq.edu.au/improving-teaching/wp-content/uploads/FNQ_ET_LessonModel_TOBECOMPLETED1.pdf.

Department of Education and Training Far North Queensland. (2017). I do, we do, you do Explicit teaching - it's how our students learn best. Retrieved from http://farnorthqld.eq.edu.au/index.php/our-schools/how-we-teach-and-learn/explicit-teaching

Dewey, J. (1910). *How we think*. USA: D.C Heath & Co., Publishers.

Dewey, J. (1916). Democracy and education: an introduction to the philosophy of education. In (Kindle ed.). Retrieved from www.amazon.com.

Dewey, J. (2010). The need for a philosophy of education (1934). *Schools: Studies in Education, 7*(2), 244-245.

Dewey, J. (2015). *The collected works of John Dewey*. In D. Reed (Ed.). Retrieved from www.amazon.com

Di Scala-Fouchereau, E., & Fouchereau, A. (2012). *Relative effectiveness of direct instruction vs. active learning in the teaching of science.* Paper presented at the New Perspectives in Science Education 2012, Florence, Italy.

Donnelly, D., McGarr, O., & O'Reilly, J. (2011). A framework for teachers' integration of ICT into their classroom practice. *Computers & Education, 57*(2), 1469-1483. doi:10.1016/j.compedu.2011.02.014

Dovros, N., & Makrakis, V. (2012). Transforming the classroom into a reflective community: A blended learning instructional approach. *Journal of Teacher Education for Sustainability, 14*(2), 73-88.

Earle, J. E., & Fraser, B. J. (2016). Evaluating online resources in terms of learning environment and student attitudes in middle-grade mathematics classes. *Learning Environments Research*. doi:10.1007/s10984-016-9221-x

Ellis, R. A., & Calvo, R. A. (2007). Minimum indicators to assure quality of LMS-supported blended learning. *Educational Technology & Society, 10*(2), 60-70.

Emelyanova, N., & Voronina, E. (2017). Introducing blended learning in the English language classroom: Students' attitudes and perceptions before and after the course. *Knowledge Management & E-Learning: An International Journal, 9*(1), 33-49.

Engelmann, S., Becker, W. C., Carnine, D., & Gersten, R. (1988). The direct instruction follow through model: Design and outcomes. *Education and Treatment of Children, 11*(4), 303-317.

Evagorou, M., Avraamidou, L., & Vrasidas, C. (2008). *Using online technologies and handhelds to scaffold students' argumentation in science.* Paper presented at the World Conference on Educational Multimedia, Hypermedia and Telecommunications (EDMEDIA), Vienna, Austria.

Fisher, D., & Frey, N. (2008). *Better learning through structured teaching: A framework for the gradual release of responsibility*. In. Retrieved from www.amazon.com

Fitzgerald, M., McKinnon, D. H., Danaia, L., & Deehan, J. (2015). A large-scale inquiry-based astronomy intervention project: Impact on students' content knowledge performance and views of their high school science classroom. *Research in Science Education, 46*(6), 901-916. doi:10.1007/s11165-015-9486-6

Florian, T. P., & Zimmerman, J. P. (2015). Understanding by design, Moodle, and blended learning: A secondary school case study. *Journal of Online Learning and Teaching, 11*(1), 120-128.

FNQ Explicit Teaching Team. (2014). Consolidation Guidelines. Retrieved from https://innisfailss.eq.edu.au/Supportandresources/Formsanddocuments/Documents/consolidation-guidelines.pdf

Fossey, E., Harvey, C., McDermott, F., & Davidson, L. (2002). Understanding and evaluating qualitative research. *Australian and New Zealand journal of psychiatry, 36*(6), 717-732.

Francis, R., & Shannon, S. J. (2013). Engaging with blended learning to improve students' learning outcomes. *European Journal of Engineering Education, 38*(4), 359-369.

Fraser, B. J. (1998). Science learning environments: Assessment, effects and determinants. In B. J. Fraser & K. G. Tobin (Eds.), *International handbook of science education* (pp. 527-564). Dordrecht: The Netherlands Academic Publishers.

Fraser, B. J. (2002). Learning environments research: Yesterday, today and tomorrow. In S. C. Goh & S. K. Myint (Eds.), *Studies in educational learning environments: An international perspective* (pp. 1-26): World Scientific Publishing Company.

Furberg, A. (2009). Socio-cultural aspects of prompting student reflection in web-based inquiry learning environments. *Journal of Computer Assisted Learning, 25*(4), 397-409. doi:10.1111/j.1365-2729.2009.00320.x

Gallagher, J. J. (1991). Prospective and practicing secondary school science teachers' knowledge and beliefs about the philosophy of science. *Science Education, 75*(1), 121-133. doi:10.1002/sce.3730750111

Gedik, N., Kiraz, E., & Ozden, M. Y. (2013). Design of a blended learning environment: Considerations and implementation issues. *Australasian Journal of Educational Technology, 29*(1), 1-19.

Gerstner, S., & Bogner, F. X. (2010). Cognitive achievement and motivation in hands-on and teacher-centred science classes: Does an additional hands-on consolidation phase (concept mapping) optimise cognitive learning work stations? *International Journal of Science Education, 32*(7), 849-870. doi:10.1080/09500690902803604

Godwin-Jones, R. (2012). Emerging technologies challenging hegemonies in online learning. *Language Learning & Technology, 16*(2), 4-13.

Goldkuhl, G. (2012). Pragmatism vs interpretivism in qualitative information systems research. *European Journal of Information Systems, 21*, 135-146.

Goodrum, D., Druhan, A., & Abbs, J. (2012). *The status and quality of year 11 and 12 science in Australian schools*. Canberra, ACT: Australian Academy of Science

Retrieved from http://www.science.org.au/reports/documents/Year-1112-Report-Final.pdf.

Greene, J. C. (2005). The generative potential of mixed methods inquiry. *International Journal of Research & Method in Education, 28*(2), 207-211. doi:10.1080/01406720500256293

Groundwater-Smith, S., Le Cornu, R. J., & Ewing, R. A. (1998). *Teaching: challenges and dilemmas*: Harcourt Brace.

Grove, N. P., & Lowery Bretz, S. (2012). A continuum of learning: from rote memorization to meaningful learning in organic chemistry. *Chemistry Education Research and Practice, 13*(3), 201-208. doi:10.1039/c1rp90069b

Gunstone, R. (2000). Science teachers as researchers in Australia. Some examples. *Research in Science Education, 30*(3), 255-257.

Guzey, S. S., & Roehrig, G. H. (2012). Integrating educational technology into secondary science teaching. *Contemporary Issues in Technology and Teacher Education, 12*(2), 162-183.

Hardy, I. (2016). Legitimating and contesting the commodification of schooling: the case of teachers' learning in Queensland. *British Educational Research Journal, 42*(3), 524-542.

Hattie, J. (2008). *Visible Learning: A Synthesis of Over 800 Meta-analyses Relating to Achievement*. Hoboken: Taylor & Francis.

Hattie, J. (2013). What is the nature of evidence that makes a difference to learning? *Form@re, 2*(13), 6-21.

Hattie, J. (2014). *Visible learning for teachers: Maximising impact on learners*. New York: Routledge.

Hayes, D. N. A. (2007). ICT and learning: Lessons from Australian classrooms. *Computers & Education, 49*(2), 385-395. doi:10.1016/j.compedu.2005.09.003

Hechter, R. P. (2012). pre-service teachers' maturing perceptions of a TPACK-framed signature pedagogy in science education. *Computers in the Schools, 29*(1-2), 53-69. doi:10.1080/07380569.2012.657999

Hoepfl, M. C. (1997). Choosing qualitative research: A primer for technology education researchers. *Journal of Technology Education, 9*(1), 47-63.

Hollingsworth, J., & Ybarra, S. (2009). *Explicit direct instruction (EDI): the power of the well-crafted, well taught lesson*: Corwin Press Inc.

Ingvarson, L., Meiers, M., & Beavis, A. (2005). Factors affecting the impact of professional development programs on teachers' knowledge, practice, student outcomes & efficacy. *education policy analysis archives, 13*. doi:10.14507/epaa.v13n10.2005

James Cook University. (2017). Code for the Responsible Conduct of Research. Retrieved from https://www.jcu.edu.au/policy/research-management/code-for-the-responsible-conduct-of-research

James, W. (1907). *Pragmatism: A new name for some old ways of thinking*: The Floating Press.

Johnson, B., & Gray, R. (2010). A history of philosophical and theoretical issues for mixed methods research. In A. Tashakkori & C. Teddlie (Eds.), *SAGE Handbook of mixed methods in social & behavioral research* (pp. 69-94). Thousand Oaks.

Johnson, B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational Researcher, 33*(2), 14-26.

Johnson, L., Adams, S., & Cummins, M. (2012). *The NMC horizon report: 2012 K-12 edition*. Retrieved from Austin, Texas: http://www.nmc.org/pdf/2013-horizon-report-k12.pdf

Jokinen, P., & Mikkonen, I. (2013). Teachers' experiences of teaching in a blended learning environment. *Nurse Education in Practice, 13*(6), 524-528. doi:10.1016/j.nepr.2013.03.014

Kang, N. H., DeChenne, S. E., & Smith, G. (2012). Inquiry learning of high school students through a problem-based environmental health science curriculum. *School Science and Mathematics, 112*(3), 147-158. doi:10.1111/j.1949-8594.2011.00128.x

Kay, R. (2013). Evaluating the instructional architecture of web-based learning tools (WBLTs): direct instruction vs. constructivism revisited. *Journal of Interactive Learning Research, 24*(1), 33.

Kay, R., & Knaack, L. (2007). Evaluating the use of learning objects for secondary school science. *Journal of Computers in Mathematics and Science Teaching, 26*(4), 261-289.

Kennedy, J., Lyons, T., & Quinn, F. (2014). The continuing decline of science and mathematics enrolments in Australian high schools. *Teaching Science, 60*(2), 34-46.

Killen, R. (2007). *Effective teaching strategies: Lessons from research and practice* (4 Ed.). Sydney, NSW: Thomson Social Science Press.

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist, 41*(2), 75-86.

Klahr, D., & Nigam, M. (2004). The equivalence of learning paths in early science instruction: effects of direct instruction and discovery learning. *Psychological Science, 15*(10), 661-667.

Kök, I., & Canbay, O. (2011). An experimental study on the vocabulary level and vocabulary consolidation strategies. *Procedia - Social and Behavioral Sciences, 15*, 891-894. doi:10.1016/j.sbspro.2011.03.206

Kolikant, Y. B.-D. (2012). Using ICT for school purposes: Is there a student-school disconnect? *Computers & Education, 59*(3), 907-914. doi:10.1016/j.compedu.2012.04.012

Koſar, G. (2016). A study of EFL instructors' perceptions of blended learning. *Procedia - Social and Behavioral Sciences, 232*, 736-744. doi:10.1016/j.sbspro.2016.10.100

Kozma, R. B. (2011). The technological, economic, and social contexts for education ICT policy. In UNESCO (Ed.), Transforming Education: The power of ICT policies (pp. 4-18): United Nations Educational, Scientific and Cultural Organization. Retrieved from http://unesdoc.unesco.org/images/0021/002118/211842e.pdf.

Kuo, Y.-C., Belland, B. R., Schroder, K. E. E., & Walker, A. E. (2014). K-12 teachers' perceptions of and their satisfaction with interaction type in blended learning environments. *Distance Education, 35*(3), 360-381. doi:10.1080/01587919.2015.955265

Lankshear, C., & Knobel, M. (2004). *A handbook for teacher research: From design to implementation*. In. Retrieved from www.amazon.com

Lee, H.-S., Linn, M. C., Varma, K., & Liu, O. L. (2010). How do technology-enhanced inquiry science units impact classroom learning? *Journal of Research in Science Teaching, 47*(1), 71-90. doi:10.1002/tea.20304

Lee, V. (2012). What is inquiry-guided learning? *New Directions for Teaching and Learning, 2012*(129), 5-14. doi:10.1002/tl.20002

Leno, L. C., & Dougherty, L. A. (2007). Using direct instruction to teach content vocabulary. *Science Scope, 31*(1), 63.

Lewin, K. (1939). Field theory and experiment in social psychology: Concepts and methods. *American Journal of Sociology, 44*(6), 868-896.

Liaw, S.-S. (2008). Investigating students' perceived satisfaction, behavioural intention, and effectiveness of e-learning: A case study of the Blackboard system. *Computers & Education, 51*(2), 864-873.

Liaw, S.-S., Huang, H.-M., & Chen, G.-D. (2007). Surveying instructor and learner attitudes toward e-learning. *Computers & Education, 49*(4), 1066-1080.

Lin, Y.-W. (2017). The effect of blended learning in mathematics course. *EURASIA Journal of Mathematics, Science and Technology Education, 13*(3). doi:10.12973/eurasia.2017.00641a

Lincoln, Y. S., & Guba, E. G. (2013). *Constructivist credo*. Walnut Creek, California: Left Coast Press Inc.

Liu, O. L., Lee, H.-S., & Linn, M. C. (2010). Multifaceted assessment of inquiry-based science learning. *Educational Assessment, 15*(2), 69-86. doi:10.1080/10627197.2010.491067

Liu, X., Waight, N., Gregorius, R., Smith, E., & Park, M. (2012). Developing computer model-based assessment of chemical reasoning: a feasibility study. *Journal of Computers in Mathematics and Science Teaching, 31*(3), 259-281.

López-Pérez, M. V., Pérez-López, M. C., & Rodríguez-Ariza, L. (2011). Blended learning in higher education: Students' perceptions and their relation to outcomes. *Computers & Education, 56*(3), 818-826. doi:10.1016/j.compedu.2010.10.023

Lorsbach, A. W., & Tobin, K. (1992). Constructivism as a referent for science teaching. In F. Lorenzo, K. Cochran, J. Krajcik, & P. Simpson (Eds.), *Research Matters... to the Science Teacher*. Manhattan, KS: National Association for Research in Science Teaching.

Loughran, J. (2002). Teacher as researcher: the PAVOT project. In J. J. Loughran, I. Mitchell, & J. Michell (Eds.), *Learning from Teacher Research* (pp. 3-18). New Your NY USA: Teachers College Press.

Loughran, J. (2007). Researching teacher education practices: Responding to the challenges, demands, and expectations of self-study. *Journal of Teacher Education, 58*(1), 12-20. doi:10.1177/0022487106296217

Luketic, C. D., & Dolan, E. L. (2013). Factors influencing student perceptions of high-school science laboratory environments. *Learning Environments Research, 16*(1), 37-47.

Lyons, T., & Quinn, F. (2010). *Choosing Science: understanding the declines in senior high school science enrolments*. Retrieved from http://www.une.edu.au/siemerr

Lyons, T., & Quinn, F. (2012). Rural high school students' attitudes towards school science. *Australian and International Journal of Rural Education, 22*(2), 21-28.

Mackenzie, N., & Knipe, S. (2006). Research dilemmas: Paradigms, methods and methodology. *Issues in Educational Research, 16*(2), 193-205.

Mavhunga, E., & Rollnick, M. (2015). Teacher- or learner-centred? Science teacher beliefs related to topic specific pedagogical content knowledge: A South African case study. *Research in Science Education, 46*(6), 831-855. doi:10.1007/s11165-015-9483-9

Maynes, N., Julien-Schultz, L., & Dunn, C. (2010). Modelling and the gradual release of responsibility: What does it look like in the classroom. *Brock Education, 19*(2), 65-77.

Merriam, S. B. (1998). Qualitative research and case study applications in education. In (Kindle ed.): ERIC. Retrieved from www.amazon.com.

Michael, J., & Modell, H. I. (2003). *Active learning in secondary and college science classrooms: A working model for helping the learner to learn* In (pp. 176). Retrieved from www.amazon.com

Ministerial Council on Education Employment Training and Youth Affairs. (2008). *Melbourne Declaration on Educational Goals for Young Australians*. Melbourne: Ministerial Council on Education, Employment, Training and Youth Affairs.

Montessori, M. (2010). *The Montessori method*. In. Retrieved from www.amazon.com

Montessori, M. (2014). The absorbent mind [Kindle Edition]. Retrieved from www.amazon.com

Morgan, D. L. (2014). Pragmatism as a paradigm for social reserach. *Qualitative Inquiry, 20*(8), 1045-1053. doi:10.1177/1077800413513733

Moskal, P., Dziuban, C., & Hartman, J. (2013). Blended learning: A dangerous idea? *Internet and Higher Education, 18*, 15-23.

Napier, N. P., Dekhane, S., & Smith, S. (2011). Transitioning to blended learning: Understanding student and faculty perceptions. *Journal of Asynchronous Learning Networks, 15*(1), 20-32.

Neimeyer, R. A., & Levitt, H. (2001). Constructivism/ Constructionism: Methodology. In N. J. Smelser & P. B. Baltes (Eds.), *International Encyclopedia of the Social & Behavioral Sciences* (pp. 2651-2654): Elsevier Science Ltd.

Ocak, M. A. (2011). Why are faculty members not teaching blended courses? Insights from faculty members. *Computers & Education, 56*(3), 689-699. doi:10.1016/j.compedu.2010.10.011

OECD. (2014). *PISA 2012 results in focus: What 15-year-olds now and what they can do with what they know*. Retrieved from PISA, Paris: http://www.oecd.org/pisa/keyfindings/pisa-2012-results-overview.pdf

OECD. (2015). *Students, computers and learning: Making the connection, PISA*. Retrieved from http://dx.doi.org/10.1787/9789264239555-en

OECD. (2016). *PISA 2015: PISA results in focus*. Retrieved from

Office of the Chief Scientist. (2012). *Health of Australian Science*. Canberra, Australia: Commonwealth of Australia Retrieved from http://www.chiefscientist.gov.au/2012/05/health-of-australian-science-report-2/.

Office of the Chief Scientist. (2014). *Science, technology, engineering and mathematics: Australia's future*. Canberra: Commonwealth of Australia.

Owston, R., York, D., & Murtha, S. (2013). Student perceptions and achievement in a university blended learning strategic initiative. *Internet and Higher Education, 18*, 38-46.

Perry, R. B. (1916). *Present philosophical tendencies, a critical survey of naturalism, idealism, pragmatism, and realism together with a synopsis of the philosophy of William James* (3rd ed.). New York: Longmans, Green, and Co.

Pina, S. (2012). From contact teaching to blended learning. *Interdisciplinary Studies Journal, 2*(2), 21-37.

Polesel, J., Rice, S., & Dulfer, N. (2013). The impact of high-stakes testing on curriculum and pedagogy: a teacher perspective from Australia. *Journal of Education Policy, 29*(5), 640-657. doi:10.1080/02680939.2013.865082

Prestridge, S. (2012). The beliefs behind the teacher that influences their ICT practices. *Computers & Education, 58*(1), 449-458. doi:10.1016/j.compedu.2011.08.028

Productivity Commission. (2012). *Schools workforce: Research report*. Retrieved from Canberra:

Psycharis, S., Chalatxoglidis, G., & Kalogiannakis, M. (2013). Moodle as a learning environment in promoting conceptual understanding for secondary school students. *Eurasia Journal of Mathematics, Science & Technology Education, 9*(1), 11-21. doi:10.12973/eurasia.2013.912a

Pugh, K. J., Linnenbrink-Garcia, L., Koskey, K. L., Stewart, V. C., & Manzey, C. (2009). Motivation, learning, and transformative experience: A study of deep engagement in science. *Science Education, 94*(1), 1-28.

Ricker, T. J., & Cowan, N. (2014). Differences between presentation methods in working memory procedures: a matter of working memory consolidation. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 40*(2), 417-428. doi:10.1037/a0034301

Rivera, J. H. (2016). Science-based laboratory comprehension: an examination of effective practices within traditional, online and blended learning environments. *Open Learning: The Journal of Open, Distance and e-Learning, 31*(3), 209-218. doi:10.1080/02680513.2016.1208080

Robinson, K. (Producer). (2006). Do schools kill creativity? Retrieved from https://www.ted.com/talks/ken_robinson_says_schools_kill_creativity

Rosen, D., & Nelson, C. (2008). Web 2.0: a new generation of learners and education. *Computers in the Schools, 25*(3-4), 211-225. doi:10.1080/07380560802370997

Rosenshine, B. V. (1986). Synthesis of research on explicit teaching. *Educational Leadership, 43*(7), 60-69.

Rosenshine, B. V. (1995). Advances in research on instruction. *The Journal of Educational Research, 88*(5), 262-268.

Ruhnau, H., Stannard, P., & Williamson, K. (2012). *Science World 10 Teacher Edition*. South Yarra, Australia: Macmillan Education Australia Pty Ltd.

Ryan, M., Taylor, M., Barone, A., Della Pesca, L., Durgana, S., Ostrowski, K., . . . Pikaard, K. (2016). Teacher as researcher, teacher as scholar, and teacher as leader

leader. *The New Educator, 13*(2), 102-116. doi:10.1080/1547688x.2016.1144120

Seimears, C. M., Graves, E., Schroyer, M. G., & Staver, J. (2012). How constructivist-based teaching influences students learning science. *The Educational Forum, 76*(2), 265-271. doi:10.1080/00131725.2012.653092

Shannon-Baker, P. (2015). Making paradigms meaningful in mixed methods research. *Journal of Mixed Methods Research*. doi:10.1177/1558689815575861

Sharplin, E. J., Stahl, G., & Kehrwald, B. (2016). "It's about improving my practice": The learner experience of real-time coaching. *Australian Journal of Teacher Education, 41*(5).

She, H.-C., & Liao, Y.-W. (2010). Bridging scientific reasoning and conceptual change through adaptive web-based learning. *Journal of Research in Science Teaching, 47*(1), 91-119.

Skelton, D. E. (2007). *An investigation into the learning environments of blended delivery (e-learning and classroom) in a tertiary environment.* (Doctor of Science Education), Curtin University of Technology,

Smithsonian Environmental Research Center. (2014). Atomosphere change is in the air. Retrieved from http://forces.si.edu/atmosphere/

Smythe, M. (2012). *Toward a framework for evaluating blended learning.* Paper presented at the ascilite 2012, Wellington, New Zealand.

So, H.-J., & Brush, T. A. (2008). Student perceptions of collaborative learning, social presence and satisfaction in blended learning environment: Relationships and critical factors. *Computers & Education, 51*, 318-336.

Sorbie, J. L. (2015). *Exploring teacher perceptions of blended learning.* (Doctor of Education), Walden University,

Staker, H., & Horn, M. B. (2012). *Classifying K-12 blended learning*. Retrieved from http://www.innosightinstitute.org/innosight/wp-content/uploads/2012/05/Classifying-K-12-blended-learning2.pdf

Stevens, M. (2016). Space for all: Middle level students in blended learning environments. *Voices from the Middle, 24*(2), 50-55.

Sun, D., & Looi, C.-K. (2013). Designing a web-based science learning environment for model-based collaborative inquiry. *Journal of Science Education and Technology, 22*(1), 73-89. doi:10.1007/s10956-012-9377-9

Swarat, S., Ortony, A., & Revelle, W. (2012). Activity matters: Understanding student interest in school science. *Journal of Research in Science Teaching, 49*(4), 515-537.

Tashakkori, A., & Teddlie, C. (2010a). Putting the human back in "human research methodology": The researcher in mixed methods research. *Journal of Mixed Methods Research, 4*(4), 271-277. doi:10.1177/1558689810382532

Tashakkori, A., & Teddlie, C. (2010b). *SAGE Handbook of mixed methods in social & behavioral research*.

Taylor, J. A., Getty, S. R., Kowalski, S. M., Wilson, C. D., Carlson, J., & Van Scotter, P. (2015). An efficacy trial of research-based curriculum materials with curriculum-based professional development. *American Educational Research Journal, 52*(5), 984-1017. doi:10.3102/0002831215585962

Teddlie, C., & Tashakkori, A. (2010). Overview of contemporary issues in mixed methods research. In C. Teddlie & A. Tashakkori (Eds.), *SAGE Handbook of mixed methods in social & behavioral research* (pp. 1-42). Thousand Oaks: SAGE Publications, Inc.

Thayer-Bacon, B. (2012). Maria Montessori, John Dewey, and William H. Kilpatrick. *Education and Culture, 28*(1), 3-20.

The State of Queensland (Department of Education and Training). (2014). Curriculum into the Classroom (C2C). Retrieved from http://education.qld.gov.au/c2c/

The State of Queensland (Department of Education Training). (2017). Research Guidelines. Retrieved from http://education.qld.gov.au/corporate/research/research_guidelines.pdf

Thomson, S. (2015). *Australian students in a digital world*. Retrieved from http://research.acer.edu.au/cgi/viewcontent.cgi?article=1002&context=policyinsights

Tobin, K. (1998). Qualitative perceptions of learning environments on the world wide web. *Learning Environments Research, 1*(2), 139-162. doi:10.1023/A:1009953715583

Treagust, D. F., Won, M., Petersen, J., & Wynne, G. (2015). Science teacher education in Australia: Initiatives and challenges to improve the quality of teaching. *Journal of Science Teacher Education, 26*(1), 81-98. doi:10.1007/s10972-014-9410-3

Trinidad, S., Aldridge, J., & Fraser, B. (2005). Development, validation and use of the online learning environment survey. *Australasian Journal of Educational Technology, 21*(1), 60-81.

Tsivitanidou, O., Zacharia, Z. C., Hovardas, T., & Nicolaou, A. (2012). Peer assessment among secondary school students: Introducing a peer feedback tool in the context of a computer supported inquiry learning environment in science. *Journal of Computers in Mathematics and Science Teaching, 31*(4), 433-465.

Tytler, R. (2007). *Re-imagining science education: Engaging students in science for Australia's future*. Retrieved from Camberwell, Victoria: http://www.acer.edu.au/documents/aer51_reimaginingsciedu.pdf

Tytler, R., Osborne, J., Williams, G., Tytler, K., & Clark, J. C. (2008). *Opening Up Pathways: Engagement in STEM across the primary-secondary school transition*. Canberra, Australia Retrieved from http://www.innovation.gov.au/Skills/ResourcesAndPublications/Documents/OpenPathinSciTechMathEnginPrimSecSchTrans.pdf.

Ültanır, E. (2012). An epistemological glance at the constructivist approach: Constructivist learning in Dewey, Piaget and Montessori. *International Journal of Instruction, 5*(2), 195-212.

UNESCO. (2000). *The Dakar Framework for Action- Education for all: Meeting our collective commitments*. Retrieved from Dakar, Senegal:

UNESCO. (2015). *Education for all 2000-2015: Achievements and challenges*. Retrieved from Paris, France:

Upadhyay, B., & DeFranco, C. (2008). Elementary students' retention of environmental science knowledge: connected science instruction versus direct instruction. *Journal of Elementary Science Education, 20*(2), 23-37.

Varma, K., & Linn, M. C. (2012). Using interactive technology to support students' understanding of the greenhouse effect and global warming. *Journal of Science Education and Technology, 21*(4), 453-464.

Waha, B., & Davis, K. (2014). University students' perspective on blended learning. *Journal of Higher Education Policy and Management, 36*(2), 172-182.

Walker, S. L., & Fraser, B. J. (2005). Development and Validation of an Instrument for Assessing Distance Education Learning Environments in Higher Education: The Distance Education Learning Environments Survey (DELES). *Learning Environments Research, 8*(3), 289-308. doi:10.1007/s10984-005-1568-3

Wallet, P. (2014). *Information and communication technology (ICT) in education in Asia*. Retrieved from Montreal, Quebec: http://www.uis.unesco.org/Communication/Documents/ICT-asia-en.pdf

Wan, N., & Nicholas, H. (2010). A progressive pedagogy for online learning with high-ability secondary school students: a case study. *The Gifted Child Quarterly, 54*(3), 239-251.

Webb, M. (2013). Changing models for researching pedagogy with information and communications technologies. *Journal of Computer Assisted Learning, 29*(1), 53-67.

Weimer, M. (2013). *Learner-Centered Teaching: Five Key Changes to Practice*: John Wiley & Sons, Incorporated.

White, G. K. (2008). *ICT trends in education*. Retrieved from http://research.acer.edu.au/cgi/viewcontent.cgi?article=1001&context=digital_learning

Wong, A. F. L., Quek, C.-L., Divaharan, S., Liu, W.-C., Peer, J., & Williams, M. D. (2006). Singapore students' and teachers' perceptions of computer-supported project work classroom learning environments. *Journal of Research on Technology in Education, 38*(4), 449-479.

Wood, D., Bruner, J. S., & Ross, G. (1976). The role of tutoring in problem solving. *Journal of Child Psychology and Psychiatry, 17*, 89-100.

Wood, D., & Wood, H. (1996). Vygotsky, tutoring and learning. *Oxford Review of Education, 22*(1), 5-16.

Yapici, İ. Ü., & Akbayin, H. (2012). The effect of blended learning model on high school students' biology achievement and on their attitudes towards the internet. *The Turkish Online Journal of Educational Technology, 11*(2), 228-237.

Yeh, Y.-C. (2009). Integrating e-learning into the Direct-instruction Model to enhance the effectiveness of critical-thinking instruction. *Instructional Science, 37*(2), 185-203. doi:10.1007/s11251-007-9048-z

Yeh, Y.-c., Huang, L.-y., & Yeh, Y.-l. (2011). Knowledge management in blended learning: Effects on professional development in creativity instruction. *Computers & Education, 56*(1), 146-156. doi:10.1016/j.compedu.2010.08.011

Zhang, W., & Zhu, C. (2017). Review on blended learning: Identifying the key themes and categories. *International Journal of Information and Education Technology, 7*(9), 673-678. doi:10.18178/ijiet.2017.7.9.952

APPENDICES

Appendix A: Modified WEBLEI Scales and Items used in the present study from (Chandra, 2004)

STATEMENTS	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree
I can access lesson on the internet at times convenient to me.	1	2	3	4	5
Lessons on the internet are available at locations suitable for me.	1	2	3	4	5
I can access lessons on the internet on days when I am not in class or absent from school.	1	2	3	4	5
Lessons on the internet allow me to work at my own pace to achieve learning objectives.	1	2	3	4	5
Lessons on the internet enable me to decide how much I want to learn in a given period.	1	2	3	4	5
Lessons on the internet enable me to decide when I want to learn.	1	2	3	4	5
The flexibility of lessons on the internet allows me to meet my learning goals.	1	2	3	4	5
The flexibility of the lessons on the internet allows me to explore my own areas of interest.	1	2	3	4	5
I communicate with my teacher in this subject electronically via email.	1	2	3	4	5
In this learning environment, I have to be self-disciplined in order to learn.	1	2	3	4	5
I have the options to ask my teacher what I do not understand by sending an email.	1	2	3	4	5

STATEMENTS	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree
I feel comfortable asking my teacher questions via email.	1	2	3	4	5
The teacher responds to my emails.	1	2	3	4	5
I can ask other students what I do not understand during computer lessons.	1	2	3	4	5
Other students respond positively to questions in relation to internet lessons.	1	2	3	4	5
I was encouraged by the positive attitude of my friends towards the internet lessons.	1	2	3	4	5
This mode of learning enables me to interact with other students an my teacher.	1	2	3	4	5
I felt a sense of satisfaction and achievement about this learning environment.	1	2	3	4	5
I enjoy learning in this environment.	1	2	3	4	5
I could learn more in this environment.	1	2	3	4	5
I can easily get students to work with me on the internet.	1	2	3	4	5
It is easy to work with other students and discuss the content of the lessons.	1	2	3	4	5
The web-based learning environment held my interest in this subject throughout this term.	1	2	3	4	5

STATEMENTS	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree
I felt a sense of boredom in this subject towards the end of this term.	1	2	3	4	5
I can work out exactly what each lesson on the internet is about.	1	2	3	4	5
The organisation of each lesson on the internet is easy to follow.	1	2	3	4	5
The structure of the lessons on the internet keeps me focused on what is to be learned.	1	2	3	4	5
Internet lessons helped me better understand the work that was taught in class.	1	2	3	4	5
Lessons on the internet are well sequenced.	1	2	3	4	5
The subject content is appropriate for delivery on the internet.	1	2	3	4	5
The presentation of the subject content is clear.	1	2	3	4	5
The multiple-choice test at the end of lessons on the internet improves my learning in this subject.	1	2	3	4	5

Please respond to these questions as best you can. All answers should be in relation to eLearn and web-based learning.

1. Do you think that eLearn improved your results in Earth Science? Explain.

2. Do you believe that it is a good idea to supplement in class learning with teacher developed websites such as eLearn? Explain.

3. What are some of the advantages of online learning when compared to in-class learning?

4. What are some of the disadvantages of online learning when compared to in-class learning?

5. What are some of the features of the websites which you though were beneficial to you as a learner? Explain.

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6. During computer lessons, did the website promote discussion on the lesson which you were doing between your classmates and you? Explain.

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7. What are thoughts on the lesson quizzes?

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8. Was the website accessible to you at all times? Explain.

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9. What are some of the other features which should be incorporated in the website to improve learning outcomes?

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____
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10. Do you have access to a reliable internet connection at all times? Yes/No

Other comments

Appendix B Explicit Teaching Lesson Model – FNQ Region

EXPLICIT TEACHING LESSON MODEL – FNQ REGION

Explicit teaching - every day, every classroom.

OPENING THE LESSON

Lesson Intent — Hollingsworth& Ybarra Chapter 4 + VIDEO link
- Present the lesson objective/intent to the students.
- Have the students interact with the learning objective or lesson intent.
- Ensure that students can describe the learning objective or lesson intent.

Success Criteria — VIDEO link
- Clearly explain success criteria to students (what they have to do to show mastery of the concept/skill).
- Include exemplars.

Activate Prior Knowledge — Hollingsworth& Ybarra Chapter 5 + VIDEO link
- Re-teach or review the critical prerequisites that link directly to the new content to be taught.

Lesson Importance — Hollingsworth& Ybarra p160 + VIDEO link
- Provide Personal, Real-Life or Academic reasons why the content is important to learn.
- Call on volunteers to provide additional reasons.

I DO

Content Delivery — Hollingsworth& Ybarra Chapter 6 + VIDEO link
- Always use clear and concise language.
- Segment complex skills into smaller instructional units.
- Present content by:
  - Explaining (telling),
  - Modelling (thinking aloud),
  - Demonstrating (using physical objects).

Concept and Skill Development — Hollingsworth& Ybarra Chapter 7 + VIDEO link

Concept Development
1. Identify the concept in the learning objective/intent.
2. Provide a written bullet proof definition.
3. Provide examples and non-examples and reveal critical and non-critical attributes.

Skill Development
1. Identify the skill in the learning objective/intent.
2. Provide a step-by-step process, method or approach.
3. Model using the steps while solving real problems.

WE DO

Working Together — VIDEO link
- Provide a range of opportunities for students to interact with the concept and to practise the skill.
- Ensure that the problem types worked match those of the "I Do" and those to be encountered in the "You Do" by students.
- Have students respond frequently (oral responses, written responses, action responses).
- Provide immediate feedback to student responses.

Guided Practice — Hollingsworth& Ybarra Chapter 8 + VIDEO link
1. 'Copy me' - work problems step-by-step with students working them at the same time.
2. 'Copy me to a point' – slowly release students to work steps by themselves.
3. Verbal prompts only.

Check for Understanding (CFU) — Hollingsworth& Ybarra Chapter 3 + VIDEO link
- Regularly check for understanding using a range of CFU strategies. Aim for 80%+ success rate before moving on.
- Before moving to the "You Do":
  - Can the majority of my students correctly describe the concept I just taught them?
  - Can the majority of my students execute the skill I just taught them?

YOU DO

Independent Practice — VIDEO link
- Ensure that the independent practice matches examples worked in the "I Do" and "We Do".
- Set minimum expectations for the whole class as to the amount of written work that has to be completed.
- Differentiate - have a range of more difficult and challenging activities for the more capable students.
- Actively monitor students and provide private, specific, individualised process feedback (encourage quality).
- In-class intervention (if required) – work with students identified through the "We Do" while other students complete the independent practice.

CLOSING THE LESSON

Lesson Review — VIDEO link
- Review and revise the critical content to aid with retention:
  - Concept definition,
  - Skill methodology.
- Revisit lesson importance.
- Ask students to reflect on what they have learnt and make a connection to the next lesson.

CHECKING FOR UNDERSTANDING

"Verifying that Students are Learning"

Students' ability to successfully answer CFU questions determines the pace of the lesson and the need to re-teach.

CFU Techniques

The TAPPLE technique.

Teach first
Ask a question
Pause
Pick a non-volunteer
Listen
Effective feedback

Other CFU strategies

- Pop sticks/dominoes etc. to select non-volunteers.
- Personal white boards
- Choral responding
- Action responses
- Using partners

Feedback

Provide immediate affirmative and corrective feedback.

The 3Es

Echo –when the student response is correct.

Elaborate – when the student response is tentative or partially correct.

Explain – (re-explain) when student response is incorrect.

Student Accountability

Don't let students off the hook - always cycle back:

"I'll come back to you."

Acknowledgements

John Hollingsworth & Sylvia Ybarra, "Explicit Direct Instruction – The Power of the Well-Crafted, Well-Taught Lesson", Hawker Brownlow, 2009.

Anita Archer & Charles Hughes, "Explicit Instruction – Effective and Efficient Teaching", The Guilford Press 2011.

Appendix C: Year 10 Unit Plan *(modified from the Curriculum into the Classroom (C2C) unit resources (The State of Queensland (Department of Education and Training), 2014)*

School name	**Unit title**	**Duration of unit**
	Earth & Space Science	10 Weeks
Unit outline		
In this unit students will be learning about Earth and Space Science. **Global Systems** Students examine the cause and effect of changes in global systems and analyse the effect of human activity on the environment. They evaluate the impact of changes to the global systems on the planets equilibrium and biodiversity. The role of science and scientific research in assisting society to address global environmental issues is explored. Students are asked to consider their individual responsibility to the sustainability of the planet. **The Universe** Students will explore features of the universe and how the Big Bang theory is used to explain the formation of the universe. They will consider how theories have changed over time in line with technological advances and how theories are continuing to be refined. Students will see how secondary data is analysed to describe astronomical phenomena.		

Identify curriculum			
Content descriptions to be taught			**General capabilities and cross-curriculum priorities**
Science Understanding	**Science Inquiry Skills**	**Science as a Human Endeavour**	
Earth & Space Science • Global systems, including the carbon cycle, rely on interactions involving the biosphere, lithosphere, hydrosphere and atmosphere (ACSSU189) • The universe contains features including galaxies, stars and solar systems and the Big Bang theory can be used to explain the origin of the universe (ACSSU188)	**Communicating** • Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS208) **Evaluating** • Critically analyse the validity of information in secondary sources and evaluate the approaches used to solve problems (ACSIS206) • Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data (ACSIS205) **Processing and analysing data and information** • Use knowledge of scientific concepts to draw conclusions that are consistent with evidence.	**Nature and development of science** • Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries (ACSHE192) • Scientific understanding, including models and theories, are contestable and are refined over time through a process of review by the scientific community (ACSHE191) **Use and influence of science** • People can use scientific knowledge to evaluate whether they should accept claims, explanations or prediction	**Literacy** listen to, read and view published and self-created texts and work towards critical evaluation of their content, use appropriate science language specific to this unit; technical vocabulary and everyday language used in science contexts; procedural vocabulary (e.g. explain, examine, link, discuss, reflect) **Numeracy** graph numerical data; • analyse data from research; use appropriate measurements; identify trends and patterns from numerical data and graphs. **Inquiring & Communicating with ICT** Use ICT to design investigations, formulate hypotheses, compile primary and secondary data, monitor and record and analyse data and draw conclusions; Conduct internet searches and critically evaluate data, information, credibility, relevance, accuracy, currency, and reliability; Use online learning environments to participate in online courses, blended courses and to access materials and services.

Achievement standard
In this unit, monitoring of student learning aligns to the following components of the Achievement standard. By the end of year 10studentsdevelop questions and hypotheses and independently design and carry out appropriate methods of investigation. When designing and undertaking investigations they take into account the need for accuracy, safety, fairness, ethical actions and collaboration. They identify where digital technologies can be used to enhance the quality of investigations and they communicate using scientific language and representations appropriate to the content. Students demonstrate an understanding of the scientific theories that explain the origin of the universe and the evolution of life on Earth. They use relationships between force, mass and acceleration to predict changes in the motion of objects. They explain the basis of the periodic table and use this organiser to distinguish between elements, and use knowledge of chemical change to predict the products of chemical reactions. They explain and predict how change, including that caused by human activity, affects the sustainability of systems at a local and global level. They describe factors that have guided scientific developments, predict how future applications of science and technology may affect people's lives, and evaluate information from a scientific perspective. *The Australian Curriculum: Science for Prep (F)-10 Version 1.2* *www.australiancurriculum.edu.au/Science/Curriculum/F-10* *[accessed on 16 October 2011]*

Assessment		Make judgments
Describe the assessment	**Assessment date**	
Summative Assessment • Pre-Test	Week 1	This assessment item will serve as a bench mark to identify any areas students already understand, and areas where students may need more time.
Summative Assessment • Weekly quizzes	Weekly	This will be provided ongoing assessment of where students are understanding and where they may need more support
Formative Assessment • Task 1 – Persuasive Essay	Week 5	Global systems, including the carbon cycle, rely on interactions involving the biosphere, lithosphere, hydrosphere and atmosphere (ACSSU189)
Formative Assessment • Task 2 – Written Exam	Week 10	The universe contains features including galaxies, stars and solar systems and the Big Bang theory can be used to explain the origin of the universe (ACSSU188)

Teaching Sequence	
Duration	**Topics**
2 Lessons	Introduction and Course Orientation
3 Lessons	Exploring Global Systems
3 Lessons	Examining a changing planet
2 Lessons	Responding to global issues
5 Lessons	Assessment Task 1 – Persuasive Essay
15 Lessons	**Global Systems**
6 Lessons	Exploring the universe
3 Lessons	Origin of the Universe
3 Lessons	Space Technology
2 Lessons	Reviewing Global Systems and Space Science
1 Lessons	Assessment Task 2 – Written Exam
15 Lessons	**The Universe**

<table>
<tr><td colspan="4">Teaching Sequence</td></tr>
<tr><td>Topic</td><td>Global Systems</td><td>Topic Duration</td><td>5 Weeks</td></tr>
<tr><td>Overview</td><td colspan="3">Students examine the cause and effect of changes in global systems and analyse the effect of human activity on the environment. They evaluate the impact of changes to the global systems on the planets equilibrium and biodiversity. The role of science and scientific research in assisting society to address global environmental issues is explored. Students are asked to consider their individual responsibility to the sustainability of the planet.</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td>Lessons</td><td colspan="3">Teaching & Learning Sequence</td></tr>
<tr><td>Lesson 1</td><td colspan="3">Introduction & Orientation
• Course Outline & Expectations
• Introduction to eLearn
Pre-Test</td></tr>
<tr><td>Lesson 2</td><td colspan="3">Discovering the Lithosphere
• Examine the structure of the lithosphere
• Describe the use of the surface of the lithosphere
Discuss the effects of changes to the lithosphere</td></tr>
<tr><td>Lesson 3</td><td colspan="3">Discovering the atmosphere
• Explore the structure of the atmosphere
• Define weather and climate
Discuss the influence of the atmosphere on other systems</td></tr>
<tr><td>Lesson 4</td><td colspan="3">Discovering the hydrosphere
• Explain the composition of the hydrosphere
• Describe the distribution of fresh and salt water on the planet
• Discuss the influence of ocean currents on global systems</td></tr>
<tr><td>Lesson 5</td><td colspan="3">Discovering the biosphere
• Explain the composition of the biosphere
• Identify the interconnectivity of the systems
Describe the influencing factors on habitats and biodiversity</td></tr>
</table>

Lesson 6	**Analysing the flow of carbon** • Explain the importance of carbon in nature • Examine the structure of the carbon cycle Explain the carbon cycle's influence on the planet	
Lesson 7	**The Changing state of the climate** • Explain the greenhouse effect • Define global warming and climate change • Examine data on climate change Identify changes to the global systems	
Lesson 8	**Analysing changes to water distribution** • Revise the water cycle • Describe the changing conditions of water use and availability • Discuss the impact of climate change on water resources	**PRACTICAL –** Melting Sea Ice
Lesson 9	**Analysing changes to nutrient cycles** • Outline the nitrogen and phosphorus cycles • Discuss how humans have influenced the cycles Analyse changes to agriculture practices	
Lesson 10	**Evaluating the effect of change on the biosphere** • Examine current ecosystems • Examine current research on biodiversity and its importance Discuss the impact of human influence on biodiversity	
Lesson 11-14	**Assessment Task 1 – Persuasive Essay**	

Teaching Sequence			
Topic	**The Universe**	**Topic Duration**	5 Weeks
Overview	Students will explore features of the universe and how the Big Bang theory is used to explain the formation of the universe. They will consider how theories have changed over time in line with technological advances and how theories are continuing to be refined. Students will see how secondary data is analysed to describe astronomical phenomena.		
Lessons	**Teaching & Learning Sequence**		
Lesson 1	**Our Place in Space** • Explore the shape and composition of the Universe		
Lesson 2	**Discovering the universe** Use appropriate scales to describe the distances between celestial bodies		
Lesson 3	**Introduction to Stars** • Examine the life cycles of stars • Identify time scales over which star changes occur Identify potential end products of star life cycles including recycling into new stars.		
Lesson 4	**Star Lifecycles** • Examine the life cycles of stars • Identify time scales over which star changes occur • Identify potential end products of star life cycles including recycling into new stars.		
Lesson 5	**Star structure & Lifecycles** • Handout " what is a star's lifecycle" and "what kind of star is the sun"		
Lesson 6-7	**Stargazing** • Examine the coordinate systems and how it is used to navigate the sky • Understand and Explain the movement of the stars across the sky • Identify the usefulness of constellations such as the Southern Cross	• star gazing notes	
Lesson 8	**Space Technology** • Outline some technologies used to study the universe, and the type of data they provide • Explore developments that improve the availability and precision of universe data	**Hubble Space Station** • Technology • Light curve • Spectral analysis • Infrared imaging	

Lesson 9 - 11	**Origin of the Universe** • Outline the Big Bang theory and the calculated age of universe • Explain red shift and how it supports Big Bang theory • Explain CMBR and how it supports Big Bang theory Explore how the scientific community, through the review process, has clarified aspects of the Big Bang theory.
Lesson 12-15	**Revision**
Lesson 15	**Assessment Task 2 – Written Exam**

Appendix D: Earth Science Pre/Post-Test

Multiple-choice questions

For each question, circle the ANSWER that is MOST correct.

1	**Groundwater** is part of the: **A** atmosphere **B** biosphere **C** hydrosphere **D** lithosphere
2	As the water temperature increases, the amount of dissolved oxygen: **A** increases. **B** decreases. **C** decreases, then increases. **D** stays the same.
3	Freshwater fish are likely to die if the pH is: **A** about 7 (neutral). **B** more than 7.6. **C** less than 6.5 or more than 7.6. **D** between 6.5 and 7.6.
4	The layer of air around Earth is called the atmosphere. It consists of three layers called the troposphere, stratosphere and ionosphere. The layer in which most of our weather occurs is called the: **A** troposphere **B** atmosphere **C** ionosphere **D** stratosphere
5	The layer of air around Earth which contains ozone and absorbs much of the ultraviolet radiation from the sun is called the: **A** troposphere **B** atmosphere **C** ionosphere **D** stratosphere

6	One of the major greenhouse gases is carbon dioxide (CO_2). Which of the following is NOT a way to reduce greenhouse gases? **A** Plant more trees. **B** Air-condition your house. **C** Use a smaller or more efficient car. **D** Buy food produced locally
7	Over the last 100 years the concentration of carbon dioxide in the atmosphere has: **A** increased. **B** decreased. **C** increased, then decreased. **D** stayed the same
8	Over the last 100 years the average global surface air temperature has: **A** stayed the same. **B** decreased slightly. **C** increased by almost 1°C. **D** increased by several degrees Celsius.
10	The main difference between global warming and the depletion of ozone is that one: **A** causes a change in composition of the gases in the atmosphere. **B** is caused by humans. **C** is caused by CFCs in the atmosphere. **D** causes more cases of cancer.
11	A light-year is best described as: **A** the time it takes light to travel from the sun to the Earth. **B** the time it takes for the sun to rotate on its axis. **C** the distance travelled by light in a year. **D** the distance to the nearest star.
12	Light travels at about 300 000 km/s. If light from the sun takes about 8 minutes to reach the Earth, approximately how far is the Earth from the sun? **A** 625 km **B** 37 500 km **C** 2 400 000 km **D** 144 000 000 km

13	Some scientists think that the impact of a meteorite with our planet approximately 65 million years ago may have led to the sudden extinction of many species. The most likely way in which the meteorite could have brought about these extinctions would be: **A** widespread fires caused by fragments of the meteorite. **B** dust and smoke in the atmosphere which reduced sunlight and caused the death of plants. **C** floods and a tidal waves caused by the impact. **D** all of the above.
14	The nearest star in the Southern Cross is about 88 light years from the Earth. This means that: **A** it would take about 88 years to travel to the star in a modern spacecraft. **B** light given off by the Earth takes 88 years to reach the star. **C** light given off by the star takes 88 years to reach the Earth. **D** it is closer to the Earth than the most distant planet in our solar system.
15	You observe an interesting star in the night sky with an azimuth of 90˚ and an elevation of 30˚. What is the best explanation of where to find it in the sky? **A** In an easterly direction and high in the sky. **B** In an easterly direction and low in the sky. **C** In a westerly direction and high in the sky. **D** In a westerly direction and low in the sky.
16	The constellation of the Southern Cross is visible from countries in the Southern Hemisphere, including Australia. It can be used as a reliable indication of direction in navigation at night because: **A** it slowly rotates around the Earth once a year. **B** the Southern Cross is always exactly due south from the Earth. **C** The south pole of the Earth points towards a point in space near the Southern Cross. **D** The Earth revolves around the Southern Cross once a year.

17	The brightest star in a constellation is: **A** beta star. **B** best star. **C** apparent star. **D** alpha star.
18	What will happen to a star many times the mass of our Sun when it runs out of its nuclear fuel? **A** it will become a red giant, then a white dwarf. **B** nothing – it will keep shining forever. **C** it will become a red giant, explode as a supernova, then become a black hole. **D** it will become a red giant, explode as a supernova, then become a white dwarf.
19	The amount of light actually given off by a star is: **A** luminosity **B** absolute magnitude **C** apparent magnitude **D** the ultra violet factor
20	The study of the formation and evolution of the universe is: **A** The big bang theory. **B** The study of cosmology. **C** The study of meteorology. **D** The study of astrology.

Short-answer questions

For each question, answer using complete sentences.

21 Name two ways in which carbon dioxide is added to the atmosphere.

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How is carbon dioxide *removed* from the atmosphere?

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22 Environmentalists often use the slogan *"Think globally—act locally"*. Explain what this means, using global warming or ozone depletion as an example.

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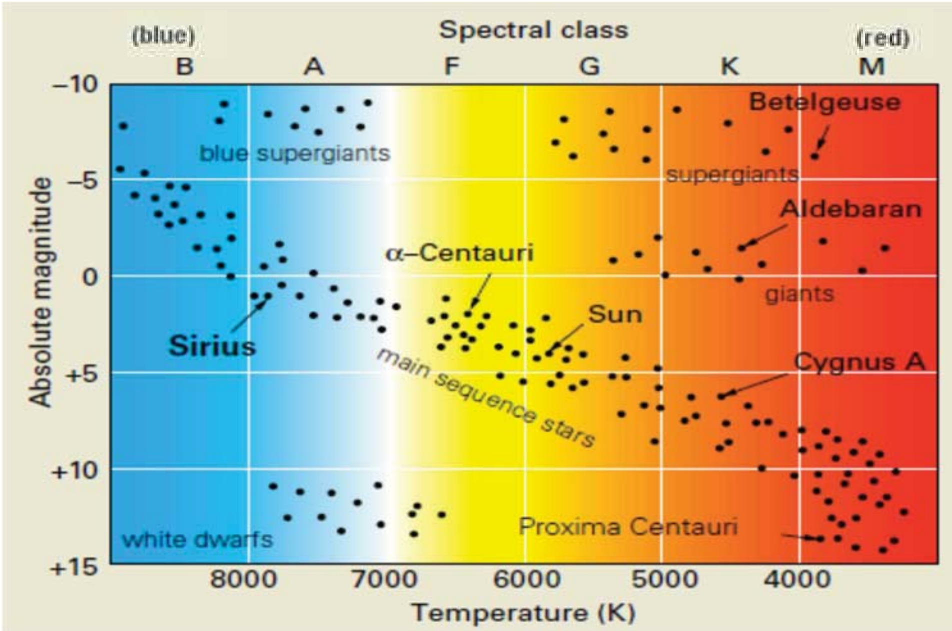
23	Explain one advantage of having telescopes, such as Hubble and Planck in Earth-orbit rather than on the ground. ____________________ ____________________ ____________________ ____________________
24	Define a light year. ____________________ ____________________ ____________________ ____________________ Define an astronomical unit. ____________________ ____________________ ____________________ ____________________ Explain why these two different units are necessary ____________________ ____________________ ____________________ ____________________
25	Describe one of the types of technology used to study the universe; Light curve, Spectral analysis, or infrared imaging. Explain what the technology is used for and how it is suited to the purpose. ____________________ ____________________ ____________________ ____________________ ____________________

26	Explain what is meant by the 'Big Bang' theory of the Universe and provide one piece of evidence to support this theory. Describe the formation of stars and planets following the big bang event in your answer ____ ____ ____ ____ ____ ____ ____

27	This scatter-graph is commonly known as the 'Hertzsprung-Russell' diagram ('H-R' for short). Refer to this diagram to answer the following questions. Note that the brightest stars are at the top (large negative absolute magnitude) and the dimmest stars are at the bottom (large positive absolute magnitude).



a) Describe the general relationship between the absolute magnitude, colour ('Spectral Class') and temperature of a star.

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____

b) Describe one similarity between the stars 'Aldebaran' and 'Cygnus A'.

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c) Describe one difference between the stars 'Aldebaran' and 'Cygnus A'.

____

____

d) Rigel is a star that has an absolute magnitude of –6.8 and has a surface temperature slightly higher than the star Sirius. Clearly plot and label a point on the graph above to represent Rigel.

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Appendix E: Focus Group Questions

Focus Group Questions

1. What are some things that help you learn best?

2. What are some barriers to your learning?

3. What do you understand by the term e-learning/ blended learning?

4. What do you think the role of e-learning is in secondary school? *Considering the potential benefits, disadvantages and role within an institution that predominantly teaches through face-to-face sessions.*

5. What effect did e-learning have on your study of Earth Science this term? *How is it used, what impact does it have on students and how do they respond?*

6. What motivates you to use e-learning?

7. What are the strengths or weaknesses of using of e-learning in science class? *Would any of these prevent you using e-learning? Can any of these be overcome?*

8. What changes could be made to better support the use of e-learning in science?

Appendix F: Explicit Teaching Observation Form

Available online at: http://www.farnorthqld.eq.edu.au/improving-teaching/wp-content/uploads/FNQ_ET_LessonModel_TOBECOMPLETED1.pdf

Explicit Teaching Observation & Feedback Date:______Coach: ___________

Queensland Government

Teacher __________________ Learning Area: Coaching Focus:

Learning Intentions & Success Criteria:

Check for Understanding and Provide Feedback throughout the lesson. (Excluding the I DO) T A P P L E

Before the Lesson	
Critical content selected – limited to specific elements; based on data and or the Curriculum	
Opening of Lesson	
Gained 100% of student attention	
Clearly established learning intention	
Clear success criteria (measurable)	
Why we are learning this	
Brief activation of prior skills and knowledge	
Teacher Modelled - I DO	
Logical sequence – progressing from simplest to more complex	
Modelled/demonstrated/explained - step by step	
Effective demonstration of think aloud	
Examples and non-examples (when appropriate) are provided	
Common errors or misconceptions are addressed	
Brisk pace or appropriate pace established	
Guided Practice - WE DO	
Guided practice is the SAME activity demonstrated in the I DO – all together, step by step	
Monitoring of students throughout – requiring varied response types (establishing readiness of students for independent work)	
Confirmation that all students are completing multiple examples with teacher	
Immediate affirmative and corrective feedback provided	
Re-teaches concept when necessary	
Brisk pace or appropriate pace maintained	
Independent Practice - YOU DO	
Independent task set- matching the task practiced and the set goals.	
Task adjusted for targeted students	
Conclusion	
Revisit – Learning Intentions	
Review – Main Points	
Reflect – Students explain or demonstrate that they have met success criteria	
Project – Follow on learning	

What went well:

Next steps/refinements:

Teacher will (when- date and time):

Coach will (when-date and time):

Routines clearly established:

Student success rate:

Student engagement:

Appendix G: Ethics Approval from James Cook University

This administrative form has been removed

Appendix H: Ethics Approval from The State of Queensland (Department of Education and Training)

This administrative form has been removed